

GRAM-POSITIVE BACTERIA:

Organism	Diagnostics	Virulence Factors	Clinical Manifestations	Treatment
<p><i>Staphylococcus aureus</i></p> <p>(nose, skin esp. hospital staff and pts; vagina)</p>	<p>1. gram stain:</p> <p>a. gram (+), clustered cocci</p> <p>2. culture:</p> <p>a. β-hemolytic</p> <p>b. golden w/ sheep blood</p> <p>3. Metabolic:</p> <p>a. catalase (+)</p> <p>b. coagulase (+)</p> <p>c. facultative anaerobe</p>	<p>1. Protective</p> <p>a. microcapsule</p> <p>b. Protein A: binds IgG</p> <p>c. Coagulase: fibrin formation around organism</p> <p>d. hemolysins</p> <p>e. leukocidins</p> <p>f. penicillinase</p> <p>2. Tissue-Destroying</p> <p>a. hyaluronidase</p> <p>b. staphylokinase (lysis of clots)</p> <p>c. lipase</p>	<p>1. Exotoxin Dependent</p> <p>a. enterotoxin \rightarrow gastroenteritis (rapid onset and recovery)</p> <p>b. TSST-1 \rightarrow toxic shock syndrome (fever, GI sx w/diarrhea, rash, hypotension, desquamation of palms and soles)</p> <p>c. exfoliatin \rightarrow scalded skin syndrome (children)</p> <p>2. Direct Invasion of Organs</p> <p>a. pneumonia</p> <p>b. meningitis</p> <p>c. osteomyelitis (children)</p> <p>d. acute bacterial endocarditis</p> <p>e. septic arthritis</p> <p>f. skin infection</p> <p>g. bacteremia/sepsis</p> <p>h. UTI</p>	<p>1. penicillinase-resistant penicillins (eg. methicillin, nafcillin)</p> <p>2. vancomycin</p> <p>3. clindamycin</p> <p>* if methicillin resistant, treat w/ IV vancomycin</p>
<p><i>Staphylococcus epidermidis</i></p> <p>(skin, mucous membranes)</p>	<p>1. gram stain:</p> <p>a. gram (+), clustered cocci</p> <p>2. Metabolic:</p> <p>a. catalase (+)</p> <p>b. coagulase (-)</p> <p>c. facultative anaerobe</p>	<p>1. Protective</p> <p>a. polysaccharide capsule (adherence to prosthetic devices)</p> <p>* high antibiotic resistance</p>	<p>1. Nosocomial Infection</p> <p>a. prosthetic joints, valves</p> <p>b. sepsis from intravenous lines</p> <p>c. UTI</p> <p>2. skin contamination in blood cultures</p>	<p>1. vancomycin</p>
<p><i>Staphylococcus saprophyticus</i></p>	<p>1. gram stain:</p> <p>a. gram (+), clustered cocci</p> <p>2. culture:</p> <p>a. γ-hemolytic</p> <p>3. Metabolic:</p> <p>a. catalase (+)</p> <p>b. coagulase (-)</p> <p>c. facultative anaerobe</p>		<p>1. UTIs in sexually active women</p>	<p>1. penicillin</p>

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<i>Streptococcus</i>				
<i>Streptococcus pneumoniae</i> (oral colonization)	1. gram stain: a. gram (+), diplococci 2. culture: a. does not grow in presence of optochin and bile b. α -hemolytic 3. Metabolic: a. catalase (-) b. facultative anaerobe 4. (+) quellung test (encapsulated bacteria)	1. capsule (83 serotypes)	1. pneumonia 2. meningitis 3. sepsis 4. otitis media (children) (secretes pneumolysins that bind cholesterol of host-cell membranes, actual effect is unknown)	1. penicillin G (IM) 2. erythromycin 3. ceftriaxone 4. vaccine: against the 23 most common capsular Ag's
<i>Streptococcus pyrogenes</i> (group A)	1. gram stain: a. gram (+), chains 2. culture: a. inhibited by bacitracin b. β -hemolytic (streptolysin O \rightarrow oxygen labile, antigenic; S \rightarrow oxygen stable, non-antigenic) 3. Metabolic: a. catalase (-) a. microaerophilic	1. M-protein (adherence factor, antiphagocytic, antigenic) 2. lipoteichoic acid (adherence factor) 3. streptokinase 4. hyaluronidase 5. DNAase 6. Anti-C5a peptidase	1. Direct Invasion/toxin a. pharyngitis (purulent exudates on tonsils, fever, swollen lymph nodes) b. sepsis c. skin infections d. scarlet fever e. toxic shock syndrome 2. Antibody-mediated a. rheumatic fever (fever, myocarditis, arthritis, chorea, rash, subcutaneous nodules) b. acute post-streptococcal glomerulonephritis	1. Penicillin G 2. Penicillin V 3. Erythromycin 4. Penicillinase-resistant penicillin (skin infections b/c might be staph) * après RF, cont. prophylaxis for repeat infection, if heart valve complications, prophylaxis avant certain procedures (eg. dental work) \rightarrow endocarditis ** invasive \rightarrow clindamycin
<i>Streptococcus agalactiae</i> (vaginal colonization)	1. gram stain: a. gram (+), chains (urine or CSF) 2. culture: (urine, CSF, blood) a. β -hemolytic 3. Metabolic: a. catalase (-) b. facultative anaerobe		1. neonatal meningitis 2. neonatal pneumonia 3. neonatal sepsis	1. penicillin G
<i>Enterococci</i> (group D) (normal colon flora)	1. gram stain: a. gram (+), chains 2. culture: a. bile, sodium chloride b. α, β, γ -hemolytic 3. Metabolic: a. catalase (-) b. facultative anaerobe	1. extracellular dextran helps bind to heart valves (high intrinsic resistance)	1. subacute bacterial endocarditis 2. biliary tract infections 3. UTI	1. ampicillin (combined w/ aminoglycosides in endocarditis) *resistance to penicillin G and emerging resistance to vancomycin
<i>Streptococcus viridans</i> (normal oropharynx flora & GI)	1. gram stain: a. gram (+), chains 2. culture: a. resistant to optochin b. α -hemolytic (green) 3. Metabolic: a. catalase (-) b. facultative anaerobe		1. subacute bacterial endocarditis 2. dental cavities 3. brain or liver abscesses	1. penicillin G

