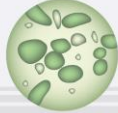


Basic Microbiology

Vaneet Arora, MD MPH D(ABMM) FCCM

Associate Director of Clinical Microbiology, UK HealthCare
Assistant Professor, Department of Pathology and Laboratory Medicine
University of Kentucky

Director, Microbiology, Environmental Microbiology and Preparedness
Associate Director, Division of Laboratory Services
Kentucky Department for Public Health



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Objectives

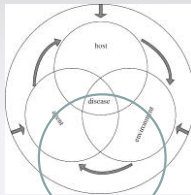
- Identify normal flora, opportunistic and pathogenic organisms by body site
- Recognize empiric antimicrobial therapies based on microbe and body site



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Infectious Disease

Influencing factors- How to decide empiric therapy



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Patient related

- Age
 - Adult vs Pediatric
- Body site
 - Normally sterile
 - Normal Commensals
- Immune status
 - Immunocompetent
 - Immunocompromised
- History
 - Co-morbidities/ Family history
 - Allergies
 - Hepatic/Renal dysfunction



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Environment related

- Setting
 - Community vs Healthcare facility vs Long term care facility
 - Outpatient vs Inpatient vs ICU
 - Circulating organisms/strains
 - Antibiograms
- Exposures
 - Childcare/workplace
 - Catheter/IV line/ PICC line/prosthesis
- Travel



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Organism related

- Type
 - Bacteria
 - Fungi
 - Parasites (Protozoa/Helminths)
 - Virus
 - Others
- Pathogenicity
 - Commensals
 - Opportunistic
 - Pathogenic
- Propensity to cause infection
 - Common
 - Uncommon/rare
- Virulence
 - High/Moderate/Low
- Predilection for body site
 - Localized
 - Systemic
 - Organ system
- Susceptibility patterns
 - Sensitive/Resistant



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Antimicrobial related

- Group
- Mechanism of action
- Spectrum
 - Broad spectrum vs narrow spectrum
- Penetration
- Availability
 - Pharmacy formulary



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All factors are interrelated

- Site of infection → type of organisms → antibiotic that reaches the site
- Allergies → what not to give → second line antimicrobial
- Travel → endemic organisms → immune status



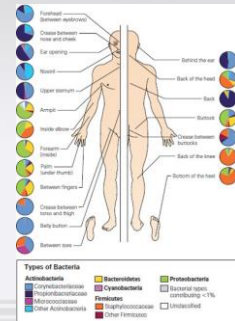
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More about Bugs



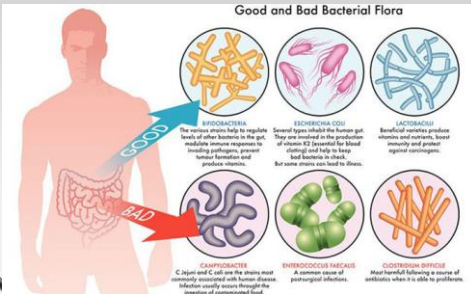
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Microbes outnumber our own cells by 10 to 1
Microbiome studies- just beginning to yield useful information



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Good and Bad Bacterial Flora



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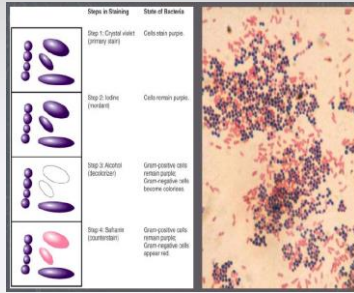
Bacteria

- Oxygen requirement
 - **Obligate aerobes**: Require O₂
 - **Microaerophilic**: Require a lower oxygen concentration for growth
 - **Obligate anaerobes**: Cannot grow in presence of O₂
 - **Facultative anaerobes**: Grow with or without O₂ (switch between aerobic and anaerobic metabolism)
 - **Aerotolerant anaerobes**: Ignore O₂ (only use anaerobic metabolism)
- Gram characteristic
 - Gram Positive or Gram Negative
 - Gram Variable/Gram neutral
 - Cocci or rods

