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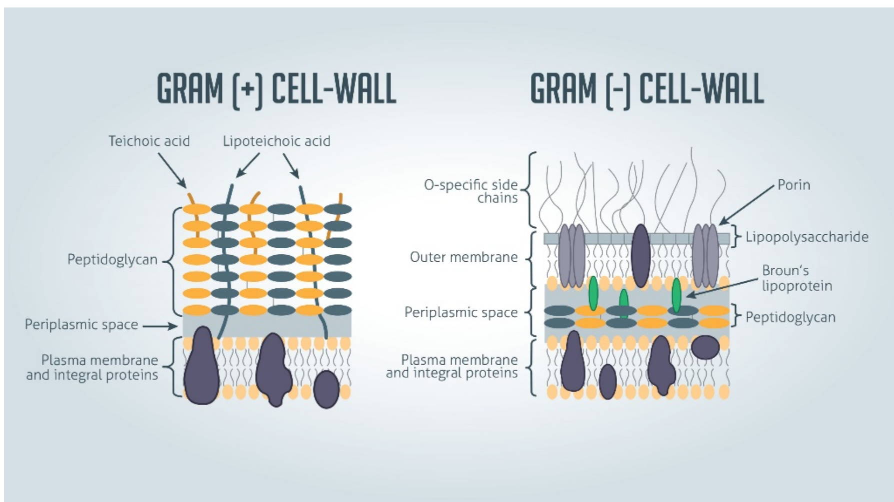
Technical Description

It is said that the human body contains 40,000 bacterial species living on the skin, gut, mouth, and throughout the human body. Most of these bacteria are in a symbiotic relationship with us which allows many physiological processes to occur such as digestion. However, not all bacteria benefit the human body. Most people are inclined to be fearful of bacteria. Consider the public attitude towards bacterial infections such as syphilis, staph infections, MRSA, tuberculosis, and more. An attitude shared by many historical events such as the black plague and more recent events like Ebola. Luckily, many bacterial infections encountered in mammals can be taken care of due to medications that thwart the growth and spread of bacteria. This is of major importance because many bacterial infections that would have proved deadly many years ago can now be adequately treated with antibiotic medications. A very common antibiotic called Penicillin is used to treat a variety of known infections such as strep throat. It works in the body by causing bacteria to burst open and explode instantly killing it.

To grasp the complex mechanism behind Penicillin we must first understand the anatomical features of the bacterium. Bacteria are characterized in one of two ways, gram-positive or gram-negative. They get their name via a staining process which elucidates the thickness of their cell wall which is made up of a polymer of sugars and amino acids known as peptidoglycan. Gram-positive bacteria appear crystal violet in the staining process due to its thick cell wall. On the other hand, gram-negative bacteria will not retain any color due to having a thin cell-wall. This is important because the effects of antibiotics strongly depend on the type of cell wall a bacterium has. Penicillin can only attack gram-positive bacteria because the gram-negative bacteria's cell wall is covered with a layer of a variety of sugars, fats, and protein preventing the chemical constituents of Penicillin to enter the bacterium. Luckily, gram-positive bacteria is an easy target for Penicillin due to not having this extra layer on its cell wall. The peptidoglycan layer of the cell wall is held together by cross-linking chains of amino acids. This cross-linking is only possible via a special enzyme called transpeptidase enzyme which is crucial in the destructive effects of Penicillin.



<u>Figure 1</u>: The anatomical differences between the cell wall of gram-positive and gram-negative bacteria.

