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One topic that interested me from the video was chemical engineering, presented by Ms. Manivannan. Chemical engineering is the practical application of chemistry to make a usable product. Chemical engineering captivates me because of its usefulness and benefits towards society, which interested me greatly. For example, one notable instance of applied chemistry was the creation of the Haber Process in 1910, which created an alternative way to produce ammonia, creating fertilizer that has helped thousands of people through healthy crops and nutrition. Today, companies like DuPont are harnessing chemistry to further improve the nutrition and crop output of the world through phosphate and nitrogen based fertilizers. The future of chemical engineering holds prospects for the improvement of the human standard of living, and I intend to be on the crest of that wave, leading our world into a better place driven by the ancient rules of chemistry.

I am also fascinated by the concept that infinitely small particles that make up chemicals so drastically change the outlook of life on Earth. Two things that don't resemble each other in any way, shape, or form are built from the same building blocks according to the Nuclear Theory. The strongest metals are made from the same protons, neutrons, and electrons as the air around us. The power to manipulate the chemical properties of atoms and elements allows for innovation and the creation of products that can positively impact our future. For example, the creation of metal alloys like steel help make buildings and equipment safer, as well as allowing for machinery to last longer, reducing waste. The synthesis of these alloys improve our day-to-day, as do the many other chemical processes that surround us.

Innovation in chemical processes have many applications for the Navy and the Marines, with uses in military combat and in Naval research. One such way is the creation and improvement of sealants and adhesives, which Ms. Manivannan touched on in her video. Sealants are helpful to the Navy for the protection and safety of their sailors on boats. Chemical engineers are able to manipulate chemical properties to improve sealants, which can help with quick boat repairs and possibly even save lives at sea. There are many ways that an engineer can change the composition of a sealant to help it seal better, like the usage of polar molecules in a sealant solution. By using polar molecules, they interact together with dipole-dipole interactions, which increases the attraction between two of these molecules. This allows sealants to stay in place and not crack, while one with looser intermolecular attractions may crack under pressure.

Chemical engineers also use chemistry to improve protection for weapons, allowing the United States to preserve their weapons and equipment for longer. Many of the equipment that the United States uses is preserved with antioxidants. For example, the normal oxidation of iron on iron tools creates iron oxide as solid iron is oxidized. By putting an antioxidant on these tools, they last longer, allowing for more resources to be allocated to other parts of the Navy. And, with improved antioxidants, this would save even more money for the Navy, allowing for more resources to be allocated to more important projects.

One scientist from the selection of videos that inspired me was Ms. Manivannan, a chemical engineer in the Navy. She works with sealants and adhesive technology and uses chemical properties to form these products. This inspires me because I aspire to become a chemical engineer in the future and Ms. Manivannan's story shows me some of the potential paths I can take. Ms. Manivannan participated in the Pathways program when she was in college, which is something I have researched as a potential option during university. I am really interested in the Pathways program because it is an option where I can apply what I already know in meaningful work while also studying and expanding my knowledge. Although I do have some laboratory experience in my high school science classes, working in a government laboratory with experienced professionals would be a game changer, as it was for Ms. Manivannan.

I also am inspired by Ms. Manivannan's work because of how it relates to my current studies in high school chemistry. In class, we often discussed intermolecular and intramolecular forces, properties that are extremely important to the development of sealants and adhesives, depending on the surface it is being placed on. Intermolecular forces like dipole-dipole interactions and London Dispersion Forces heavily impact the type of chemicals and bonds used in sealants. This is why silicones are so effective as sealants and have a variety of industrial purposes. Silicones have a Silicon atom bonded to Oxygen in a chain and then bonded to hydrocarbons with other bonds. The bond between Silicon and Oxygen is highly polar, increasing the bond energy and making silicones very effective as sealants, as not many things can penetrate the high bond energy created between a highly electronegative element like Oxygen and much less electronegative element of Silicon. This link to my chemistry courses today helps me further understand the concepts that I am learning in my chemistry classes and contextualizes the practical applications of what I am learning for my future career in chemistry.

Another field where chemical engineering will be useful in the next 15 to 20 years will be in the emerging field of geneic engineering. In 2040, it is very possible that many types of medicine, agricultural products, and energy sources will be impacted by CRISPR-Cas9. CRISPR-Cas9 is made up of two parts: the guide RNA and the Cas9 protein. The guide RNA has 20 specific letters it matches to, allowing the Cas9 protein to cut the DNA at the right place, altering the DNA in the cell. Many of the applications of CRISPR are clinical, like the curing of genetic diseases like sickle cell anemia. This would improve medical care around the country and the world, with applications as far reaching as curing cancer. This technology has the possibility to change medical care for the next century and in the future.

In addition to the far reaching clinical applications of CRISPR, CRISPR could be used to improve fuel and energy, allowing energy sources to be more efficient and less harmful to the environment. Some naval ships burn more than 1,000 gallons of petroleum oil an hour, which is very expensive and harmful to the environment. Organisms engineered by CRISPR can be used as additives or even substitutes to fossil fuels. Currently, researchers are experimenting with genetically engineered algae as a replacement for oil. Although the research is still in the early stages, algae biofuel has the potential to be cheaper and better for the environment. Cutting fuel costs for the Navy and Marine Corps would save the Navy a large amount of money, especially since the Navy spends around 4 billion dollars a year on fuel. If in 2040 the Navy is able to use biofuels instead of gasoline for even a small portion of their fuel output, it could lead to millions of dollars in savings, savings that could be used to fund further scientific discoveries by Naval research facilities.

In the future, chemical engineering will have a large effect on the efficiency and usage of CRISPR-Cas9. One way that chemical engineers do to improve CRISPR is editing CRISPR delivery systems into cells. For the in vivo delivery of CRISPR to cells, scientists use viral vectors to infiltrate cells and edit the DNA in the nucleus. However, oftentimes the viral vector containing CRISPR is unable to reach the cells without being destroyed by the immune system, or because the cell rejects the viral vector all together. Chemical engineers continue to modify these vectors to improve their effectiveness, and in

2040 it is very likely that many medical treatments will employ CRISPR in viral vectors, improving the health of people around the world.

So, as technology continues to change, the roles of chemical engineers will also adapt to suit the changing needs of the world. However, whether it be creating sealants, adhesives, viral vectors, or any other product, chemical engineers will still work by the same chemical laws that have been in place for all time. The same rules of intermolecular attraction, electronegativity, gases, and many more. This consistency is what makes chemistry so intriguing to me, and I can’t wait to study more in the future, because, in reality, aren’t we all just products of chemistry?