

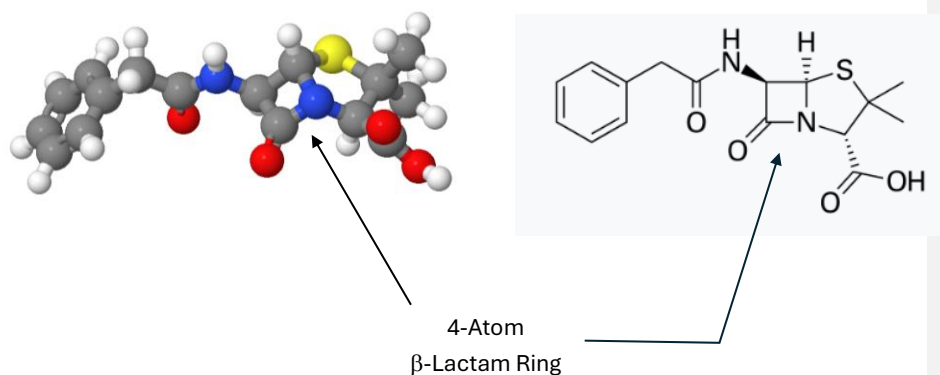
3D-printed Penicillin Model

This model has been designed to discuss penicillin and its modifications to combat bacterial resistance through the addition of different functional groups.

Commented [MA1]: [Benzylpenicillin - Wikipedia](#)

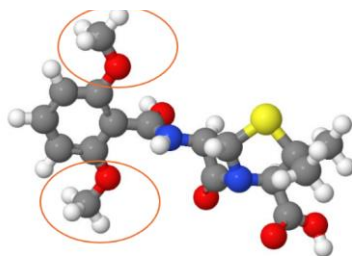
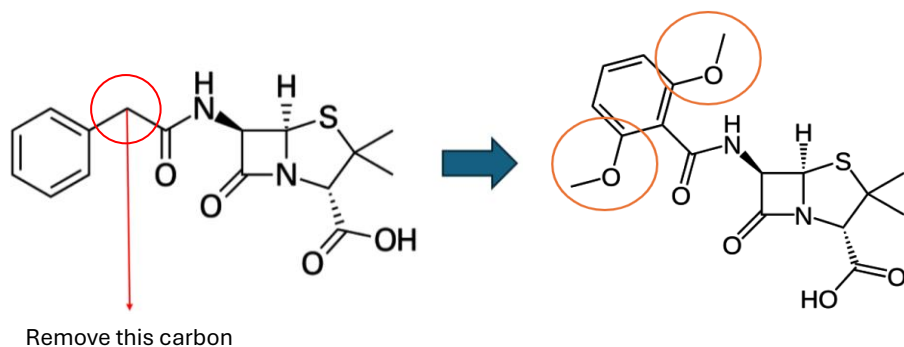
Penicillin deactivates the DD-transpeptidase activity of penicillin-binding proteins (PBP) by forming a covalent bond with a reactive serine residue. It acts as a D-Ala D-Ala analog.

Benzylpenicillin (Penicillin – G)



From Benzylpenicillin to Methicillin

Commented [MA2]: [Methicillin - Wikipedia](#)



Methicillin is a penicillin analog that was created to evade the beta-lactamase of *Staphylococcus aureus*. The bulky methoxy groups that were added to the benzyl ring prevents the antibiotic from binding to the beta-lactamase in such a way that the beta-lactam ring can be hydrolyzed.

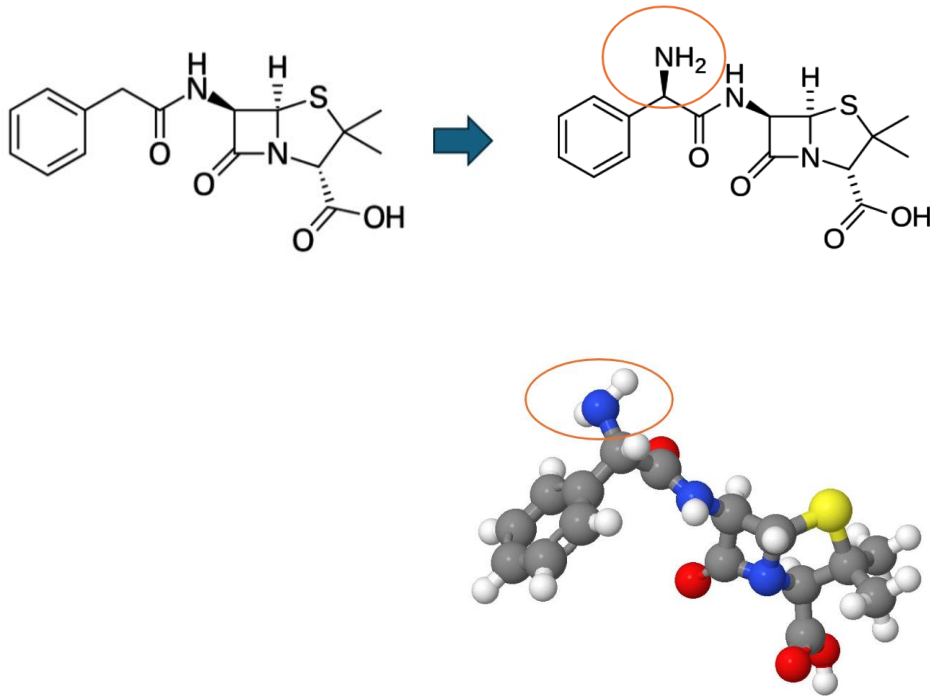
To convert penicillin to Methicillin...:

Frist, remove the carbon atom just to the right of the benzyl group... as shown in the figure above.