Organism	Diagnostics	Virulence Factors	Clinical Manifestations	Treatment
<i>Clostridium</i>				
<i>Clostridium tetani</i> (soil; entry via wounds)	1. gram stain: a. gram (+), spore-forming rods (drumstick appearance) 2. metabolism: a. anaerobe	1. flagella (H-Ag (+))	1. tetanospasmin: inhibits release of GABA and glycine from nerve cells → sustained muscle contraction a. muscle spasm b. lockjaw (trismus) c. risus sardonica (grin) d. opisthotones (pronounced back arch) e. respiratory muscle paralysis	1. tetanus toxoid: vaccine w/ formalin-inactivated toxin (DPT) 2. antitoxin: human tetanus immune globulin (for those never immunized) 3. clean the wound 4. penicillin or metronidazole 5. ventilatory assistance
<i>Clostridium botulinum</i> (soil, smoked fish, canned food, honey)	1. gram stain: a. gram (+), spore-forming rods 2. metabolism: a. anaerobe	1. flagella (H-Ag (+))	1. neurotoxin: inhibits release of ACh from peripheral nn (not secreted; released upon death of organism) a. cranial nerve palsies b. muscle weakness c. respiratory paralysis * infants: constipation and flaccid paralysis	1. antitoxin 2. penicillin 3. hyperbaric oxygen 4. ventilatory assistance and intubation
<i>Clostridium perfringens</i> (soil, food)	1. gram stain: a. gram (+), spore-forming rods 2. metabolism: a. anaerobe	1. non-motile	1. alpha toxin: lecithinase (splits lecithin into phosphocholine & diglyceride) a. gaseous gangrene • cellulites/wound infection • clostridial myonecrosis: fatal if no tx 2. superantigen (spores in food) a. food poisoning	1. radical surgery (amputation) 2. penicillin & clindamycin 3. hyperbaric oxygen
<i>Clostridium difficile</i> (GI, hospitals and nursing homes)	1. gram stain: a. gram (+), spore-forming rods 2. metabolism: a. anaerobe 3. immunoassay for <i>C. difficile</i> toxin 4. colonoscopy	1. flagella (H-Ag (+))	1. toxin A a. diarrhea 2. toxin B a. cytotoxic to colonic epithelial cells → pseudomembranous enterocolitis (antibiotic-associated diarrhea)	1. metronidazole 2. oral vancomycin 3. terminate use of responsible antibiotic

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<i>Bacillus</i>				
<i>Bacillus anthracis</i> (herbivores; cutaneous, inhaled, ingested endospores)	1. gram stain: b. gram (+), spore-forming rods 2. metabolism: b. aerobe (can be facultative) 3. serology	1. unique protein capsule (polymer of γ -D-glutamic acid: antiphagocytic) 2. non-motile 3. virulence depends on acquiring 2 plasmids; one carries gene for protein capsule, other carries gene for exotoxin	1. anthrax toxin (exotoxin): 3 proteins (protective Ag (PA), edema factor (EF), lethal factor (LF)) a. anthrax : painless black vesicles; can be fatal if untreated, woolsorter's pulmonary disease, abdominal pain, vomiting and bloody diarrhea (infection results in permanent immunity if pt survives)	1. penicillin G 2. erythromycin 3. vaccine: for high-risk individuals a. composed of protective Ag b. animal vaccine composed of live strain, attenuated by loss of its protein capsule

Organism	Diagnostics	Virulence Factors	Clinical Manifestations	Treatment
<p>Listeria</p> <p><i>Listeria monocytogenes</i></p> <p>(ingestion of contaminated raw milk or cheese; vaginal transmission)</p>	<p>1. gram stain:</p> <p>a. gram (+), non-spore-forming rods</p> <p>2. culture:</p> <p>a. low temperature (2.5°C)</p> <p>3. metabolism:</p> <p>a. catalase (+)</p> <p>b. β-hemolysis</p> <p>c. facultative intracellular anaerobic parasite</p>	<p>1. flagella (H-Ag (+))</p> <p>2. hemolysin</p> <p>a. heat labile</p> <p>b. antigenic</p>	<p>1. neonatal meningitis</p> <p>2. meningitis in immuno-suppressed pts*</p> <p>3. septicemia</p> <p>* cell-mediated immunity protective</p> <p>** only gram (+) w/endotoxin (LPS-Lipid A)—clinical significance is ambiguous</p>	<p>1. ampicillin</p> <p>2. trimethoprim/sulfamethoxazole</p>

GRAM-NEGATIVE BACTERIA:

