Antibiotics Overview

Multiple different classes of antibiotics exist, all with varying mechanisms of action. Cell wall inhibitors represent a major class whose mechanism of action involves preventing the bacterial cell wall from forming. Examples of cell wall inhibitors include penicillins, cephalosporins, monobactams, glycopeptides, and carbapenems. Bacteria try to defend themselves against these medications using the enzyme beta-lactamase. Because of this, beta-lactamase inhibitors such as clavulanic acid are often added to penicillins to improve their stability. Another class of antibiotics is the protein synthesis inhibitors, which bind to bacterial ribosomes and prevent the production of crucial proteins. These include macrolides, aminoglycosides, tetracyclines, clindamycin, linezolid, and chloramphenicol. Two other important classes of antibiotics are the fluoroquinolones and the sulfonamides

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Cell Wall Inhibitors

Cell Wall Inhibitors

Disrupted Cell Wall

Cell wall inhibitors are antibiotics called beta-lactams which mechanism of action involves disruption of the bacterial cell wall, typically by preventing the peptidoglycan building blocks from being cross-linked together. Without an intact cell wall, bacteria cannot maintain normal metabolic functions and will either stop proliferating or die. Antibiotics under this category include penicillins, cephalosporins, monobactams, carbapenems, and vancomycin.

Penicillins

Pencil-villain

Penicillins are a group of antibiotics typified by the presence of a beta-lactam ring in their molecular structure. Normally, bacteria create their cell wall by producing peptidoglycan subunits which are then cross-linked together by transpeptidase enzymes, also known as penicillin-binding proteins. Penicillins bind to these enzymes, as their name suggests, and prevent the cell wall from being cross-linked together. This process leads to bacterial cell death. There are different subclasses of penicillins. For example, oxacillin and nafcillin are resistant to the bacterial enzyme penicillinase and have activity against Staph aureus. Ticarcillin and piperacillin, conversely, have activity against Pseudomonas.

Cephalosporins

Chef Spore Head

Cephalosporins are a class of antibiotics that are similar to penicillins in that they both share a beta-lactam molecular structure and inhibit cross-linking of the bacterial cell wall. Cephalosporins are generally more broad spectrum and have multiple generations, which help define their activity. First-generation cephalosporins like cefazolin have good gram-positive coverage. Generally, as the generations go up, more gram-negative coverage is added. For example, second-generation cephalosporins like cefuroxime have improved gram-negative coverage. Check out our Cephalosporin Picmonics for more information.

Monobactams

Mono-man-backgammon

Monobactams are another class of beta-lactam cell wall-inhibiting antibiotics, and the only relevant member of this class is aztreonam. In contrast to many other beta-lactam antibiotics, aztreonam only has coverage against gram-negative bacteria. It is useful for patients with penicillin allergies.

Glycopeptides

Glider-pepper-tie

Vancomycin is a key glycopeptide antibiotic. It inhibits cell wall synthesis by binding to the D-Ala-D-Ala terminal of peptidoglycan precursors. It is effective against gram-positive bacteria and, more importantly, against resistant infections such as Methicillin-Resistant Staphylococcus Aureus (MRSA).

Carbapenems (Imipenem & Meropenem)

Emmy-penny and Mirror-penny

Carbapenems, such as imipenem and meropenem, are a class of broad-spectrum antibiotics. They share a beta-lactam molecular structure with the other cell wall-inhibiting antibiotics and similarly work by preventing cell wall formation. Carbapenems are active against most bacteria, including gram-positive, gram-negative, and anaerobic species. Cilastin is often given alongside these medications because it prevents their breakdown by the kidneys.

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Beta-Lactamase Inhibitors

Black-beta-fish-ace in Inhibiting-chains

Beta-lactamase inhibitors are a type of medication given alongside certain penicillins to prevent the breakdown of the antibiotic by the bacterial enzyme beta-lactamase. They do not have direct antimicrobial effects. Beta-lactamase inhibitors include clavulanic acid, sulbactam, and tazobactam.