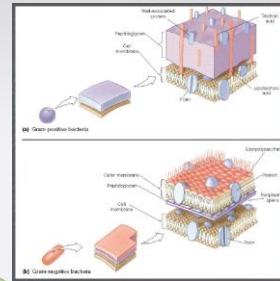


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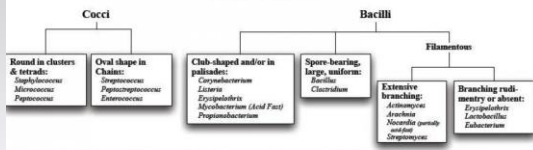
Gram staining



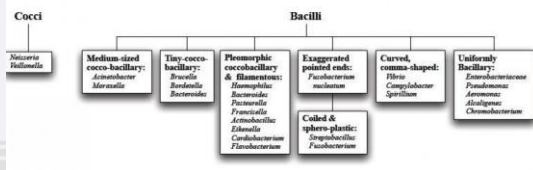
Bacterial cell wall



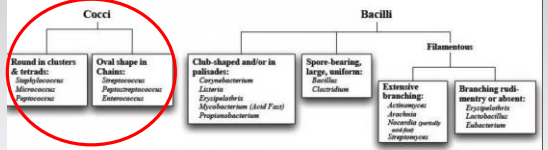
Gram Positive



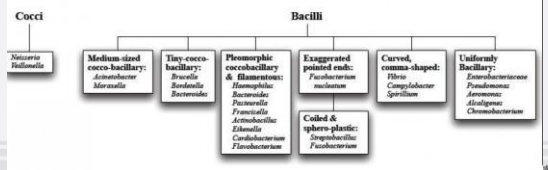
Gram Negative



Gram Positive



Gram Negative

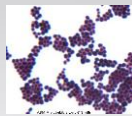


Gram positive

- Cocci

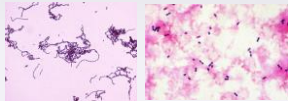
• Staphylococcus

- *S. aureus*
- » MSSA/MRSA
- Coagulase negative staphylococci (CoNS)



