

WHAT ARE ANTIBIOTICS?

Antibiotics are medicines that kill bacteria or stop them from multiplying. Common families include:

- β -lactams (penicillin, cephalosporins)
- Macrolides (erythromycin)
- Tetracyclines (doxycycline)
- Quinolones (ciprofloxacin)

They target bacterial cell walls, protein synthesis, and DNA replication.

RESISTANCE AND IMPACT

How Bacteria Outsmart Drugs:

- Mutations change drug targets (e.g., altered ribosomes)
- Enzymes break down antibiotics (β -lactamases destroy penicillin)
- Efflux pumps eject drugs before they act
- Gene swaps via plasmids spread resistance fast

Real-World Impact:

- 700 000 deaths/yr now; could rise to 10 million by 2050
- MRSA causes dangerous skin and blood infections
- Superbugs force longer hospital stays and cost billions

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ANTIBIOTIC RESISTANCE

Imagine a world where scraped knees or strep throat could become life-threatening again. This is the rising challenge of antibiotic resistance—bacteria evolving to survive our best drugs.

HOW RESISTANCE DEVELOPS

Spontaneous mutations

- DNA copying errors alter antibiotic targets
- Mutant bacteria survive and multiply under drug pressure

Plasmid exchange

- Plasmids are small DNA rings carrying resistance genes
- Spread by conjugation (cell-to-cell), transformation, or transduction

Selection pressure

- Antibiotics kill sensitive bacteria first
- Misuse (skipping doses, leftovers) lets resistant survivors dominate

Biofilm protection

- Bacteria form slimy layers that shield them from antibiotics
- Cells within biofilms share resistance genes and thrive

WHAT YOU CAN DO

- Only take antibiotics when prescribed by a healthcare professional
- Never share or use leftover antibiotics from friends or family
- Finish every dose, even if you feel better early
- Set phone reminders or use a pill organizer to avoid missed doses
- Wash hands with soap for at least 20 seconds before eating, after restroom use, and after outdoor activities
- Keep cuts and scrapes clean and covered to stop bacteria from entering
- Design posters, social-media posts, or short videos to share with classmates
- Organize a “Superbug Awareness” day or join your school’s health club
- Return unused antibiotics to pharmacy take-back programs
- Never flush medications or throw them in the trash

References

- [1] R. Urban-Chmiel et al., “Antibiotic Resistance in Bacteria—A Review,” *Antibiotics*, vol. 11, no. 8, art. no. 1079, Aug. 2022. doi: 10.3390/antibiotics11081079
- [2] G. Mancuso et al., “Bacterial Antibiotic Resistance: The Most Critical Pathogens,” *Pathogens*, vol. 10, no. 10, art. no. 1310, Oct. 2021. doi: 10.3390/pathogens10101310

Molecular Mechanisms

1. Enzymatic Inactivation
 - ESBLs (CTX-M, SHV) hydrolyze β -lactams.
 - AAC/ANT/APH modify aminoglycosides.
2. Target Alteration
 - *mecA* \rightarrow PBP2a in MRSA.
 - erm-encoded methylases alter 23S rRNA.
3. Efflux & Permeability
 - RND pumps (AcrAB-TolC, MexAB-OprM).
 - Porin mutations (OmpK36 loss in *K. pneumoniae*).

Scope and Urgency

- ~ 700 000 annual deaths due to AMR; projected 10 million by 2050.
- WHO priority “ESKAPE” pathogens: *Enterococcus faecium*, *Staph. aureus*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, *Enterobacter* spp.

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Antibiotic Resistance and Emerging Counter-measures

Novel Therapeutics

- Phage-Based Therapies: tailored lytic phages & engineered endolysins.
- Antivirulence Agents: quorum-sensing inhibitors, T3SS blockers.
- Host-Directed: monoclonal antibodies against toxins (e.g., α -toxin).
- Nanotech Delivery: lipid nanoparticles for colistin to reduce toxicity.

Drug Development and repurposing

- HTS of FDA-approved drugs reveals off-target antibacterial activity.
- AI/in silico modeling predicts resistance pathways and optimizes leads.
- Regulatory incentives: CARB-X grants, subscription payment models.
- Economic models to ensure sustainable R&D beyond blockbuster paradigm.

References

- [1] R. Urban-Chmiel et al., "Antibiotic Resistance in Bacteria—A Review," *Antibiotics*, vol. 11, no. 8, art. no. 1079, Aug. 2022. doi: 10.3390/antibiotics11081079
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- [3] A. Tarín-Pelló, B. Suay-García, and M.-T. Pérez-Gracia, "Antibiotic resistant bacteria: current situation and treatment options to accelerate the development of a new antimicrobial arsenal," *Expert Rev. Anti-infect. Ther.*, vol. 20, no. 8, pp. 1095–1108, 2022. doi: 10.1080/14787210.2022.2078308