Organism	Diagnostics	Virulence Factors	Clinical Manifestations	Treatment
Enterobacteriaceae				
<i>Salmonella species</i> (zoonotic: turtles, chicken, uncooked eggs)	1. gram stain: a. gram(-) rods 2. culture: (EMB/MacConkey) a. H₂S production 3. metabolism: a. catalase (+) b. oxidase (-) c. glucose fermenter d. does not ferment lactose e. facultative anaerobe	1. flagella (H antigen) 2. capsule (Vi antigen): protects from intracellular killing 3. siderophore * lives in Mφ in lymph nodes ** asplenic or non-fxn splenic pts are at increased risk	1. paratyphoid fever (similar to typhoid fever) 2. gastroenteritis 3. sepsis 4. osteromyelitis (esp SS pts)	1. ciprofloxacin 2. ceftriaxone 3. trimethoprim & sulfamethoxazole 4. azithromycin 5. diarrhea: only fluid and electrolyte replacement
<i>Salmonella typhi</i> (fecal-oral transmission)	1. gram stain: a. gram(-) rods 2. culture: (urine, blood, CSF; EMB/MacConkey agar) a. H₂S production 3. metabolism: a. catalase (+) b. oxidase (-) c. glucose fermenter d. does not ferment lactose e. facultative anaerobe	1. flagella (H antigen) 2. capsule (Vi antigen): protects from intracellular killing 3. siderophore * lives in Mφ in lymph nodes **can live in gall bladder for years *** asplenic or non-fxn splenic pts are at increased risk	1. typhoid fever a. fever b. abdominal pain c. hepatosplenomegaly d. rose spots on abdomen (light skinned pts) 2. chronic carrier state	1. ciprofloxacin 2. ceftriaxone 3. trimethoprim & sulfamethoxazole 4. azithromycin
<i>Shigella dysenteriae</i> (humans; fecal-oral transmission)	1. gram stain: a. gram(-) rods 2. culture: (stool; EMB/MacConkey agar) a. no H₂S production 3. metabolism: a. catalase (+) b. oxidase (-) c. glucose fermenter d. does not ferment lactose e. facultative anaerobe	1. non-motile (no H antigen) 2. invades submucosa not lamina propria *IgA best defense	1. Shiga toxin : inactivates the 60S ribosome, inhibiting protein synthesis and killing intestinal cells a. bloody diarrhea with mucus and pus	1. fluoroquinolones 2. trimethoprim & sulfamethoxazole
<i>Klebsiella pneumoniae</i>	1. gram stain: a. gram(-) rods 2. culture: (EMB/MacConkey) 3. metabolism: a. indole, oxidase (-) b. glucose, lactose fermenter c. facultative anaerobe	1. capsule 2. non-motile	1. pneumonia , with significant lung necrosis and bloody sputum, commonly in alcoholics, or those with underlying lung disease 2. hospital acquired UTI and sepsis	1. 3 rd generation cephalosporins 2. ciprofloxacin

Organism	Diagnostics	Virulence Factors	Clinical Manifestations	Treatment
<p>Enterobacteriaceae</p> <p><i>Escherichia Coli</i> (human GI and UT; transmitted fecal-oral, urethral migration, colonization of catheters, aspiration)</p>	<ol style="list-style-type: none"> 1. gram stain: <ol style="list-style-type: none"> a. gram(-) rods 2. culture: (urine, blood, CSF on EMB or MacConkey agar) <ol style="list-style-type: none"> a. grow at 45.5°C b. indole (+) c. β-hemolytic 3. metabolism: <ol style="list-style-type: none"> a. catalase (+) b. oxidase (-) c. glucose , lactose fermenter d. facultative anaerobe 	<ol style="list-style-type: none"> 1. fimbriae (pili): colonization factor 2. siderophore 3. adhesins 4. capsule (K antigen) 5. flagella (H antigen) 	<ol style="list-style-type: none"> 1. enterotoxins <ol style="list-style-type: none"> a. LT (heat labile) ↑cAMP (similar to cholera toxin) b. ST (heat stabile): ↑cGMP c. Shiga-like toxin (verotoxin): inhibits protein synthesis by inactivating the 60S ribosomal subunit → diarrhea <ol style="list-style-type: none"> a. <i>enterotoxigenic (ETEC)</i>: non-invasive; LT and ST toxins, causing traveler's diarrhea b. <i>enterohemorrhagic (EHEC)</i>: bloody diarrhea, no fever, no stool pus; secretes Shiga-like toxin → hemorrhagic colitis and hemolytic uremic syndrome (E.coli strain O157:H7) c. <i>enteroinvasive(EIEC)</i>: bloody diarrhea w/ stool pus and fever; secretes small amounts of shiga-like toxin 2. LPS <ol style="list-style-type: none"> a. hospital acquired sepsis 3. newborn meningitis 4. UTI 5. hospital acquired pneumonia 	<ol style="list-style-type: none"> 1. cephalosporins 2. aminoglycosides 3. trimethoprim & sulfamethoxazole 4. fluoroquinolones

