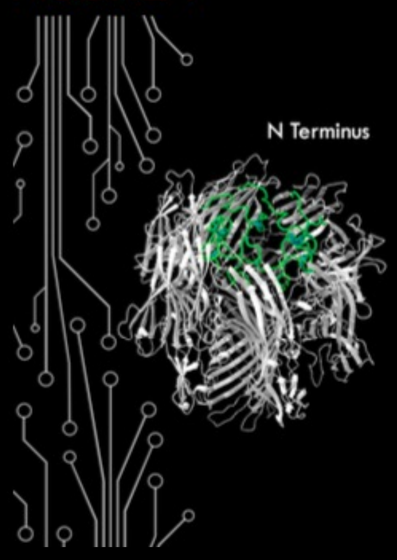
Design of a DNA Origami Construct to Secure Gold Nanoparticles

Shankar Haridas
College Park Scholars – Science & Global Change Program
Operations Management and Business Analytics
sharidas@umd.edu
College Park Scholars Academic Showcase, May 5, 2023

Introduction

Gold nanoparticles (AuNPs) are of special interest to biological research because of their biocompatible properties. This success is the result of their low toxicity, ability to interact with different substances, and a large surface area to volume ratio. The purpose of this research is to design a DNA origami construct to implement the advantageous properties of AuNPs into a biological environment. The property that this research focuses on is the high photothermal efficiency of gold nanoparticles. By exciting the AuNPs with a laser, the temperature in the region surrounding the particles can be accurately controlled.

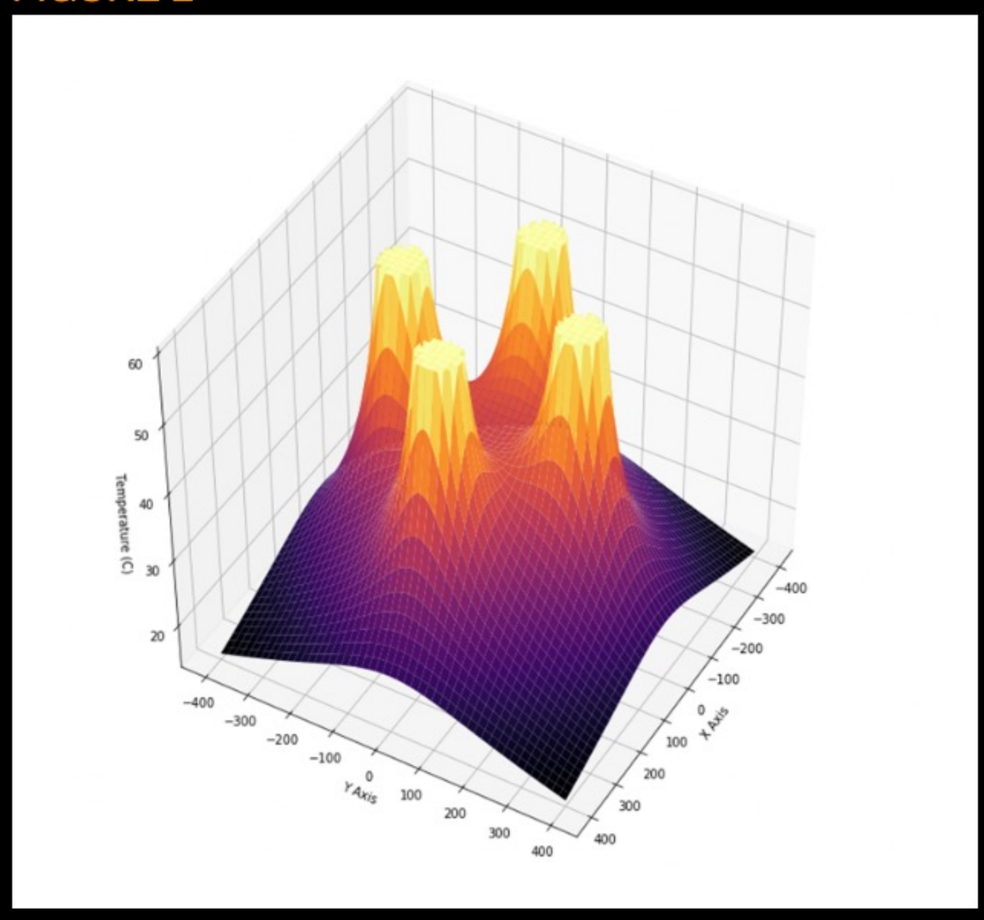
FIGURE 1



The first step in the research was to determine what membrane protein to base the origami structure off of. My mentor and I decided to use the N293 mutant of the Alpha Hemolysin protein for its "semi-universal" structure with a diameter of approximately 100nm across the pore. Additionaly, around the circumference of the protein are cystine resides which contain sulfur, making them good anchor points.

The second step was to determine the appropriate combination of AuNP count, orientation, and distance from the pore. To determine this, a program was written using Python to calculate the dispersion of temperature as a function of particle count, radius, surface temperature, and location. Figure 2 is an example of a graph from a single permutation of the parameters stated with location on the XY coordinate grid, and the calculated temperature on the Z axis. The peaks represent the centers of the nanoparticles and the origin (0,0) represents the pore of the membrane protein.

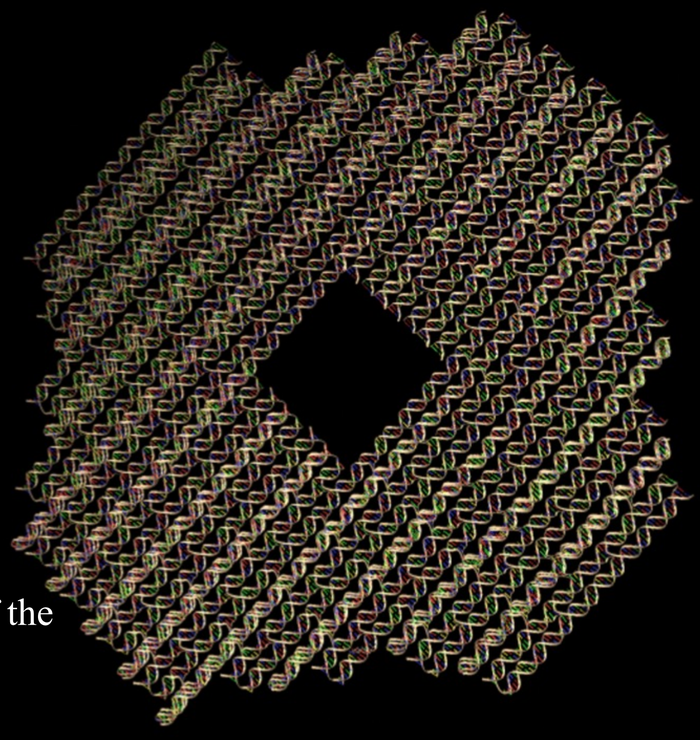
FIGURE 2



Design:

The final DNA origami structure had to have anchor points for the deicded 4 particles, 35 nanometers from the pore. The structure also had to remain within the approximately 7000 base pairs allowed by the Mpm13 bacterial DNA strand, which we used as our scaffold strand. Also, the natural curvature of DNA had to be considered when designing in CaDNAno because the origami structure needs to be able to anchor flat on top of the membrane protein.

FIGURE 3



ChimeraX render of the final structure

Site Information:

National Institute of Standards and Technology

100 Bureau Drive, Gaithersburg

Dr. Joseph Robertson

SCIENCE AND GLOBAL CHANGE

Acknowledgments:

Dr. Holtz Dr. Joseph Robertson

Dr. Merck