

BREAKING BARRIERS: DIVERSITY AND EQUITY IN CHEMISTRY

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SHUAI SUN; JOHN KAISER;
AND ALEX MEIER



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Introduction: Embracing Diversity and Equity in Chemistry Education

Shuai Sun; John Kaiser; and Alex Meier

The field of chemistry has long been associated with the pursuit of objective facts and the uncovering of the building blocks of our universe. However, this view can often exclude the important role that diversity, equity, and inclusion (DEI) play in the advancement of scientific knowledge. By highlighting the contributions of minority chemists and integrating DEI principles into chemistry education, we can promote a more inclusive environment and foster greater understanding of the complex connections between chemistry and society.

In recent years, there has been a growing recognition of the need to incorporate DEI into STEM education, and chemistry is no exception. Despite this, there remains a scarcity of learning materials that directly introduce diversity and equality in chemistry education. As a result, students may view chemistry as an isolated discipline that is removed from the broader community.

This book aims to challenge that perception by introducing readers to minority chemists, their research, and the ways in which their work is related to topics taught in general chemistry courses. By exploring the lives and research of chemists who come from diverse backgrounds, we hope to showcase the importance of diverse perspectives in the advancement of the field and inspire a new generation of scientists who embrace and promote DEI in their own work. Each chapter of this book is divided into three main sections, highlighting the personal and professional lives of these extraordinary individuals and demonstrating the impact their work has had on the field.

In the first section, we provide a biography of each chemist, discussing their personal and professional lives and how their minority identity has interacted with their careers. The second section summarizes their research and accomplishments in the field of chemistry, emphasizing the importance of their work and the implications it has had on the broader scientific community. Finally, the third section explores how their research is related to the topics and contents taught in general chemistry, creating a connection between the material students learn in the classroom and the real-world applications of chemistry.

In addition to being an educational resource, this book holds practical value within the classroom. Each chapter of the book includes carefully crafted reading questions that integrate chemistry and sociology concepts, making

them ideal for inclusion in mid-term and final exams for chemistry courses. By integrating DEI-focused content into assessments, we hope to encourage students to think critically about the role of diversity and equity in chemistry and beyond.

Ultimately, this book serves as a stepping stone toward a more inclusive and diverse chemistry education. By showcasing the contributions of minority chemists and integrating DEI principles into the learning process, we can inspire future generations of scientists to view chemistry as a field that is not only grounded in objective facts but also deeply interconnected with the broader human experience.

We would like to acknowledge the invaluable support and contributions of the University of Kansas Library and Center of Teaching Excellence. Their assistance through the Open Educational Resources Grant Initiative and Course Transformation Grant has been instrumental in the creation of this book.

Special thanks go to Karan Younger, Josh Bolick, and Heather L. Mac Bean, the librarians who have provided us with ideas and technical support throughout the process of completing this book. Their expertise and guidance have been crucial in shaping its content.

We would also like to express our gratitude to the students in Dr. Shuai Sun's General Chemistry class. Their enthusiasm and engagement have inspired the author teams to delve deeper into the significance of

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diversity, equity, and inclusion in STEM education. Their perspectives and insights have enriched the content of this book.

Thank you to everyone involved for their support and contributions, which have made this project possible.

I

JAMES ANDREW HARRIS

John Kaiser; Alex Meier; Canon Nesmith; Jad
Shaheen; Michelle Han; Ryan Wittman;
Sammye Saruwatar; and Shuai Sun



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James Andrew Harris was the chemist who would discover
Rutherfordium (element 104) and Dubnium (element 105).

Despite being one of the first and most influential Black chemists, Harris' work remains largely underappreciated. However, Harris' life and career remains an inspiring story of determination and fortitude, defined by overcoming systemic inequality in both his personal and professional life.

Born in Waco, Texas in 1932, James Harris faced oppression throughout his life. Jim Crow laws established racial segregation throughout all of Texas during this period, dividing White and Black racial communities. Following his parents' divorce, he moved to Oakland, California to complete his high school education. Harris would then move back to Texas to attend Huston-Tillotson College. Pursuing a chemistry degree, Harris would graduate in 1953 before choosing to serve in the U.S. army. Two years later, Harris would be honorably discharged. Following his short military career, Harris began searching for a job in chemistry.

