Identifying and Quantifying Synergistic Effects of Antibiotics from C. leucodermis Formulated with Nanoparticles Using a Simulation-Aided Method

Feng, Daniel (School: University High School)

Antibiotic-resistant strains of bacteria, called superbugs, require new strategies to improve infection treatment. In my previous years' research, I discovered that the Native American herb Ceanothus leucodermis has antibacterial properties and identified the active compounds within it as catechin derivatives. This year, motivated by research claiming that green teas containing natural nanoparticles show increased activities, I investigated if the antibacterial activity of C. leucodermis molecules could be enhanced by interactions with nanoparticles. I combined experimental data from diffusion assays with a Python computer program I wrote to quantify synergistic activity between antibiotics and nanoparticles. In Phase 1, I determined the optimal method for evaluating antibacterial activity of nanoparticles against E. coli. A well-diffusion assay was found to be the most effective method, and baseline Minimum Inhibitory Concentrations (MICs) were determined. In Phase 2, I used a laccase enzyme to conjugate C. leucodermis molecules to gold nanoparticles and showed that this increased the C. leucodermis molecules' antibacterial activity by 5 times. In Phase 3, I showed that this conjugation, rather than the mere presence of nanoparticles, was causing this synergy. I used double well-diffusion assays and my simulation to test unconjugated C. leucodermis molecules with nanoparticles and showed that unconjugated nanoparticles showed no added effect. This project demonstrates the antibacterial enhancement of C. leucodermis molecules when conjugated to nanoparticles, but not when unconjugated. It shows that reorganizing the spatial distribution of antibiotics at a molecular level can greatly increase their strength, giving a promising approach to improve existing medicines.