Kayla Neville

When my lab work at Stony Brook ended last year, I felt like something was missing. I constantly felt my mind wandering, wanting to know how progress on the projects was going or how the lab members were. Fortunately, I was given the opportunity to conduct research in Dr. Balu Sitharaman's laboratory once again this summer with the support of two amazing programs. Both the Students and Scientists Environmental Research Program (sponsored by the Huntington Breast Cancer Action Coalition) and the Simons Summer Research Fellowship Program (sponsored by the Simons Foundation) guided me throughout the summer and offered different perspectives to my research that shaped my experience.

This year I opted to dorm at Stony Brook, a new experience after commuting last year. I moved into Irving College dorm, which was filled with high school students conducting research in just about every subject from math to linguistics. I quickly became friends with people who lived as far away as California or Texas, and grew closer to students who lived on Long Island as well. Before and after lab work, we would eat breakfast and dinner together and discuss the subjects we were researching. I learned a lot about the Black Plague from my roommate Laura, and subsequently taught her about the carbon nanoparticles I was researching. It was comforting to have a friend who would understand and sympathize with my frustration when an experiment wouldn't work. Interacting with a diverse group of students and learning pieces of their research allowed me to realize that so much in the world is unknown.

As this was my second year working in the lab, I was treated with more independence and freedom in the guidance of my project. This year, I worked with oxygenated graphene nanoribbons (O-GNR) which are carbon-based nanoparticles currently being explored for potential medical applications due to their unique properties. These nanoparticles can potentially be used as targeted drug delivery agents to not only increase the efficiency of the drugs, but also reduce the side effects by localizing the drug only where it's needed. Currently, most chemotherapy drugs are designed to kill fast dividing cells. This means the drugs destroy not just cancer cells, but also stomach lining, blood cells, and hair follicles. This leads to side effects such as nausea, vomiting, low blood cell counts, and hair loss. However, if a targeted drug delivery system were used, chemotherapy drugs would only destroy cancerous cells, which would relieve many of the painful side effects of chemotherapy. O-GNR and other carbon-based nanoparticles have the potential to be used as delivery agents to quickly diagnose and improve the accuracy and efficiency of drug treatment. A process called functionalization alters the surface topography of O-GNR to make the molecule more biocompatible. These nanoparticles have the potential to be multi-functionalized, which would allow molecular imaging probes to consist of O-GNR functionalized with a targeting agent, e.g. antibodies, that recognizes a biomarker specific to a tumor. Once the nanoparticles loaded with anticancer drugs reaches the tumor site, they would be released into the specific cancerous cells. This method would use O-GNR in a way that improves accuracy and efficiency of drug delivery agents. By coating nanoparticles with proteins that recognize receptors on cell membranes, a wide range of chemotherapy drugs can enter cells through endocytosis.

In order for their potential applications to be realized, however, O-GNR must first be functionalized to make them water-soluble so that they are stable in biological media and blood. The purpose of my summer research was to determine the efficiency of various surface coatings for solubilization and for drug delivery into cells. Three different surface coatings were tested: 1,2-distearoyl-*sn*-glycero-3-phosphoethanolamine-N-[amino(polyethylene glycol)-2000] (PEG-DSPE), Dextran with a molecular weight of six kilodaltons and ten kilodaltons. O-GNR was synthesized and solubilized with each surface coating, after which the coated nanoparticles were loaded with the anti-cancer drug doxorubicin via simple π-stacking. Raman spectra of the O-GNRs were taken and analyzed to ensure that the structures and bonds of the nanoparticles were not disrupted during the coating and loading process. Two colorimetric cell viability assays (LDH and Presto Blue) were used to determine the effectiveness of the different nanoparticle coatings in delivering the drug to cells. Four cell lines were used to test the uptake of the O-GNRs: Michigan Cancer Foundation-7 breast cancer cells (MCF7); Medical Research Council 5 (MRC-5) derived from Normal Human Fetal Lung Fibroblasts; and Henrietta Lacks (HeLa) and SiHa cells, both derived from cervical cancer tissue.

It was determined that there is a direct relationship between the charge of the coating and the amount of cellular uptake. The nanoparticles coated with PEG-DSPE, which has positive charge, demonstrated greater uptake than those coated in dextran, which has a negative charge. It is interesting to note that the HeLa and SiHa cells accepted the nanoparticles at a much higher rate than the other cells. Since HeLa and SiHa cells are both cell lines infected with HPV, it is possible that the human papillomavirus (HPV) may play a role in this interesting behavior. Future studies will test this hypothesis.

Having hands-on experience conducting scientific research has increased my interests in biomedical engineering significantly by allowing me to directly apply the skills and knowledge learned in my classes to solve clinical problems. In my research, I discovered that the most revolutionary experiments contain elements from all areas of science: mathematics, life sciences, and natural sciences. Discovering how the different areas of science are connected to each other has helped me understand the real-life applications of concepts that once seemed foreign to me. I learned that in an experiment sometimes outcomes occur that are not expected; yet every outcome provides for at least three more directions. As long as people continue to follow up on the questions they have about the world around them, science will never die. I am excited to continue to share information I learned these past two years with others, as education is an essential part of prevention.