Organism	Diagnostics	Virulence Factors	Clinical Manifestations	Treatment
<i>Vibrionaceae</i>				
<i>Vibrio cholera</i> (fecal-oral transmission)	<ol style="list-style-type: none"> gram stain: <ol style="list-style-type: none"> short, comma shaped, gram(-) rods w/ single polar flagellum culture: (TCBS agar) <ol style="list-style-type: none"> flat yellow colonies dark field microscopy of stool <ol style="list-style-type: none"> motile organisms immobilized with antiserum metabolism: <ol style="list-style-type: none"> ferments sugar (except lactose) 	<ol style="list-style-type: none"> flagellum (H antigen) mucinase: digests mucous layer to attach to cells fimbriae: helps with attachment to cells noninvasive 	<ol style="list-style-type: none"> cholergen (enterotoxin): like LT, ↑ cAMP → secretion of electrolytes from the intestinal epithelium (secretion of fluid into intestinal tract) <ol style="list-style-type: none"> cholera: severe diarrhea with rice water stools, no pus (death by dehydration) <p>* epidemics 1991 Latin America 1993 Bangladesh and India</p>	<ol style="list-style-type: none"> replace fluids doxycycline fluoroquinolone
<i>Campylobacter jejuni</i> (zoonotic: wild and domestic animals and poultry; transmitted by uncooked meat and fecal-oral)	<ol style="list-style-type: none"> gram stain: <ol style="list-style-type: none"> curved gram(-) rods w/ singular polar flagellum culture: (stool; EMB/MacConkey agar) <ol style="list-style-type: none"> optimum temp is 42°C metabolism: <ol style="list-style-type: none"> oxidase (+) does not ferment lactose microphilic aerobe 	<ol style="list-style-type: none"> flagella (H antigen) invasiveness 	<ol style="list-style-type: none"> enterotoxin: similar to cholera toxin and LT cytotoxin: destroys mucosal cells <p>→ secretory or bloody diarrhea</p> <p>* one of the three most common causes of diarrhea in the world</p>	<ol style="list-style-type: none"> fluoroquinolone erythromycin

Organism	Diagnostics	Virulence Factors	Clinical Manifestations	Treatment
<i>Pseudomonadaceae</i>				
<i>Pseudomonas aeruginosa</i> (opportunistic)	1. gram stain: <ol style="list-style-type: none"> gram(-) rods 2. culture: (blood agar) <ol style="list-style-type: none"> greenish-metallic appearance w/ fruity smell 3. metabolism: <ol style="list-style-type: none"> oxidase (+) non-lactose fermenter obligate aerobe 	1. polar flagellum (H antigen) 2. hemolysin 3. collagenase 4. elastase 5. fibrinolysin 6. phospholipase C 7. DNAase 8. some strains possess an antiphagocytic capsule	1. exotoxin A (similar to diphtheria toxin): inhibits protein synthesis by blocking EF2 <ol style="list-style-type: none"> pneumonia (cystic fibrosis and immunosuppressed pts) osteomyelitis (diabetics, IV drug users, children) burn wound infections sepsis UTI endocarditis (IV drug users) malignant external otitis corneal infections in contact lens wearers 	1. ticarcillin 2. timentin 3. carbenicillin 4. piperacillin 5. mezlocillin 6. ciprofloxacin 7. imipenem 8. tobramycin 9. aztreonam

Organism	Diagnostics	Virulence Factors	Clinical Manifestations	Treatment
<i>Bacteroidaceae</i>				
<i>Bacteroides fragilis</i> (normal GI flora)	1. gram stain: <ol style="list-style-type: none"> gram(-) rods non-spore forming polysaccharide capsule 2. metabolism: <ol style="list-style-type: none"> anaerobe 	* infection when organism enters peritoneal cavity	1. does not contain Lipid A <ol style="list-style-type: none"> abscesses in GI tract, pelvis, lungs 	1. metronidazole 2. clindamycin 3. chloramphenicol 4. surgically drain abscess
<i>Actinomyces</i>				

GRAM-NEGATIVE COCCI:

Organism	Diagnostics	Virulence Factors	Clinical Manifestations	Treatment
<i>Neisseria</i>				
<i>Neisseria Meningitidis</i> (neonates & army recruits)	<ol style="list-style-type: none"> gram (-) diplococci culture (Thayer-martin VCN) <ol style="list-style-type: none"> high CO₂ environment metabolism <ol style="list-style-type: none"> ferments maltose, glucose facultative anaerobe 	<ol style="list-style-type: none"> capsule: <ol style="list-style-type: none"> A, B, C serotypes associated w/ meningitis IgA₁ protease can extract Fe from transferrin pili (adherence) 	<ol style="list-style-type: none"> endotoxin: LPS <ol style="list-style-type: none"> meningitis (fever, stiff neck, vomiting, lethargy, altered mental state, petechial rash) septicemia (fever, petechial rash, hypotension, waterhouse-friderichsen syndrome: bilateral hemorrhage of adrenal glands along w/ hypotension & petechial rash) asymptomatic carriage in nasopharynx <p>* complement deficiency (MAC) renders susceptibility</p>	<ol style="list-style-type: none"> vaccine against capsular Ag's: A, C, Y and W-135. not B Antibiotics <ol style="list-style-type: none"> penicillin G ceftriaxone (3rd gen. c'sporins) rifampin used prophylactically for close contact of infected people
<i>Neisseria gonorrhoeae</i> (humans; sexually transmitted)	<ol style="list-style-type: none"> gram (-) diplococci culture (urethral pus; Thayer-martin VCN) <ol style="list-style-type: none"> WBCs high CO₂ environment metabolism <ol style="list-style-type: none"> ferments glucose facultative anaerobe 	<ol style="list-style-type: none"> pili <ol style="list-style-type: none"> adherence antigenic variation antiphagocytic: binds bacteria tightly to host cell IgA₁ protease outer membrane proteins: <ol style="list-style-type: none"> Protein I: porin Protein II (opacity protein): presence associated w/dark, opaque colonies for adherence 	<ol style="list-style-type: none"> endotoxin: LPS <ol style="list-style-type: none"> men: urethritis women: cervical gonorrhoea → PID (ascending) cx: sterility, ectopic pregnancies, abscesses, peritonitis, perihepatitis, salpingitis men and women: gonococcal bacteremia, septic arthritis neonates: ophthalma neonatorum conjunctivitis (usu erupts in first 5 days) <p>* complement deficiency (MAC) renders susceptibility</p>	<ol style="list-style-type: none"> 1st line <ol style="list-style-type: none"> 3rd generation C'sporins (ceftriaxone) + doxycycline for chlamydia and syphilis 2nd line (not effective for syphilis) <ol style="list-style-type: none"> fluoroquinolones spectinomycin ophthalmia neonatorum <ol style="list-style-type: none"> erythromycin eye drops prophylaxis w/disease: ceftriaxone + erythromycin serum for chlamydia