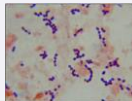
• Streptococcus

- GAS/GBS
- *S. pneumoniae*

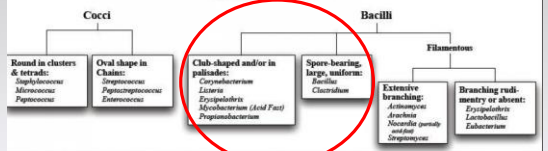


• Enterococci

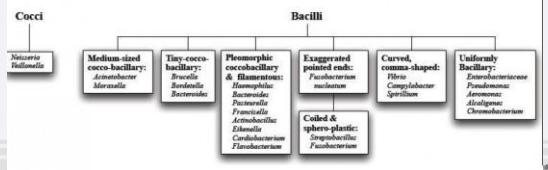
- *E. faecium* / *E. faecalis*
- VRE



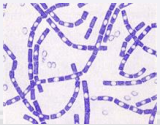



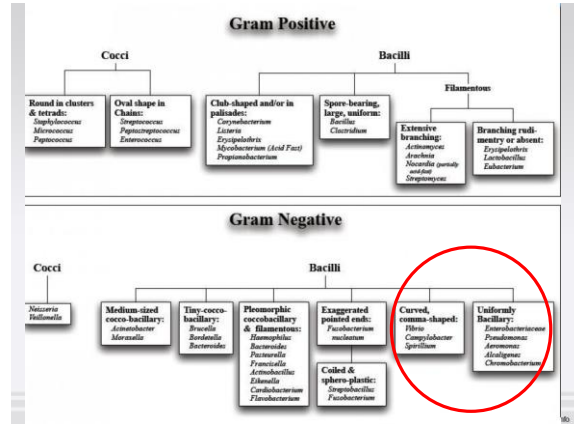
Gram Positive

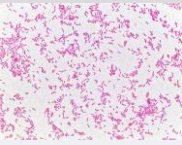



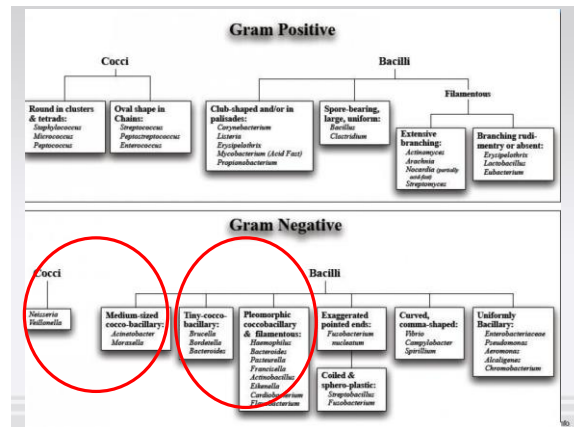
Gram Negative




- Gram Positive Rods
 - Listeria
 
 - Corynebacteria
 - Diphtheroids
 - Clostridium (Anaerobe spore forming)
 - C. perfringens
 - C. tetani
 - C. difficile
 - C. botulinum
 - Bacillus (Aerobe spore forming)
 - B. anthracis
 - B. cereus

- Gram Negative Rods
 - Enterobacteriaceae
 - E. coli
 - Klebsiella
 - Salmonella
 - Shigella
 - Yersinia
 - Proteus
 - Pseudomonads
 - P. aeruginosa
 - Burkholderia
 - Stenotrophomonas
 - Vibrios
 - V. cholerae
 - Non cholera vibrio

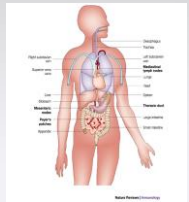



Body sites normally sterile



- Bladder
- Lower Respiratory Tract
- Tissues (beyond epithelial barriers)
- Fluids:
 - Blood
 - Cerebrospinal fluid (CSF)
 - Pleural and pericardial fluids

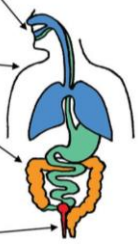
Colonized by Commensals




- Skin
- Mucosal Surfaces:
 - Gastrointestinal Tract
 - Upper Respiratory Tract
 - Urogenital Tract (female)
 - Urethra

Normal flora

Bacterial Flora in a Normal Person in the Community



- Upper Respiratory Tract
 - Staphylococcus sp.
 - Streptococcus sp.
 - Streptococcus pneumoniae
 - Viridans Streptococcus
 - Haemophilus sp.
 - Anaerobes
- Skin
 - Staphylococcus sp.
 - Coryneform bacteria or "Diphtheroids"
 - Propionibacterium sp.
- Gastrointestinal Tract
 - Anaerobes
 - Enterococcus sp.
 - Enterobacteriaceae
 - Escherichia coli
 - Klebsiella sp.
 - Streptococcus sp.
 - Streptococcus anginosus (milleri) group
 - Lactobacillus sp.
 - Candida sp.
- Genital Tract
 - Lactobacillus sp.
 - Streptococcus sp.
 - Streptococcus agalactiae



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Common BACTERIAL pathogens

Overview of Bacterial Infections

- Bacterial meningitis**
 - Streptococcus pneumoniae
 - Neisseria meningitidis
 - Haemophilus influenzae
 - Streptococcus agalactiae
 - Listeria monocytogenes
- Otitis media**
 - Streptococcus pneumoniae
- Pneumonia**
 - Community-acquired:
 - Streptococcus pneumoniae
 - Haemophilus influenzae
 - Staphylococcus aureus
 - Atypical:
 - Mycoplasma pneumoniae
 - Chlamydia pneumoniae
 - Legionella pneumophila
 - Tuberculosis:
 - Mycobacterium tuberculosis
- Skin infections**
 - Staphylococcus aureus
 - Streptococcus pyogenes
 - Pseudomonas aeruginosa
- Eye infections**
 - Staphylococcus aureus
 - Neisseria gonorrhoeae
 - Chlamydia trachomatis
- Sinusitis**
- Upper respiratory tract infection**
 - Streptococcus pyogenes
- Gastritis**
 - Helicobacter pylori
- Food poisoning**
 - Campylobacter jejuni
 - Salmonella
 - Shigella
 - Clostridium
 - Staphylococcus aureus
 - Escherichia coli
- Sexually transmitted diseases**
 - Chlamydia trachomatis
 - Neisseria gonorrhoeae
 - Treponema pallidum
 - Ureaplasma urealyticum
 - Haemophilus ducreyi
- Urinary tract infections**
 - Escherichia coli
 - Other Enterobacteriaceae
 - Staphylococcus saprophyticus
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Primary tract infections