Being a black male in the Jim Crow era subjugated Harris to a lot of heavy-handed racism, putting him at a disadvantage when applying for jobs. When applying for a chemistry level job, a job requiring advanced scientific knowledge and advanced education, Harris would often face shocked interviewers. He would often be directed to, or assumed to be applying for, janitorial jobs. Harris would later recount how he could "write a book" about his job-hunting experiences. Eventually, Harris would find a job at Tracer lab in Richmond, California. Due to his scientific

talent, Harris would relocate to the Lawrence radiation lab, where he really had the opportunity to really make a name from self.

Disgruntled with his job hunting experience, Harris worried about the future career prospects of upcoming Black chemists. Following his retirement, Harris began advocating for African American Youth communities, organizing efforts and providing resources to improve job prospects and education for Black youth. Harris would travel around the entire country in efforts to provide resources for underrepresented black communities. In impoverished areas of the United States, Harris would teach elementary school students to advocate for science in the classroom. Harris passed away at the age of 68, on December 12, 2000.

James Andrew Harris's contribution to chemistry was the discovery of elements 104 and 105, Rutherfordium and Dubnium. He got a position at the Lawrence Radiation Lab at the University of California Berkeley after five years of doing work that was well below what he was qualified to do. Harris served as the head of the Heavy Isotopes Production Group in the Nuclear Chemistry Division. Their goal was to discover new elements by using bombardment. This involved taking one element called the projectile and accelerating it to incredibly fast speeds before smashing it into a second element called the target. Sometimes, the elements will combine to form a completely new element. This process of combining

elements together is called nuclear fusion, and requires a large amount of energy, which is why the projectile element is sped up to such high speeds. Harris was responsible for purifying and preparing the atomic target materials of curium and californium that would be bombarded with carbon, nitrogen, and neon by using a particle accelerator.

Element 104, known as rutherfordium, is an unnaturally occurring element with the periodic symbol of Rf. It was named after the British physicist Earnest Rutherford. The discovery of rutherfordium was discovered by a Russian research group as well as the research group including Harris, earning him the title of the first African American to discover a new element. It is a solid, radioactive metal with an atomic number of 104. Because rutherfordium is an unnatural element, many of its properties have not been measured. Rutherfordium has 5 different isotopes. The most stable form being ^{263}Rf which has a half-life of around 10 minutes and decays through spontaneous fission, where the atom can split into two similarly sized pieces releasing a large amount of heat. This is the opposite of nuclear fusion, what was used to create Rutherfordium in the first place. The heat generated through nuclear fusion is also what is generally used to fuel nuclear powerplants, and in large enough quantities with no control, is also what fuels nuclear weapons. Other isotopes of rutherfordium can decay by alpha decay, where a helium nucleus is ejected from the atom, or electron

capture where a proton is converted into a neutron. There are two other types of radioactive decay that are not exhibited in Rutherfordium. Those are beta decay, or the loss of an electron, and gamma decay, where gamma rays are emitted as high-energy electromagnetic radiation. All of these types of radiation are first order exponential decay, and depend only on the concentration of the starting material. Since there is only a small amount of rutherfordium that is produced and the element has a short half-life, no practical uses for it have been discovered. Little is known about the radioactive properties of this element, because it decays so quickly.

One year later in 1970, Element 105, Dubnium was discovered. It is also a solid, radioactive metal that does not occur naturally, with an element symbol of Db. the atomic number of Dubnium is 105 and like rutherfordium, many of its properties have not been measured. The most stable form of this element is 268-Db and has a half-life of around 32 hours, which decays through fission and alpha decay. Like Rutherfordium, Dubnium is made artificially. Only small amounts have been produced and due to its short half-life, the element is only used for scientific research.