GRAM-NEGATIVE RODS RELATED TO RESPIRATORY TRACT INFECTIONS:

Organism	Diagnostics	Virulence Factors	Clinical Manifestations	Treatment
Hemophilus				
<i>Hemophilus influenzae</i> (humans; respiratory transmission)	1. gram (-) rods 2. culture: (blood agar heated to 80°C for 15 min) a. high CO ₂ environment 3. Fluorescent Ab's 4. (+) Quellung test	1. capsule (6 types, b most virulent) 2. attachment pili (FHA) 3. IgA ₁ protease	I. encapsulated 1. meningitis (type b): infants 3 – 36 m/o cx: retardation, seizures, deafness, and death 2. acute epiglottitis 3. septic arthritis in infants 4. sepsis esp pts w/o functioning spleens 5. pneumonia II. nonencapsulated 1. otitis media 2. sinusitis	1. 2 nd or 3 rd generation c'sporins 2. Hib vaccines: DTP 3. passive immunization (↑ mother transfer of immunity)
<i>Hemophilus dureyi</i> (STD)	1. gram (-) rods 2. culture: (ulcer exudates & pus from lymph node)	1. no capsule	1. chancroid : painful genital ulcer, often associated w/ unilateral swollen lymph nodes that rupture releasing pus	1. azithromycin or erythromycin 2. ceftriaxone 3. ciprofloxacin
Bordetella				
<i>Bordetella pertussis</i> (man; highly contagious; resp transmission)	1. gram (-) rod 2. culture: (Bordet-Gengou media) 3. serologic tests (ELISA) a. specimen from post. pharynx (does not grow on cotton) 4. direct fluorescein-labeled Ab's	1. pertussis toxin : activate G proteins that ↑ cAMP → ↑ histamine sensitivity, ↑ insulin release, ↑ lymphocytes in blood 2. extracytoplasmic AC: "weakens" PMNs, lymphocytes, and monocytes 3. FHA: binding to ciliated epi cells 4. tracheal cytotoxin: kills ciliated epi cells	1. whooping cough a. catarrhal phase : 1-2wks; pt is high contagious (low grade fever, runny nose, & mild cough) b. paroxymal phase : 2-10wks (whoop, ↑ lymphocytes in blood smear, antibiotics ineffective) c. convalescent phase	1. erythromycin (before paroxymal stage) 2. Vaccine: DPT (may cause rash & fever, rarely systemic disease) 3. newer-acellular vaccine w/pertussis toxin, FHA, pertactin, and frimbrial Ag 4. treat household contacts w/ erythromycin
Legionella				
<i>Legionella pneumophila</i> (ubiquitous in man & natural water environ.; air conditioning, cooling towers)	1. gram (-) rod (faint) 2. culture: (buffered charcoal yeast extract) 3. serologic tests (IFA, ELISA) 4. urinary Ag can be detected by radioimmunoassay; remains (+) for months after infection 5. facultative intracellular parasite	1. capsule 2. flagella & multiple fimbriae 3. hemolysin	1. cytotoxin 2. Pontiac fever : headache, fever, myalgia (self-limiting) 3. Legionnaires' Disease : pneumonia (atypical), fever, non-productive cough *compromised immune systems, greater risk	1. erythromycin 2. rifampin

GRAM-NEGATIVE RODS RELATED TO THE ENTERIC TRACT:

Organism	Diagnostics	Virulence Factors	Clinical Manifestations	Treatment
<i>Enterobacteriaceae</i>				
<i>Salmonella species</i> (zoonotic: turtles, chicken, uncooked eggs)	1. gram stain: a. gram(-) rods 2. culture: (EMB/MacConkey) a. H₂S production 3. metabolism: a. catalase (+) b. oxidase (-) c. glucose fermenter d. does not ferment lactose e. facultative anaerobe	1. flagella (H antigen) 2. capsule (Vi antigen): protects from intracellular killing 3. siderophore * lives in Mφ in lymph nodes ** asplenic or non-fxn splenic pts are at increased risk	1. paratyphoid fever (similar to typhoid fever) 2. gastroenteritis 3. sepsis 4. osteomyelitis (esp SS pts) 5. pneumonia and meningitis	indicated for neonates or pts at risk for septicemia or dissemination 1. ciprofloxacin (sepsis) 2. ceftriaxone (sepsis) 3. trimethoprim & sulfamethoxazole 4. azithromycin 5. diarrhea: only fluid and electrolyte replacement
<i>Salmonella typhi</i> (fecal-oral transmission)	1. gram stain: a. gram(-) rods 2. culture: (urine, blood, CSF; EMB/MacConkey agar) a. H₂S production 3. metabolism: a. catalase (+) b. oxidase (-) c. glucose fermenter d. does not ferment lactose e. facultative anaerobe	1. flagella (H antigen) 2. capsule (Vi antigen): protects from intracellular killing 3. siderophore * lives in Mφ in lymph nodes ** can live in gall bladder for years *** asplenic or non-fxn splenic pts are at increased risk	1. typhoid fever a. fever b. abdominal pain c. hepatosplenomegaly d. rose spots on abdomen (light skinned pts) 2. chronic carrier state	1. ciprofloxacin 2. ceftriaxone 3. trimethoprim & sulfamethoxazole 4. azithromycin 5. ampicillin (carriers)
<i>Shigella dysenteriae</i> (humans; fecal-oral transmission)	1. gram stain: a. gram(-) rods 2. culture: (stool; EMB/MacConkey agar) a. no H₂S production 3. metabolism: a. catalase (+) b. oxidase (-) c. glucose fermenter d. does not ferment lactose e. facultative anaerobe	1. non-motile (no H antigen) 2. invades submucosa not lamina propria * IgA best defense ** very low ID ₅₀	1. Shiga toxin : inactivates the 60S ribosome, inhibiting protein synthesis and killing intestinal cells a. bloody diarrhea with mucus and pus (dysentery)	1. fluid and electrolyte replacement 2. fluoroquinolone (severe cases) 3. trimethoprim & sulfamethoxazole
<i>Klebsiella pneumoniae</i> (colon, soil, water)	1. gram stain: a. gram(-) rods 2. culture: (EMB/MacConkey) a. viscous colonies 3. metabolism: a. indole, oxidase (-) b. glucose, lactose fermenter c. facultative anaerobe	1. capsule 2. non-motile	1. pneumonia , with significant lung necrosis and bloody sputum , commonly in alcoholics, or those with underlying lung disease 2. hospital acquired UTI and sepsis	1. 3 rd generation cephalosporins 2. ciprofloxacin