- Escherichia coli
- Other Enterobacteriaceae
- Staphylococcus saprophyticus
- Pseudomonas aeruginosa

Skin infections

- Staphylococcus aureus
- Streptococcus pyogenes
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Skin infections

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- Pseudomonas aeruginosa

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Common VIRAL pathogens

Overview of Viral Infections

Encephalitis/meningitis

- JC virus
- Measles
- LCM virus
- Arbovirus
- Rabies

Common cold

- Rhinovirus
- Parainfluenza virus
- Respiratory syncytial virus

Pharyngitis

- Adenovirus
- Epstein-Barr virus
- Cytomegalovirus

Cardiovascular

- Coxsackie B virus

Hepatitis

- Hepatitis virus types A, B, C, D, E

Skin Infections

- Varicella zoster virus
- Human herpesvirus 6
- Smallpox
- Molluscum contagiosum
- Human papillomavirus
- Parvovirus B19
- Rubella
- Measles
- Coxsackie A virus

Eye infections

- Herpes simplex virus
- Adenovirus
- Cytomegalovirus

Parotitis

- Mumps virus

Pneumonia

- Influenza virus
- Types A and B
- Parainfluenza virus
- Respiratory syncytial virus
- Adenovirus
- SARS coronavirus

Myelitis

- Poliovirus
- HTLV-1

Gastroenteritis

- Adenovirus
- Rotavirus
- Norovirus
- Astrovirus
- Coronavirus

Pancreatitis

- Coxsackie B virus

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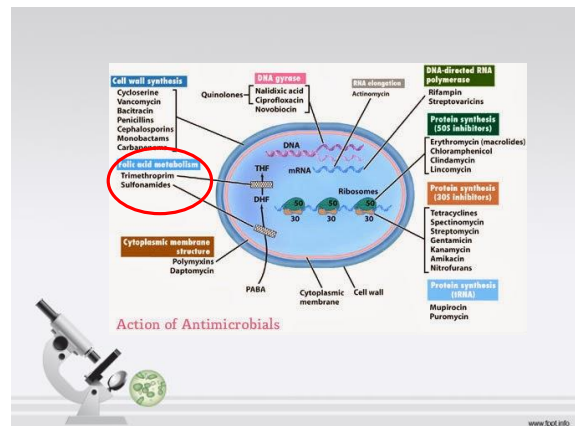
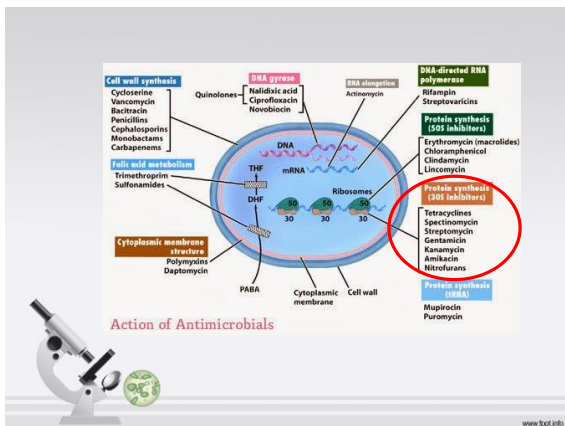
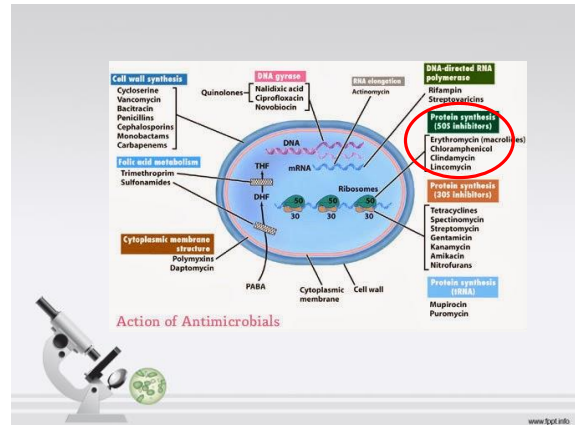
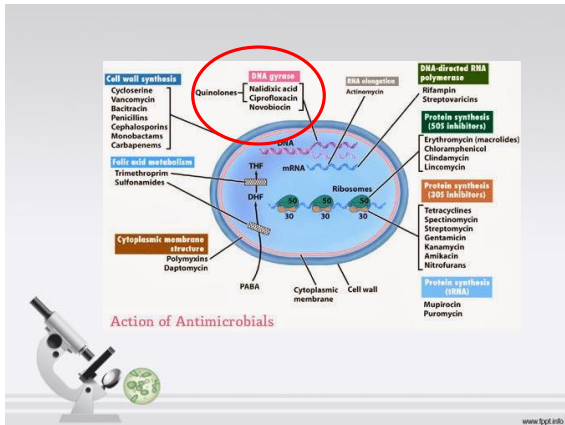
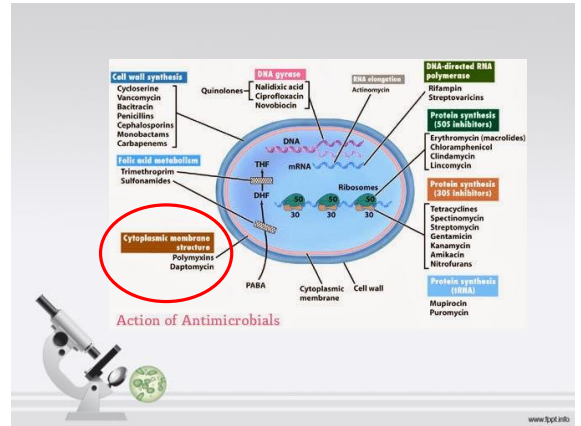
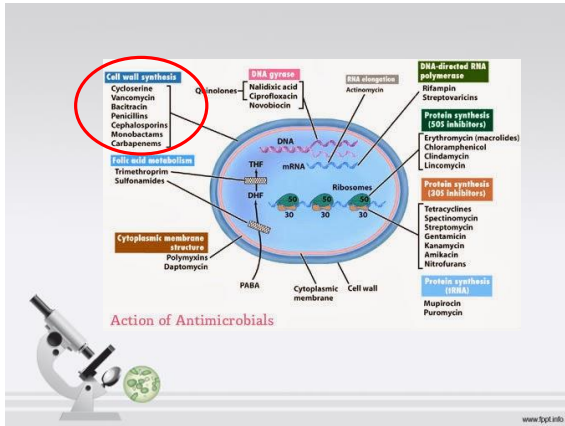
Pathogenic Organisms According to Body System¹:

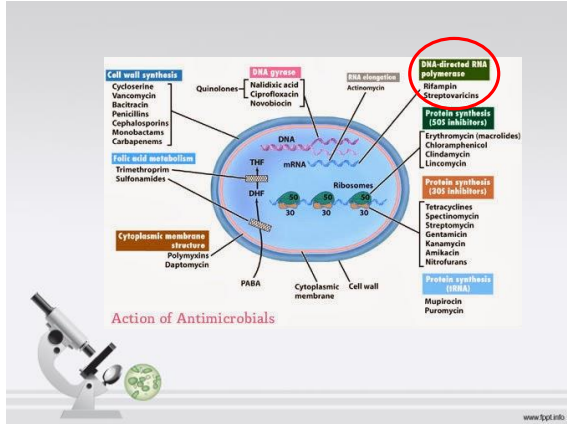
System	Disease	Possible Causative Organism [1] = community acquired infection [2] = nosocomial infection (acquired in a hospital)
Central Nervous System	Meningitis	Streptococcus pneumoniae, Staph. aureus, Strep. agalactiae, Strep. pneumoniae, Haemophilus influenzae, Listeria monocytogenes, Mycobacterium tuberculosis, Neisseria meningitidis, Pseudomonas aeruginosa, E. coli, Klebsiella spp., Gram negative bacilli, Anaerobic bacteria, Coxsackievirus
Eye	Conjunctivitis	Haemophilus influenzae, Strep. pneumoniae, Staph. aureus, Moraxella lacunata, Mycobacterium tuberculosis, Pseudomonas aeruginosa, Herpes simplex virus, Varicella zoster virus, Toxoplasma gondii
Eye	Blepharitis	Staph. aureus, Staph. epidermidis, Herpes Simplex Virus, Pityriasis rubra
Gastrointestinal tract	Dysentery	Shigella spp., Shigella spp., E. coli, B. cereus, Staph. aureus, Campylobacter spp., Clostridium difficile, Fibro spp., Yersinia enterocolitica, Aeromonas hydrophila, Cyclospora parvum, Cyclospora spp., Entamoeba histolytica, Giardia lamblia, Isospora, Naegleria fowleri, Cryptosporidium
Genitourinary tract	Urinary tract infection (UTI) and prostatitis	Pseudomonas aeruginosa [2], Proteus mirabilis [2], Staph. saprophyticus [2], Enterococcus spp. [2], Enterobacter spp., Escherichia coli [2], Klebsiella pneumoniae [2], Chlamydia trachomatis, Citrobacter spp., Neisseria gonorrhoeae, Mycoplasma
Respiratory tract	Lung abscess	S. pneumoniae, Streptococcus spp. (non-pneumoniae), Staph. aureus, Klebsiella spp., Strep. pneumoniae [2], Strep. agalactiae, Strep. pyogenes, Staph. aureus [2], Enterobacteriaceae including E. coli [2], Pseudomonas aeruginosa [2], Klebsiella pneumoniae [2]
Respiratory tract	Pneumonia	Haemophilus influenzae, Mycoplasma pneumoniae, Moraxella catarrhalis, Serratia spp., Mycoplasma spp., Non-fermenting Gram negative bacilli [2], and many more including fungi, bacteria, parasites and viruses
Respiratory tract	Bronchitis	Streptococcus pneumoniae [2], Staph. aureus [2], Staph. aureus [2], P. aeruginosa [2]
Skin and soft tissue	Skin infections	Pseudomonas aeruginosa, Staph. aureus, Strep. pyogenes, Strep. agalactiae, Pasteurella multocida, Candida albicans (diaper rash), Corynebacterium jeikeium, Mycobacterium abscessus, Erysipelothrix
Systemic	Endocarditis	Staph. aureus, Strep. pneumoniae, Strep. viridans
Systemic	Bacteremia	Streptococcus pneumoniae, Staph. aureus, Strep. pyogenes, Strep. pneumoniae, Enterococcus spp., Enterobacter spp., E. coli, Klebsiella pneumoniae, Proteus mirabilis, Pseudomonas aeruginosa, Salmonella typhi, Acinetobacter spp., Pseudomonas aeruginosa, Neisseria meningitidis, Pasteurella multocida, Yersinia pestis, Citrobacter spp., Mycobacterium tuberculosis

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More about Drugs

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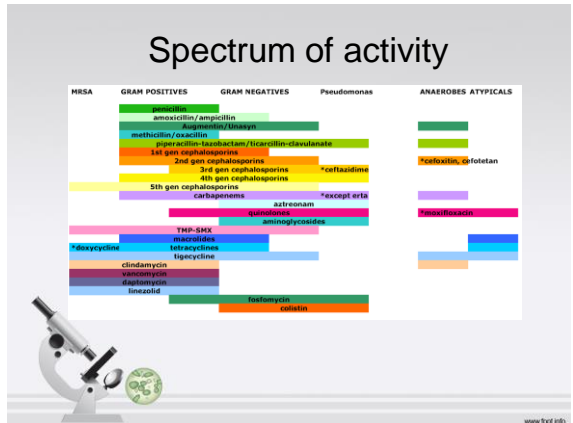


