Antimicrobials : Classification, MOA, Uses, And Side Effects

Antimicrobials are agents designed to inhibit or kill infecting microorganisms while minimizing harm to the host. This type of therapy, known as chemotherapy, targets systemic infections by selectively suppressing microorganisms without significantly affecting the host.

Antibiotics are natural substances produced by microorganisms that suppress the growth or kill other microorganisms at very low concentrations. This excludes substances like antibodies that are produced by higher organisms.

Classification of Antimicrobials

Antimicrobials can be classified based on various criteria:

1. **Chemical Structure**

   - **Sulfonamides** : e.g., sulfadiazine.
   - **Quinolones** : e.g., ciprofloxacin, norfloxacin.
   - **?-lactam Antibiotics** : Penicillins, Cephalosporins, monobactams, carbapenems.
   - **Tetracyclines** : e.g., doxycycline.
   - **Aminoglycosides** : e.g., streptomycin, gentamicin.
   - **Macrolides** : e.g., erythromycin.
   - **Azole Derivatives** : e.g., miconazole, clotrimazole, ketoconazole.

2. **Mechanism of Action**

   - **Inhibit Cell Wall Synthesis** : e.g., penicillins, cephalosporins.
   - **Inhibit Protein Synthesis** : e.g., tetracyclines, chloramphenicol, erythromycin.
   - **Cause Leakage from Cell Membranes** : e.g., Amphotericin B, nystatin.
   - **Inhibit DNA Gyrase** : e.g., ciprofloxacin (Fluoroquinolones).
   - **Interfere with DNA Synthesis** : e.g., zidovudine, acyclovir.

3. **Type of Organism Targeted**

   - **Antibacterial** : e.g., penicillins, aminoglycosides.
   - **Antifungal** : e.g., ketoconazole, amphotericin B.
   - **Antiviral** : e.g., zidovudine, acyclovir.
   - **Antiprotozoal** : e.g., chloroquine, metronidazole.
   - **Antihelmintic** : e.g., mebendazole, albendazole.

4. **Spectrum of Activity**

   - **Narrow Spectrum** : e.g., penicillin G, erythromycin, streptomycin.
   - **Broad Spectrum** : e.g., tetracyclines, chloramphenicol.

5. **Type of Action**

- **Bacteriostatic** : e.g., sulfonamides, tetracyclines, chloramphenicol, erythromycin.
- **Bactericidal** : e.g., penicillins, aminoglycosides, rifampicin, cephalosporins.

6. **Source**

- **Fungal-derived** : e.g., penicillin, cephalosporins.
- **Bacterial-derived** : e.g., colistin, bacitracin.

Mechanisms of Antibacterial Action

Bactericidal agents kill bacteria rapidly (e.g., aminoglycosides, polymyxin).
Bacteriostatic agents prevent bacteria from replicating without killing them (e.g., sulfonamides, tetracyclines, chloramphenicol). At high doses, some bacteriostatic agents can become bactericidal.

Antibiotics and the Bacterial Cell Wall

Antibiotics often act by disrupting the bacterial cell wall or interfering with bacterial metabolism. The structure of the bacterial cell wall varies between **Gram-positive** and **Gram-negative** bacteria, influencing their susceptibility to specific antibiotics.

- **Gram-positive bacteria** : Thick cell walls, e.g., Staphylococcus aureus, Streptococcus pyogenes.
- **Gram-negative bacteria** : Thinner cell walls, e.g., Escherichia coli, Pseudomonas aeruginosa.

Gram-positive bacteria are typically more susceptible to antibiotics like erythromycin, which can penetrate their cell walls.

Problems with Antimicrobial Use

1. **Toxicity**
    - **Local irritancy** : e.g., pain or abscess formation at injection sites.
    - **Systemic toxicity** : dose-related organ toxicities (e.g., bone marrow depression with chloramphenicol).
2. **Hypersensitivity Reactions**
    - Allergic reactions range from rashes to anaphylaxis, particularly with penicillins, cephalosporins, sulfonamides, and fluoroquinolones.
3. **Drug Resistance**
    - **Natural resistance** : Some microbes are inherently resistant to certain drugs due to the lack of the target site.
    - **Acquired resistance** : Resistance develops in organisms previously sensitive to a drug, often due to overuse of antimicrobials.
4. **Superinfection**
    - Broad-spectrum antibiotics can disrupt normal microbial flora, allowing opportunistic infections (e.g., Candida). This is common with drugs like tetracyclines, chloramphenicol, and newer cephalosporins.

Minimizing Superinfection

- Use narrow-spectrum antibiotics whenever possible.
- Avoid unnecessary antimicrobial use for self-limiting infections.

- Limit the duration of therapy.

5. **Nutritional Deficiencies**
   - Disruption of gut flora by antibiotics can lead to deficiencies in B vitamins and vitamin K.
6. **Masking of Other Infections**
   - A short course of antimicrobials might suppress one infection while masking another. For example, penicillin may cure gonorrhea but mask an underlying syphilis infection.