Organism	Diagnostics	Virulence Factors	Clinical Manifestations	Treatment
<p>Enterobacteriaceae</p> <p><i>Escherichia Coli</i></p> <p>(human GI and UT; transmitted fecal-oral, urethral migration, colonization of catheters, aspiration)</p>	<ol style="list-style-type: none"> 1. gram stain: <ol style="list-style-type: none"> a. gram(-) rods 2. culture: (urine, blood, CSF on EMB or MacConkey agar) <ol style="list-style-type: none"> a. grow at 45.5°C b. indole (+) c. β-hemolytic 3. metabolism: <ol style="list-style-type: none"> a. catalase (+) b. oxidase (-) c. glucose , lactose fermenter d. facultative anaerobe 	<ol style="list-style-type: none"> 1. fimbriae (pili): colonization factor 2. siderophore 3. adhesins 4. capsule (K antigen) 5. flagella (H antigen) 	<ol style="list-style-type: none"> 1. enterotoxins <ol style="list-style-type: none"> a. LT (heat labile) ↑cAMP (similar to cholera toxin) b. ST (heat stabile): ↑cGMP c. Shiga-like toxin (verotoxin): inhibits protein synthesis by inactivating the 60S ribosomal subunit <p>→ diarrhea</p> <ol style="list-style-type: none"> a. <i>enterotoxigenic (ETEC)</i>: non-invasive; LT and ST toxins, causing traveler's diarrhea b. <i>enterohemorrhagic (EHEC)</i>: bloody diarrhea, no fever, no stool pus; secretes Shiga-like toxin → hemorrhagic colitis and hemolytic uremic syndrome (E.coli strain O157:H7) c. <i>enteroinvasive(EIEC)</i>: bloody diarrhea w/ stool pus and fever; secretes small amounts of shiga-like toxin 2. LPS <ol style="list-style-type: none"> a. hospital acquired sepsis 3. neonatal meningitis 4. UTI 5. hospital acquired pneumonia 	<ol style="list-style-type: none"> 1. cephalosporins (sepsis) 2. aminoglycosides (sepsis) 3. trimethoprim & sulfamethoxazole (lower UTI) 4. fluoroquinolones <p>* diarrhea usually self-limited</p>

Organism	Diagnostics	Virulence Factors	Clinical Manifestations	Treatment
<i>Vibrionaceae</i>				
<i>Vibrio cholera</i> (fecal-oral transmission)	<ol style="list-style-type: none"> gram stain: <ol style="list-style-type: none"> short, comma shaped, gram(-) rods w/ single polar flagellum culture: (TCBS agar) <ol style="list-style-type: none"> flat yellow colonies dark field microscopy of stool <ol style="list-style-type: none"> motile organisms immobilized with antiserum metabolism: <ol style="list-style-type: none"> ferments sugar (except lactose) 	<ol style="list-style-type: none"> flagellum (H antigen) mucinase: digests mucous layer to attach to cells fimbriae: helps with attachment to cells noninvasive 	<ol style="list-style-type: none"> cholergen (enterotoxin): like LT, ↑ cAMP → secretion of electrolytes from the intestinal epithelium (secretion of fluid into intestinal tract) <ol style="list-style-type: none"> cholera: severe diarrhea with rice water stools, no pus (death by dehydration) <p>* epidemics 1991 Latin America 1993 Bangladesh and India</p>	<ol style="list-style-type: none"> replace fluids doxycycline fluoroquinolone
<i>Campylobacter jejuni</i> (zoonotic: wild and domestic animals and poultry; transmitted by uncooked meat and fecal-oral)	<ol style="list-style-type: none"> gram stain: <ol style="list-style-type: none"> curved gram(-) rods w/ singular polar flagellum culture: (stool; EMB/MacConkey agar) <ol style="list-style-type: none"> optimum temp is 42°C metabolism: <ol style="list-style-type: none"> oxidase (+) does not ferment lactose microphilic aerobe 	<ol style="list-style-type: none"> flagella (H antigen) invasiveness 	<ol style="list-style-type: none"> enterotoxin: similar to cholera toxin and LT cytotoxin: destroys mucosal cells <p>→ secretory or bloody diarrhea (associated with Guillain-Barre syndrome—acute neuromuscular paralysis; autoimmune)</p> <p>* one of the three most common causes of diarrhea in the world</p>	<ol style="list-style-type: none"> fluoroquinolone erythromycin ciprofloxacin
<i>Helicobacter pylori</i>	<ol style="list-style-type: none"> gram stain: <ol style="list-style-type: none"> curved gram(-) rods w/ tuft of flagella metabolism: <ol style="list-style-type: none"> urease (+) microaerobe 		<ol style="list-style-type: none"> duodenal ulcers chronic gastritis 	<ol style="list-style-type: none"> bismuth, ampicillin, metronidazole & tetracycline clarithromycin & omeprazole <p>* both reduce duodenal ulcer relapse</p>