Protein Synthesis Inhibitors

Protein Synthesis Inhibitors

Mr. Protein in Inhibiting-chains

Protein synthesis inhibitors are antibiotics whose mechanism of action involves targeting ribosomes within bacteria and stopping the production of vital proteins. The bacterial ribosome is composed of two parts named the 50S subunit and the 30S subunit, and different antibiotics target different parts. Most are bacteriostatic, although some, such as aminoglycosides, are bactericidal.

Aminoglycosides

A-mean-ol'-glider

Aminoglycosides are a class of antibiotics that inhibit the 30S subunit of the bacterial ribosome, leading to cell death or bactericidal activity. They are active against gram-negative rods. Examples include gentamicin, neomycin, and amikacin. Important side effects include nephrotoxicity and ototoxicity. Aminoglycosides also have synergistic activity against gram-positive cocci (e.g., Enterococcus) when combined with beta-lactams.

Macrolides

Macaroni-lights

Macrolides are a class of antibiotics that bind to the 50S subunit of the bacterial ribosome and prevent protein production. This results in bacteriostatic activity and prevents bacteria from replicating. Macrolides include erythromycin, azithromycin, and clarithromycin. They can treat multiple types of infections, including Mycoplasma and Chlamydia.

Clindamycin

Cleaning-mice

Clindamycin inhibits the 50S ribosomal subunit and is an important antibiotic for its activity against gram-positive bacteria and anaerobes. It is useful in cases of group A streptococcal infection as well as certain cases of MRSA. It can also be used in aspiration pneumonia or other infections where anaerobic organisms are suspected. An important side effect can be the development of pseudomembranous colitis, which occurs secondary to overgrowth of C. difficile.

Tetracyclines

Tetris-cycle

Tetracyclines are another class of protein synthesis inhibitors that work by binding to the 30S bacterial subunit. Examples include tetracycline itself, doxycycline, and minocycline. Tetracyclines are broad-spectrum antibiotics that can treat various infections, such as Lyme disease, Mycoplasma pneumonia, or Chlamydia infections. Side effects include photosensitivity and, in children, discoloration of teeth.

Linezolid

Linen-soldier

Linezolid inhibits the 50S ribosomal subunit and is only effective against gram-positive bacteria. It is useful for treating cases of methicillin-resistant Staph aureus (MRSA) or vancomycin-resistant Enterococci (VRE). Side effects can include bone marrow suppression or peripheral neuropathy.

Chloramphenicol

Chlorine-fanny-pack

Chloramphenicol inhibits the 50S ribosomal subunit and has broad-spectrum activity. However, due to significant side effects, it is not often used. Side effects include bone marrow suppression, including aplastic anemia, as well as gray baby syndrome, which is seen in exposed infants.

Other

Fluoroquinolones

Flower-queen

Fluoroquinolones are a class of antibiotics whose mechanism of action involves inhibition of the bacterial enzyme topoisomerase II (DNA gyrase) and topoisomerase IV. Inhibition of these enzymes prevents bacteria from properly replicating their DNA, resulting in cell death. These antibiotics often end with the suffix “-floxacin” and include ciprofloxacin, levofloxacin, and moxifloxacin. They are broad spectrum with excellent gram-negative activity, including coverage of Pseudomonas in some cases. Side effects can include tendon rupture, cartilage damage in younger patients, and QT prolongation. Because of the side effects, fluoroquinolones are contraindicated in pediatric and pregnant patients.

Sulfonamides

Sulfur-match-fondue

Sulfonamides are a class of antibiotics whose mechanism of action involves inhibition of bacterial DNA replication. Normally, bacteria require two enzymes in the folate pathway to carry out DNA synthesis: dihydropteroate synthase and dihydrofolate reductase. Sulfonamide antibiotics such as sulfamethoxazole

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inhibit the first enzyme, dihydropteroate synthase. Trimethoprim is often added to sulfonamides because it inhibits the second enzyme, dihydrofolate reductase. This combination results in broad-spectrum activity against gram-positive and negative organisms, including MRSA.

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