Harris' work in element discovery not only taught us more about the periodic table and heavy elements, but also inspired future chemists for years to come. The creation of new elements, even unstable ones that have no practical

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use, is a symbol of the progression of science and the human race.

MILDRED COHN

John Kaiser; Alex Meier; Liberty Cavender;
David Matson; Zoe Oxford; JJ Ramm; Ayanna
Spruill; and Shuai Sun



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Mildred Cohn was a pioneer in the scientific community during a time when hardships and adversities were

common obstacles facing women. Born in 1913, Cohn grew up in New York City to a Jewish family and showed outstanding academic achievement at a young age. However, the rest of society viewed her as inferior for her gender and religion. Since she was a woman, professors discouraged her from becoming a chemist while teaching her to become a chemistry teacher, saying that a career as a chemist was “unladylike.” Further, she was denied many opportunities for her Jewish religion, as only Christians were allowed in most science-based positions. Nonetheless, Cohn defied the odds and made her career working alongside Nobel Peace Prize winners, earning a Professional Doctorate in Physical Chemistry, and discovering connections between biology and chemistry. Ultimately, Cohn pushed past adversity and became a successful and educated chemist in an era where most women were housewives and Jewish people were viewed as inferior.

Growing up, Cohn was raised by her father alongside her brother Albert, who was two years older than her. Her father was a rabbi in Russia before moving to New York in 1907, leading to their family to place major emphasis on Yiddish culture. When Cohn was 13, her family moved to a Yiddish-speaking cooperative. This proved very beneficial to Cohn as the cooperative emphasized educational attainment, which would help Cohn later in life.

Cohn started her college education at Hunter University in New York City, a university that was free

and accepting of women. However, Cohn eventually saved up enough money to attend the University of Columbia and receive her Masters' degree. In 1938, Cohn married Henry Primakoff but chose not to change her last name because she didn't want her Jewish identity revealed during World War II. In 1960, Cohn and her husband moved to the University of Pennsylvania, where they would work for the rest of their careers. However, Cohn's husband would pass away at 69.

Much like her personal life, Cohn's professional life was greatly impacted by discrimination for her gender and religion. Despite the trials of her personal life, Mildred Cohn continued to advance her research despite the gender bias and prejudice she faced. Cohn refused the recommendation from her peers to stop after her bachelor's degree, and in 1932, just a year after completing her bachelor's, she earned her master's degree in Chemistry from the University of Columbia. However, Cohn could not attend an extra year of her graduate program, as the Great Depression led to a national economic crisis. Individuals all over the United States could not afford basic needs such as food, clothes, or shelter. While Cohn was able to afford for her basic needs, she was unable to afford school. Reflective of the discrimination she faced, there were programs such as teaching assistantships to help, but since Cohn was not Christian or male, she was not allowed to participate in these financial opportunities.

Rather than taking an assistantship, Cohn had to find another way to pay for her education. She took a job at a government aeronautics lab to save up money, a process that took two years. This lab was the predecessor to The National Aeronautics and Space Administration or NASA. Eventually, the director heard there was a female in his lab who was doing more advanced experiments than her male counterparts, and Cohn was kicked out of the lab solely because she was female. After a lot of convincing, she worked under Nobel Peace Prize winner Harold Urey where she wrote her Ph.D. dissertation over the behavior of isotopes of oxygen. This work allowed her to achieve her doctorate in Physical Chemistry from Colombia in 1938 and laid the foundations for her career as a chemist.

Cohn's work both at the government aeronautics lab and at Colombia focused primarily on using mass spectrometry (MS). This technique would bombard samples with high energy until they broke apart, and then measure the ratio of mass-to-charge of the fragments of the molecule. This allows for identification of the compound placed inside the instrument. Mass spectrometers are very expensive and complicated instruments, however, at both of these institutions, Cohn built her own mass spectrometers. She was not only able to build these incredibly complicated instruments, but was also an expert in their usage.

Cohn was now an established figure in chemical science. However, this did not mean that her male

counterparts respected her. Cohn eventually ended up at Washington University as a post-doctorate researcher. Her position there was largely because her husband was offered a position there as well, but Cohn was able to take full advantage of this opportunity. She began to work with Gerty Cori, another chemist discussed in this book, and at this time she started her work studying adenosine triphosphate (ATP) with nuclear magnetic resonance (NMR).

