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As teenagers, it is fairly easy for us to assume that we are immortal—and who can blame us? We're young, healthy, and strong; we are seemingly indestructible. We are not necessarily as careful as we should be. As teenage scientists, it is not as easy to assume that we are immortal. The education I received this past summer at Warner-Babcock Green Chemistry Institute is one that taught me that as a scientist, it is important to understand the effect our work has on the world around us. In 1891, Alexander Pavlovich Dianin synthesized a chemical that would later change the world. After combining two moles of phenol and one mole of acetone, Dianin was left with bisphenol A, the compound that would eventually be a major carcinogen. Various studies have shown a link between BPA and breast cancer. Dianin could never have expected the effect BPA would have; as young scientists, it is important that we understand the kind of impact our actions inside the lab can have. Having the opportunity to research environmental links to breast cancer has been one of the best experiences of high school.

Before starting at the lab, I knew roughly of Green Chemistry, however, I truly had a meager understanding of it. I was never specifically taught of toxins and their effect on the environment in my Regents level chemistry course. I had no knowledge of how many chemicals had carcinogenic capabilities or why and how they functioned. When I actually learned the twelve principles of Green Chemistry, my view of science changed entirely. It is frightening to think that toxicology is not a required course for all undergraduate and graduate science students, and that it is not included as a unit in high school science classes. If this next generation of scientists could have a greater understanding of toxins, we could create an entirely more benign world. I was especially excited to start work at the Warner-Babcock Green Chemistry Institute after learning that John Warner co-founded the Green Chemistry movement.

Upon starting our first day at the lab, Katherine and I quickly realized that not only were the chemists a family, but that they were more than eager to welcome us. Coffee breaks in the kitchen would turn into hour-long discussions with a chemist about how they decided to study chemistry. Not only were they eager to talk to us, but they were also eager to hear about what we were interested in and if there was anything they could do to help. Although we were initially frightened by their incredible knowledge, we soon understood that they were so eager to enlighten us and teach us all they could. John Warner, the founder of the lab, graciously agreed to be our mentor and assisted us in our methodology, project concept, and organization. Having a world-renowned chemist as our mentor showed us just how excited the lab was to have us there.

The facility was state of the art, and more benign than most. We had two tours: one general tour of the building, and another safety tour. The Director of Sustainability, Paul Richard, gave us the safety lesson that is typically given to new employees (six hours spread out over the course of three days). Simply having that thorough knowledge of safety is indispensable; most college students do not get safety training the way they should. With college just around the corner, it is especially comforting to know that I feel entirely safe in a lab setting. In the Beyond Benign lab where we spent most of our time working, only chemicals that could be neutralized and poured down the drain could be used. The lab only orders minimal amounts of chemicals, so as not to have excess in storage.

After the first week, John proposed to us the topic that would later be our focus: bisphenol-A in epoxy resins in can linings. BPA is a carcinogen found to be linked to numerous cancers, most frequently a cause of breast cancer, and neurological disorders. After reading many articles on BPA, we began our experiment by testing various metals in different acids and salt concentrations; we did this in order to have a better understanding of the process of corrosion. We tested the metals in five naturally occurring acids that are frequently found in canned foods: ascorbic, citric, folic, lactic, and malic. We found that zinc, which is typically used to galvanize steel cans, was most corrosive when placed in these acids typically found in canned foods. We then purchased twelve cans of food: peaches, green beans, black beans, and corn. For each type of food, we had one or two cans that had an epoxy resin (BPA coated lining) and one or two cans that were advertised as having a BPA-free lining. The cans with the epoxy resin linings were not supposed to corrode, while the cans with BPA-free linings were supposed to corrode. We had judges rank the level of corrosion from one through five (one being least corroded, five being most corroded) for four consecutive days. Upon completion, we noticed that all of the peach cans had corroded incredibly; the liquid had turned orange and the exposed metal was rusting. We began to understand that the high pH of the peaches—due to the amount of malic and citric acid found—could be degrading the BPA lining and causing accelerated corrosion. We used the information that we gained from these initial steps to design the rest of our experiment.

The fact of the matter is that developing a new polymer, suitable for coating cans and preventing corrosion and bacterial problems, could take a decade. We decided that we would test four polymers that had already been developed. We took Polyvinyl chloride (PVC), Polymethyl methacrylate (PMMA), Polyvinyl propylene (PVP), and Polyacrylic Acid (PAA). Each polymer had a different functional group; the aim of this part of our experiment was to understand how different functional groups could cause resistance, or lack there of, to corrosion. We created different weights of polymers: 1%, 3%, and 6%. We purchased over 300 zinc screws in order to mimic the cans (many cans are made of galvanized steel, meaning they have zinc linings) and how the metal would react without the BPA lining. We had six groups of twelve screws for each polymer. After dipping all of the screws in their respective polymers and weights, three groups were left out overnight to air-dry, while the other three groups were cured in the oven at 210 C for 40 seconds. In total, we had 144 baked screws and 144 air-dried screws. Next, we placed two screws of each group into different 0.1 M solutions: malic acid, citric acid, sodium bicarbonate, pure sodium chloride, malic acid with sodium chloride, and sodium bicarbonate with sodium chloride. We had chemists go through the screws each day for approximately seven days, judging each screw on a scale of one to five (one being least corroded, five being most corroded). This process took almost an hour for each judge; thankfully, the chemists at WBI were gracious enough to help us and take the time out of their day to act as judges.

After the seven days of judging, Katherine learned how to use the program Chem Draw to recreate zinc molecules and the polymers graphically on the computer. As she did this, I photographed the 288 screws using an Olympus SZ61 microscope. We are still calculating our immense amount of data, but are optimistic about our results. Hopefully our findings can assist other chemists in creating a polymer with similar characteristics of BPA: the ability to resist corrosion, without the carcinogenic and harmful side effects.

I am so thankful to have had such an amazing experience at WBI. I am so grateful to John Warner, Kate Anderson, the many chemists that assisted us, and the Great Neck Breast Cancer Coalition for so generously sponsoring us. The Students & Scientists Program has helped foster my new passion for chemistry and research, my growing interest in the study of biochemistry, and my changed view of science in regards to Green Chemistry. I hope to create a petition for greater education in toxicology in the future and to continue my research on environmental links to breast cancer. This was a once in a lifetime opportunity and I could not be more excited to see the relationship between Green Chemistry and breast cancer research burgeon.