To most accurately explain the mechanism that Penicillin undergoes to treat a bacterial infection lets imagine a scenario. You wake up one morning with a fever, headache, chills, and you notice your throat is red with white patches. You decide to make an appointment with your physician who eventually diagnoses you with strep throat, a gram-positive bacteria. Your physician prescribes you a course of Penicillin and sends you on your way home. Upon oral ingestion of Penicillin, it will travel into your gastrointestinal tract and eventually absorbed into the bloodstream. Once the Penicillin reaches the bacteria causing the infection it will begin its function. First, the Penicillin will enter the bacterium's outer cell wall via a protein channel called a porin which allows outside materials to enter the bacterium. Next, the Penicillin travels across the peptidoglycan layer, eventually landing on receptors of the inner cell membrane called penicillin-binding protein. Consequently, the Penicillin-binding protein activates the penicillin which travels back to the peptidoglycan layer. The activated Penicillin attacks the transpeptidase enzyme causing it to no longer be active. Once inactivated, the transpeptidase enzyme can no longer maintain the cross-linking required for the peptidoglycan layer which results in inhibited growth of the bacterial cell wall. Also, it makes the bacterial cell wall extremely fragile. A fragile cell wall can result in water moving into the bacterial cell via osmosis. If there is too much water moving into the bacterium relative to the outside of the bacterium this will cause the bacterium to explode. This is analogous to too much air entering a balloon causing it to explode. I must mention that Penicillin is a chemical with an important structure called a beta-lactam ring. If penicillin were a gun, the beta-lactam ring would be the bullet. This is the part of penicillin that binds to the transpeptidase enzyme and causes it to stop working. Many antibiotics have a beta-lactam ring and are thus classified as "beta-lactams".

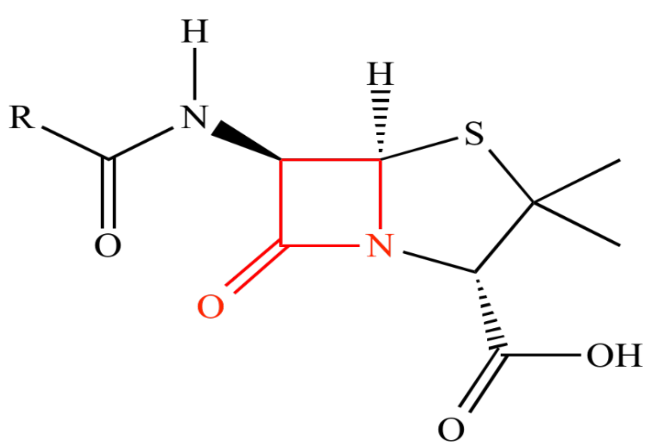


Figure 2: The chemical structure of Penicillin with beta lactam highlighted in red.

Penicillin is one of the first antibiotics used in the medical field to treat a variety of bacterial infections. Before Penicillin most bacterial infections were treated with herbs, leeches, and chemicals such as mercury. This all changed in 1928 when Alexander Fleming accidentally discovered Penicillin. Fleming was investigating a strain of bacteria known as Staphylococcus. He left the bacteria on a petri dish out in the open before going on vacation. Many suggest that the bacterium in the petri dish must have somehow mixed with a Penicillium mold spore which caused both the bacteria and mold spore to interact. Upon Fleming's arrival, he found that the bacteria had lysed or exploded. This caused him to conduct multiple investigations on the interactions between bacteria and mold spores. Eventually, Fleming found that not all mold spores caused the bacteria to die. Only certain strains of Penicillium, specifically Penicillium notatum. He named the active chemical constituent Penicillin. Although Fleming discovered Penicillin, he only knew it to be a topical antiseptic used for wounds and skin infections. It wasn't until the 1940s when Howard Florey and Ernst Chain discovered that Penicillin can be used to combat a legion of bacterial infections.

Penicillin's efficacy is notable in the treatment of many bacterial infections. Diseases such as anthrax and staph infections proved deleterious to those infected. However, through the discovery of beta-lactam antibiotics, many of these diseases can be easily treated and their victims revitalized. I must mention that there is a caveat. Recently, the overuse of antibiotics to treat bacterial infections have resulted in bacteria developing antibiotic-resistant genes. This means that bacteria are becoming increasingly stronger and better at surviving. This has raised public concern and is currently a major focus of scientific research. Overall, Penicillin is a drug that has saved countless lives and continues to do so. We will have to see how well it withstands the increase in antibiotic resistance.

Work Cited

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