NMR is a complicated process that helps determine the identity and structure of compounds. The NMR creates a strong magnetic field, and nuclei that contain an odd mass number interact with the magnetic field producing a signal. These signals can be converted to peaks which differ based on the polarity of nearby atoms. The more polar the area around the atom is, the more the peak moves to the left of the spectrum. These are called 'down-field' peaks.

Cohn used NMR to study ATP, the primary source of energy that our body uses. She looked for ^{31}P , which contains the odd mass number necessary for NMR, and through her work she was able to define each phosphate group present on ATP. Using this method she was also able to study how ATP was converted to ADP which produces energy, and how ADP was converted back into ATP to store energy. This process of creating energy, called the metabolic pathway, had been proposed before,

but Cohn's work was the first time that direct evidence for it had been seen.

Perhaps more importantly, NMR, the process Cohn was using, was non-destructive. Her previous work with MS would completely destroy the valuable samples they were attempting to analyze, but NMR used weaker fields, and thus the sample was not destroyed in the process of measuring it. This allowed for Cohn to study what happens to samples over time, which eventually became her work studying the metabolic pathway.

Cohn worked with Cori for 22 years before eventually being offered a professorship at the University of Pennsylvania in 1960, where she continued to work for another 22 years before she retired. Cohn was a remarkable chemist as she not only build her own instruments and became an expert in mass spectrometry, but was able to change and also become one of the most prolific chemists working with NMR. Over the course of her career Cohn published over 160 papers, many of them concerning the metabolic pathways that occur in humans. This work not only increased our knowledge of how energy is produced in us, but also helped with the identification and diagnosis of several diseases.

SAINT ELMO BRADY

John Kaiser; Alex Meier; Kyler Luong; Soumi Vesali; and Shuai Sun



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<https://opentext.ku.edu/deichemistry/?p=30#h5p-3>

Saint Elmo Brady was the first African American to receive a Ph.D. in chemistry. Born on Dec. 22, 1884, in Louisville, Kentucky, Brady was the oldest of three

children. After graduating from Louisville Colored High School in 1903, he left home at the age of 20 to attend Fisk University, an all-black college in Nashville, Tennessee. There he met and was encouraged to study chemistry by Thomas W. Talley. In 1908, Brady graduated from Fisk University with a bachelor's degree, then took a teaching position in chemistry at Tuskegee University. He then took a leave of absence from Tuskegee Normal and Industrial Institute after teaching for four years when he was given a scholarship to University of Illinois at Urbana-Champaign. He started in the summer of 1913 and completed his M.S in chemistry in 1914. Brady's Ph.D. research sought to examine how the acidity of straight chain carboxylic acids was affected when a pair of hydrogen atoms was replaced with an oxygen atom to give a keto acid.

Brady was the first to discover new methods for preparing and purifying certain compounds and was able to clarify the influence of carbonyl groups on the acidity of carboxylic acids. Brady was able to get his Ph.D. after two years, becoming the 40th person to receive a Ph.D. in chemistry from University of Illinois at Urbana-Champaign, and also the first African American chemist to earn a Ph.D. in the U.S. When first starting to get his Ph.D. there were 20 white males and he was the only black student. By the end of it, there were only 6 white males and himself getting a Ph.D. It was a struggle for Brady to find a home, for since he was African American he lived

in segregated communities. During the time Brady was getting a PhD or even higher education it was very rare for someone other than a Caucasian getting or having the freedom to get higher education. During the time of the 6.3 % of African Americans that graduated high school only 1.2% of them got a bachelor's degree and then of the 1.2% that got a bachelors only 1.8% got a master's degree of the 1.2% that got a bachelor's degree in the 1920s in the United States.