Classes of antibacterial agents

SUBSET	CLASSIFICATION	ANTIBIOTICS
Cell Wall	Peptidoglycan	Natural Penicillins: Penicillin G, Penicillin V, Penicillinase-resistant (PC, MR)
		Semisynthetic Penicillins: Penicillin V, VXI
		Antipseudomonas: Ticarcillin, Zosyn
		Resistant to beta-lactamase: Acetaminophen-resistant (very narrow spectrum)
		Vancomycin
		Daptomycin
		Carbapenems: Imipenem, Meropenem
		Monobactams: Aztreonam, Ceftazidime
Protein Synthesis	30S Subunit	Tetracyclines: Doxycycline, Minocycline, Tigecycline
		Streptogramins: Pristinamycin, Synergid
		Macrolides: Erythromycin, Clarithromycin, Azithromycin, Clindamycin
		Chloramphenicol
	50S Subunit	Aminoglycosides: Gentamicin, Tobramycin, Amikacin, Netilmicin
		Streptogramins: Pristinamycin, Synergid
		Clindamycin
		Linezolid
	Peptidyl transferase	Linezolid
		Chromadanes: Tedizolid
		Streptogramins: Pristinamycin, Synergid
		Chloramphenicol
DNA	Fluoroquinolones	Ciprofloxacin, Levofloxacin, Moxifloxacin, Gemifloxacin, Delamanid, Besifloxacin
		Nitroimidazole: Metronidazole, Secnidazole
		Rifampin, Rifabutin, Rifapentin
Cellular Membrane	Daptomycin	Daptomycin
		Polymyxins: Colistin, Polymyxin B
		Amphotericin B, Fluconazole, Caspofungin, Isavuconazole
		Tyrosyl-tRNA synthetase inhibitors: Mupirocin

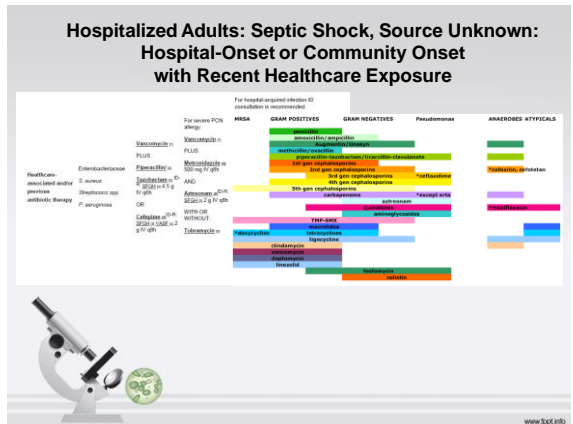
Classes of antibacterial agents

SUBSET	CLASSIFICATION	ANTIBIOTICS
Cell Wall	Peptidoglycan	Natural Penicillins: Penicillin G, Penicillin V, Penicillinase-resistant (PC, MR)
		Semisynthetic Penicillins: Penicillin V, VXI
		Antipseudomonas: Ticarcillin, Zosyn
		Resistant to beta-lactamase: Acetaminophen-resistant (very narrow spectrum)
		Vancomycin
		Daptomycin
		Carbapenems: Imipenem, Meropenem
		Monobactams: Aztreonam, Ceftazidime
Protein Synthesis	30S Subunit	Tetracyclines: Doxycycline, Minocycline, Tigecycline
		Streptogramins: Pristinamycin, Synergid
		Macrolides: Erythromycin, Clarithromycin, Azithromycin, Clindamycin
		Chloramphenicol
	50S Subunit	Aminoglycosides: Gentamicin, Tobramycin, Amikacin, Netilmicin
		Streptogramins: Pristinamycin, Synergid
		Clindamycin
		Linezolid
	Peptidyl transferase	Linezolid
		Chromadanes: Tedizolid
		Streptogramins: Pristinamycin, Synergid
		Chloramphenicol
DNA	Fluoroquinolones	Ciprofloxacin, Levofloxacin, Moxifloxacin, Gemifloxacin, Delamanid, Besifloxacin
		Nitroimidazole: Metronidazole, Secnidazole
		Rifampin, Rifabutin, Rifapentin
Cellular Membrane	Daptomycin	Daptomycin
		Polymyxins: Colistin, Polymyxin B
		Amphotericin B, Fluconazole, Caspofungin, Isavuconazole
		Tyrosyl-tRNA synthetase inhibitors: Mupirocin



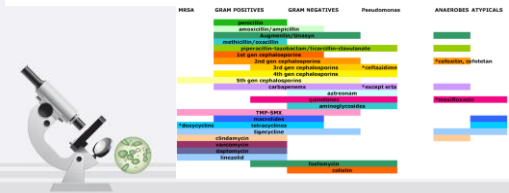
Hospitalized Adults: Skin and Soft Tissue Infections: Cellulitis

Diagnosis	Common Pathogens	Drug(s) of First Choice	Alternative Drug(s)	Comments
Cellulitis	Group A streptococci Other beta-hemolytic streptococci S aureus	Vancomycin Alternatively, Cefazolin or p IV with if patient is stable and cellulitis is not associated with an abscess or other purulent focus of infection		Empirical Gram-negative and/or anaerobic coverage is not routinely indicated.