Second, add the two methoxy groups to the benzyl ring as shown in the figure.

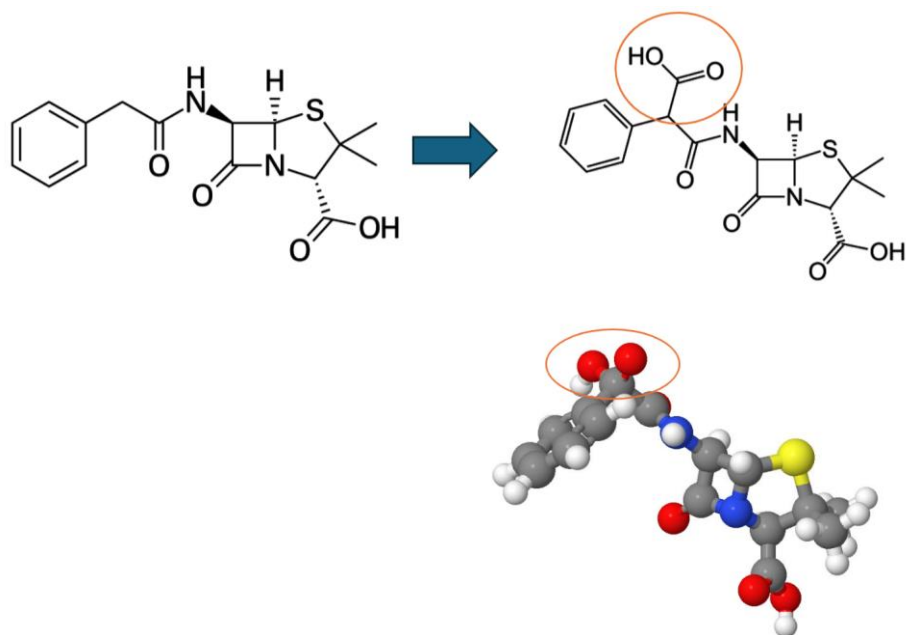
Commented [MA3]: [Ampicillin - Wikipedia](#)

From Benzylpenicillin... to Ampicillin



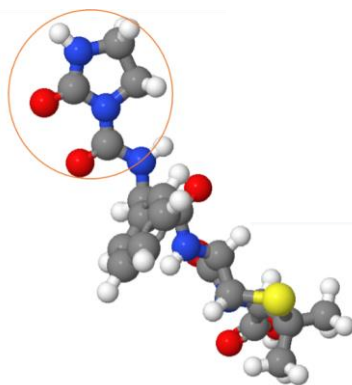
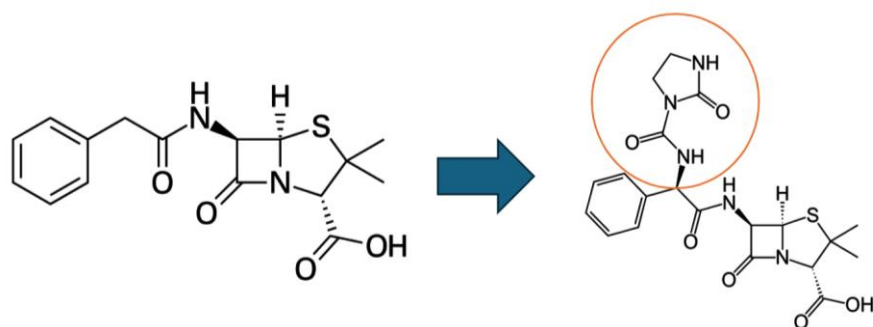
Due to increased antibiotic resistance to beta-lactams, additional penicillin analogs have been created. The addition of an amine group to penicillin creates ampicillin,... and allows for the targeting of gram-negative bacteria by facilitating movement of the antibiotic across the outer membrane. The amine group can interact with the lipopolysaccharides and phospholipids in the outer membrane of gram-negative bacteria, allowing it to pass through.

Benzylpenicillin to Carbenicillin



Carbenicillin was designed to combat *Pseudomonas aeruginosa* (a Gram-negative bacterium). The addition of a carboxyl (COOH-) group enhanced its ability against *P. aeruginosa* and other Gram-negative bacteria. There are some rare, but severe side effects in humans.

Benzylopenicillin to Alzocillin



Commented [MA4]: [Azlocillin - Wikipedia](#)

Azlocillin was designed to combat *Pseudomonas aeruginosa* (a Gram-negative bacterium) without causing bleeding and K⁺ loss in humans taking the drug. This expanded its use against Gram-negative activity, with a higher binding affinity for Penicillin Binding Proteins. It is used for “severe infections” due to its broad spectrum and potency.