Organism	Diagnostics	Virulence Factors	Clinical Manifestations	Treatment
<i>Pseudomonadaceae</i>				
<i>Pseudomonas aeruginosa</i> (opportunistic , soil, water; usually nosocomial)	1. gram stain: <ol style="list-style-type: none"> gram(-) rods 2. culture: (blood agar) <ol style="list-style-type: none"> greenish-metallic appearance w/ fruity smell 3. metabolism: <ol style="list-style-type: none"> oxidase (+) non-lactose fermenter obligate aerobe 	1. polar flagellum (H antigen) 2. hemolysin 3. collagenase 4. elastase 5. fibrinolysin 6. phospholipase C 7. DNAase 8. some strains possess an antiphagocytic capsule *high antibiotic resistance	1. exotoxin A (similar to diphtheria toxin): inhibits protein synthesis by blocking EF2 <ol style="list-style-type: none"> pneumonia (cystic fibrosis and immunosuppressed pts) osteomyelitis (diabetics, IV drug users, children) burn wound infections sepsis UTI endocarditis (IV drug users) malignant external otitis corneal infections in contact lens wearers 	1. ticarcillin 2. timentin 3. carbenicillin 4. piperacillin 5. mezlocillin 6. ciprofloxacin 7. imipenem 8. tobramycin 9. aztreonam

Organism	Diagnostics	Virulence Factors	Clinical Manifestations	Treatment
<i>Bacteroidaceae</i>				
<i>Bacteroides fragilis</i> (normal GI flora)	1. gram stain: <ol style="list-style-type: none"> gram(-) rods non-spore forming polysaccharide capsule 2. metabolism: <ol style="list-style-type: none"> anaerobe 	* infection when organism enters peritoneal cavity (resistant to penicillins, 1 st generation cephalosporins, aminoglycosides)	1. does not contain Lipid A a. abscesses in GI tract, pelvis, lungs (disease below the diaphragm)	1. metronidazole 2. clindamycin 3. chloramphenicol 4. surgically drain abscess
<i>Actinomyces</i>				

GRAM-NEGATIVE SPIROCHETES:

Organism	Diagnostics	Virulence Factors	Clinical Manifestations	Treatment
<i>Treponema</i>				
<i>Treponema pallidum</i> (humans, STD)	<ol style="list-style-type: none"> dark field microscopy (Q lesions): <ol style="list-style-type: none"> gram (-), thick rigid spirals ELISA, silver stain non-specific treponemal test (VDRL) specific-treponemal test (FTA-ABS) microaerophilic, sensitive to high temperatures 	<ol style="list-style-type: none"> motile: six axial filaments wind around organism between the peptidoglycan layer and the outer cell membrane (contraction→ spinning motion) 	<ol style="list-style-type: none"> Syphilis <ol style="list-style-type: none"> primary stage: painless chancre secondary stage: palm & sole rash, painless wart-like lesion in moist areas eg. vulva, scrotum (condyloma latum), CNS, eyes, bones, kidneys, or joints may be involved latent stage: 25% may relapse back to 2° tertiary stage (33%): gummas of skin and bone, CV syphilis, neurosyphilis (Argyll-Robertson pupil) congenital: contracted in-utero (tx w/in first four months) 	<ol style="list-style-type: none"> penicillin G erythromycin doxycycline <p>* Jarisch-herxheimer rxn: acute worsening of sx after antibiotics are started</p>
<i>Borrelia</i>				
<i>Borrelia burgdorferi</i> (Ixodes tick from white footed mice and white tailed deer)	<ol style="list-style-type: none"> clinical observation elevated levels of Ab's against organism detected by ELISA western immunoblot microaerophilic 		<ol style="list-style-type: none"> Lyme Disease <ol style="list-style-type: none"> early localized stage (1): erythema chronicum migrans (ECM) early disseminated stage (2): multiple smaller ECMs, aseptic meningitis, CN palsies (Bell's), peripheral neuropathy, transient heart block or myocarditis, brief arthritis attacks of large joints late stage (3): chronic arthritis, encephalopathy 	<ol style="list-style-type: none"> doxycycline (acute) amoxicillin (acute) ceftriaxone for neurologic disease penicillin G (chronic)
<i>Borrelia recurrentis</i> (louse, Europe)	<ol style="list-style-type: none"> dark field microscopy of blood from febrile periods blood culture from febrile periods wright's, giemsa stain of peripheral blood serologies microaerophilic 	<ol style="list-style-type: none"> antigenic variation of outer membrane Vmp lipoproteins 	<ol style="list-style-type: none"> relapsing fever <ol style="list-style-type: none"> recurring fever about every 8 days fevers break with drenching sweats rash and splenomegaly occasional meningeal involvement 	<ol style="list-style-type: none"> doxycycline erythromycin penicillin G
<i>Borrelia hermsii</i> (ticks)	<ol style="list-style-type: none"> dark field microscopy of blood from febrile periods blood culture from febrile periods wright's, giemsa stain of peripheral blood serologies microaerophilic 	<ol style="list-style-type: none"> antigenic variation of outer membrane Vmp lipoproteins 	<ol style="list-style-type: none"> relapsing fever <ol style="list-style-type: none"> recurring fever about every 8 days fevers break with drenching sweats rash and splenomegaly occasional meningeal involvement 	<ol style="list-style-type: none"> doxycycline erythromycin penicillin G