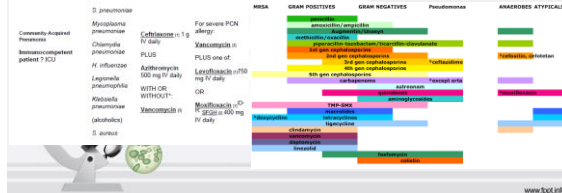
Hospitalized Adults: Respiratory Tract Infections: Hospital-Acquired Pneumonia

Line-related bacteremia	Community-acquired pneumonia	Healthcare-associated pneumonia	Hospital-acquired pneumonia	For severe PCN allergy
<i>S. epidermidis</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>
<i>S. aureus</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>
<i>Enterococcus spp.</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>
Gram-negative rods	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>
Yeast	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>



Hospitalized Adults: Respiratory Tract Infections: Community-Acquired Pneumonia

Community-acquired pneumonia	Healthcare-associated pneumonia	For severe PCN allergy	ID consultation is recommended if ICU admission or high level PCN resistant pneumococci documented
<i>S. pneumoniae</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>
<i>S. pneumoniae</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>
<i>S. pneumoniae</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>
<i>S. pneumoniae</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>	<i>S. pneumoniae</i>



Hospitalized Adults: Intravascular Catheter-Related Infections

Line-related bacteremia	Remove the offending intravascular device immediately, if possible.
<i>S. epidermidis</i>	<i>S. pneumoniae</i>
<i>S. aureus</i>	<i>S. pneumoniae</i>
<i>Enterococcus spp.</i>	<i>S. pneumoniae</i>
Gram-negative rods	<i>S. pneumoniae</i>
Yeast	<i>S. pneumoniae</i>



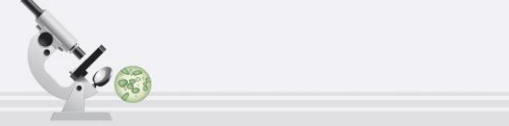
Hospitalized Adults: Healthcare-Associated Urinary Tract Infection

Healthcare-associated UTI	Criteria: signs and symptoms compatible with a UTI, no other identified source of infection, & 7/1003 col of 7 bacterial species on urine culture.
<i>Enterobacteriaceae (e.g. E. coli)</i>	<i>S. pneumoniae</i>
<i>P. aeruginosa (less common)</i>	<i>S. pneumoniae</i>
<i>S. pneumoniae</i>	<i>S. pneumoniae</i>
<i>S. pneumoniae</i>	<i>S. pneumoniae</i>

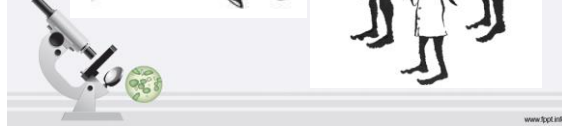


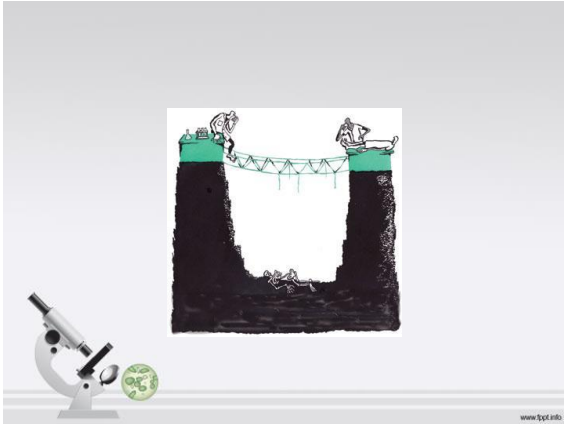
- Body site
- Organism
- Spectrum of Antimicrobial activity

Common denominator ?



Key to appropriate therapy





Thank you