During this period of the 1920s, Brady was in the middle of a segregation area in the United States. During the segregation era especially since Brady was living in the South there was a heightened sense of discrimination. Before the segregation era, politicians developed the "separate but equal" phrase to "provide equal opportunities to African Americans". "Separate but equal" would eventually be abolished because it was recognized to reinforce ideas of systemic oppression.

Brady's research focused on various acids. He synthesized various carboxylic acids and analyzed the change in acidity when changing the group attached to the acid. Although this had not been termed yet, it is now known as the inductive effect, where the electronegativity of a connected atom can affect the acidity of an acid.

The acidity of a compound is measured by its pKa. This measures the ability of an acid to give away its proton to lead to what is called a conjugate base. The lower the pKa, the more acidic the compound. The more stable the

conjugate base is, the more acidic the compound is. Once the proton is removed from an acid, it results in a negative charge on the conjugate base. A more electronegative atom connected to the acid helps compensate for this high negative charge by ‘pulling’ some of the electron density towards it. The distance between the electronegative atom and the acid also affects the pK_a , and the closer the electronegative atom is to the acid, the larger of an effect on the acidity it has. pK_a is a logarithmic scale, which means that a change of 1 pK_a unit will be a 10-fold change in acidity. pK_a is also a measure of the pH at which 50% of the compound is protonated (acid) and 50% of the compound is deprotonated (base).

Brady’s work for his doctorate focused on synthesis of carboxylic acids that had carbon chains, or an oxygen atom at the α , β , or γ position to the acid. The α , β , and γ are ways to measure the distance from a group on a compound. If a group is one atom away, it is considered the α position, two atoms away is the β position, and three atoms away is the γ position (Figure 1)

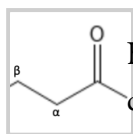


Figure 1. α , β , and γ positions on a

Brady’s work was the first to demonstrate what came to be known as the inductive effect on acidity. This is one of the four primary parameters that are used when attempting to identify the pK_a of a compound. Despite performing his work in the 1800s, he was still

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able to discover an effect that is taught to
carboxylic acid undergraduate students every year.

BETTYE WASHINGTON GREENE

John Kaiser; Alex Meier; Roxanne
Markowsky; Kate Duff; Catherine Darche;
Mauri Peterson; Kathryn Case; and Shuai Sun



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BREAKING BARRIERS: DIVERSITY AND EQUITY IN CHEMISTRY

Betty Washington Greene was the first African American female Ph.D. chemist. Originally attending a segregated high school in Fort Worth, Texas before moving to Alabama for college, Greene graduated from Tuskegee Institute with a bachelor of science in chemistry. She then went on to earn her Ph.D. in physical chemistry at Wayne State University. Her academic success earned her a spot at the Dow Chemical Company, making her the first African American female Ph.D. chemist to work in such a field. Her research looked at latex polymers, colloid chemistry, and phosphate coatings, all of which would pave the way for her to continue her research into other fields. As the senior promoter investigating a number of chemical advancements, Greene filed for a number of patents while working at Dow Chemical. Greene worked with these materials at this company up until her retirement in 1990. Dow Chemical Company is located in Michigan and today is one of the 3 largest chemical producers in the world focusing on plastics, chemicals, and agricultural products. Five years after retiring from Dow Chemical, Betty Washington Greene passed away in June 1995. With tons of contributions to the research of polymers, Greene made a gateway for improvement and a better understanding of how to improve latex with the use of polymers.

Greene was born in 1935, years before the Civil Rights movement kicked off. Truly exposed to her minority identity at a young age, Greene attended all public schools

in a segregated environment; however, she did not let the injustice she faced affect her education. She continued to go to high school and eventually went to Tuskegee Institute, an all-African American university, where she earned her bachelors before she eventually got her Ph.D. in 1962 (James A. Barham, Academic Influence). This was a time when the Civil Rights movement had compelled African Americans to fight for their rights. Black individuals were not being treated equally, which is what makes Greene's success so valuable. In 1965, Greene became the first African American female chemist to work at Dow Chemical Company, where she continued her research and utilized her skills. Greene was eventually promoted to Senior Research Specialist in 1975. Greene continued to make a mark as she joined the Delta Sigma Theta sorority in Midland, Michigan. Here, she was an alumna charter member and was able to emphasize work for African American Women. Greene's work ethic and intelligence never went unnoticed as she was able to balance an intense work and social life, promoting other African American women that they could be destined for greatness. Today, Greene's work and dedication continue to help motivate women and people of color to achieve their goals in STEM fields.