GRAM-NEGATIVE OBLIGATE INTRACELLULAR PARASITES:

Organism	Diagnostics	Virulence Factors	Clinical Manifestations	Treatment
<i>Chlamydia</i>				
<i>Chlamydia trachomatis</i> (humans, direct contact)	1. gram stain: a. gram (-), lacks peptidoglycan layer 2. culture: (conjunctiva surface, genital secretions) a. no gram(-) diplococci 3. immunofluorescent slide test 4. serologies	1. resistant to lysozyme 2. prevents phagosome-lysosome fusion 3. nonmotile 4. no pili 5. no exotoxins Cell Cycle: 1. elementary body infects cells→ reticulate body that replicates (req' host ATP →elementary body that leaves cell and infects other cells 2. tropism for endothelial columnar cells	1. serotypes A, B, C: a. trachoma : scarring of inside of eyelid→ redirection of eyelashes onto corneal surface (corneal scarring and blindness) 2. serotypes D-K: a. inclusion conjunctivitis (ophthalmia neonatorum) b. infant pneumonia c. urethritis, cervicitis, PID in women d. nongonoccal urethritis, epididymitis, prostatitis in men cx: sterility, ectopic pregnancy, chronic pain, reiter's syndrome, perihepatitis (Fitz-Hugh-Curtis Syndrome) 3. serotypes L ₍₁₋₃₎ : a. lymphogranuloma venereum	1. doxycycline (adults) 2. erythromycin (infants and pregnant women) 3. azithromycin * systemic tx needed for any eye infection → pneumonia
<i>Chlamydia pneumoniae</i> (humans; respiratory route; TWAR)	1. gram stain: a. gram (-), lacks peptidoglycan layer 2. culture: (conjunctiva surface, genital secretions) b. no gram(-) diplococci 3. immunofluorescent slide test 4. serologies	cell cycle similar to above	1. atypical pneumonia : viral-like atypical pneumonia, with fever and dry, non-productive cough in young adults	1. doxycycline 2. erythromycin
<i>Rickettsia</i>				
<i>Rickettsia rickettsii</i> (transmitted by dog and wood ticks; southeastern tick belt)	1. clinical exam 2. ELISA of skin biopsy from rash site 3. serology 4. Weil-Felix reaction: (x-rxn to proteus Ag), OX-2,19 (+)		1. Rocky Mountain Spotted Fever a. fever b. conjunctival injection c. severe headaches d. rash on wrists, ankles, soles, and palms initially, becomes more generalized later (centrifugal)	1. doxycycline 2. chloramphenicol
<i>Rickettsia akari</i> (transmitted by mites on house mice)	1. clinical exam 2. weil-felix reaction (-)		1. Rickettsial Pox : a. vesicular rash similar to chicken pox (resolves over 2 wks)	1. doxycycline 2. chloramphenicol
<i>Ehrlichia</i>				
<i>Ehrlichia canis/chaffeensis</i> (dog ticks)	1. rise in acute and convalescent Ab titers 2. morula bodies in leukocyte blood smears		1. Human Ehrlichiosis a. similar to Rocky Mountain spotted Fever, but rash is rare	1. doxycycline 2. rifampin (resistant to chloramphenicol)

MISCELLANEOUS BACTERIA:

Organism	Diagnostics	Virulence Factors	Clinical Manifestations	Treatment
<i>Actinomycetes</i>				
<i>Actinomyces israelii</i> (normal oral flora)	1. gram (+), long branching filaments 2. hard, yellow granules (sulfur granules) formed in pus 3. culture of pus or tissue 4. anaerobe 5. immunofluorescence		1. Actinomycosis a. abscess with draining sinuses b. initial lesion involves face and neck (rest→ chest and abdomen) c. not communicable	1. prolonged penicillin G w/ surgical drainage
<i>Nocardia asteroides</i> (soil)	1. gram (+) filaments, acid fast 2. aerobic		1. Nocardiosis a. abscesses in brain and kidneys in immunodeficient pts b. pneumonia c. not communicable	1. trimethoprim-sulfamethoxazole 2. surgical drainage may be necessary
<i>Mycoplasma</i>				
<i>Mycoplasma pneumoniae</i> (humans, resp droplets)	1. absence of cell wall 2. bacterial membrane contains cholesterol 3. grown on artificial media req' lots of different lipids; characteristic "fried egg" colonies w/raised center 4. rod-shaped w/ pointed tip 5. serologies; cold-agglutinin titer (IgM autoAb's against type O blood cells)—non-specific	1. produces hydrogen peroxide damages resp tract cells 2. Ab's against RBCs (cold agglutinins), brain, lung, and liver cells produced during infection	1. Atypical Pneumonia a. most common cause of pneumonia in young adults b. gradual onset with non-productive cough, sore throat, ear ache c. constitutional sx of fever, headache, malaise, and myalgias pronounced d. minimal chest x-ray findings e. resolves spontaneously in 10-14 days	1. macrolide (erythromycin, azithromycin) 2. tetracycline (doxycycline) (penicillins and c'sporins ineffective b/c no cell wall)