Greene's work primarily focused on polymer chemistry. Polymers are large molecules, sometimes called macromolecules, that are made up of smaller units called monomers. Linking these monomers together to form a

polymer is called polymerization, and is the same process by which many everyday items are now made. From the fibers in clothes, to the paint on our walls, most people see or interact with polymers every day. Much of the polymer research the Greene did focused on latex. Latex contains many natural polymers that are suspended in water, and once dry it stiffens to form a rubber-like substance that is used in products from glue to gloves. Greene used latex based polymers in order to develop a pressure-sensitive adhesive which could coat items such as paper. This became one of the bases for latex adhesive tapes.

Greene also studied colloids during her time at Dow Chemical. A colloid is a mixture of particles suspended in another substance such as smoke particles suspended in the air, or oil particles suspended in a mayonnaise. It is more common to hear about an emulsion, which is a specific type of colloid when both substances are liquids such as mayonnaise or vinaigrette. One of Greene's patents focuses on an adhesive made by a process called emulsion polymerization which involves a suspension of the monomers into water, and then a polymerization reaction which binds the monomers to the final polymer.

Greene had also worked on how to properly determine the size of particles within an emulsion. Her doctoral thesis focused on using light scattering to determine the size of these particles in the emulsion. When light is shone through an emulsion, some of the light will hit the particles that are suspended within. This light will 'scatter'

or reflect to another direction. By measuring the amount of light that passed through the solution, Greene was able to estimate the size of particles within an emulsion. This technique is still used to this day to determine particle sizes.

Greene was able to overcome an immense amount of hardship in her life, and a majority of her education took place during segregation in the United States. Despite this, Greene achieved a Ph.D. as an African-American woman, and also was able to make her excellence seen, and by the time she retired she had pushed the world to better understand the variety and usefulness of polymer science in the everyday world.

AHMED HASSAN ZEWAİL

John Kaiser; Alex Meier; Mckenzy Chu; Abby Rickman; Anna Scarpaci; Raegan Stiger; Maclaine Spears; and Shuai Sun



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Ahmed Hassan Zewail was born in 1946 in Damanhur, Egypt. Growing up in Alexandria, Ahmed was the only

son among three girls. His father worked in the government while his mother was a stay-at-home mom. As a child, Ahmed naturally gravitated towards physical sciences, especially math, engineering, and chemistry. When choosing where to go for his secondary education, Ahmed was pushed heavily by his parents to study abroad. Despite this, Ackman decided to study in Egypt for his college.

During Zewail's childhood, the 23 July Revolution took place, culminating in the ousting of the Egyptian monarchy. The revolutionaries that spearheaded this revolution were mainly concerned with decolonization and modernizing politics in Northern Africa and the Middle East. The 23 July Revolution would establish Gamal Nasser as president of Egypt. Under Nasser's rule, a new standardized test was created that modernized Egyptian education. One aspect of this education reform was the Thanaweya Amma, a standardized test that any prospective college students must take. Zewail took the test, and was assigned to attend the University of Alexandria. It was here that Zewail would earn both a B.S. and M.D. degree in chemistry. Zewail successfully completed his Master's degree in a short period of time, lasting only 18 months compared to the typical two year program.

Upon completing his Master's degree, Zewail was again compelled by his professors to go abroad and study. Two of his professors, Professor El Ezaby and Professor El

Tantaway, recommended that Zewail study spectral changes of various molecules in different solvents. At first apprehensive, Zewail eventually applied to travel to the United States. Zewail's initial hesitance lied with geopolitical conflicts at the time. Nasser's reign over Egypt had led to the country siding with the Soviet Union. Many Egyptians studying abroad would therefore either go to the U.S.S.R. or to Eastern Europe for their research. Additionally, Zewail had no ties to the United States and practically no knowledge of how to assimilate. Regardless, Zewail was offered a scholarship by the University of Pennsylvania and a stipend, both of which would allow him to complete his studies.

As a foreigner, Zewail found it difficult to become accustomed to the social structure and language of the United States. This was especially difficult when he was trying to form friendships. A lot of communication between individuals, such as humor and flow of conversation, is language and culture-specific. Despite this, Zewail was enamored by the new knowledge he was acquiring, as well as the new culture that he was being exposed to.

After finishing his PhD, Zewail ruminated on whether he should return to Egypt or stay in the U.S. to become a professor. Ultimately, Zewail decided that the U.S. was a better option because of the better resources and academic freedom that he could have. Although Zewail decided to

stay in the U.S., he still held very strong pride in his Egyptian ethnicity.

With his decision to stay in the United States, Zewail ended up taking a position at Berkley. He found that he could connect with many of his peers through a shared love of science. One of these peers was Charles Harris, who would offer Zewail an IBM fellowship. However, Zewail was more interested in an assistant professorship at Caltech. Zewail would become a Professor, and would continue the rest of his academic career there. Zewail's work at Caltech would earn him a Nobel Prize in 1999. This served as a realization of a dream he had since his childhood, as he reminisced over times when he was younger and Egyptian scientists would be recognized for their achievements.

Zewail's interests extended beyond just the chemistry lab. In addition to his chemistry work, Zewail engaged in political and social activism in Egypt. The same year he was awarded the Nobel Prize in Chemistry, he was awarded the Grand Collar of the Nile. This award was given to Egyptian citizens who had contributed to Egyptian society. Zewail is the only scientist to have received this award. In 2010, Zewail was also named as a science envoy to Muslim-majority countries throughout the world. One of Zewail's books *Reflections on World Affairs, Peace, and Politics*, looked at the connections between Egypt, the U.S., and the role of science on global affairs. During the 2011 Egyptian protests, Zewail also

served as a communications envoy between the military state and revolutionary groups that were protesting the brutality of the government. Zewail would pass in 2016 at the age of 70, survived by his wife and four kids. A national funeral, attended by the Egyptian President, Prime Minister, and many very important Egyptian officials and Muslim leaders, was held in Cairo.

Ahmed Zewail was a pioneer in the field of femtochemistry. While Zewail received many accolades throughout his career, this is most evident by his Nobel prize. Ahmed Zewail was the first Egyptian/Arab man to win The Nobel Prize in Chemistry. His research changed the world in the way that we now understand chemical reactions. Ahmed's research used laser technology to snapshot the exact moment in which the chemical reaction occurred. He used a technique of rapid ultrafast lasers to be able to determine that it is possible to map out chemical reactions. Zewail was able to study the bonds and formations of these chemical reactions in detail. Later he designed a four-dimensional ultrafast electron microscope, this helped to visualize how complex chemical reactions are. The microscope showed the physical and chemical changes between the chemical reactions.

In his career, Zewail was a chemist, professor, and advisor to the United States. After he earned his PhD from Berkeley, Zewail became a professor at the California Institute of Technology. Zewail's main focus in research

was femtochemistry, his main research is what made him known around the world today. His research group in CalTech was designing and constructing instruments to view chemical reactions. In 2009, he served was appointed to the Advisory Science Council to The United States under the administration of former President Barack Obama. While he served in the advisory council, he raised awareness of the need to invest in fundamental research of science and mathematics. He believed that this initial investment would help economic development but provide political stability in The United States. He is the reason that Barack Obama started a new program of Science Envoys specifically for the United States and Muslims.

Although Zewail was widely successful, his work primarily involved femtochemistry. Femtochemistry studies the area of physical chemistry that looks over chemical reactions in a short timescale. This is an important contribution to chemistry because it explains why chemical reactions react in the way that they do. Zewail became known as the “father of femtochemistry” due to how much he progressed the field. Zewail used laser technology as a method to capture chemical reactions. These lasers used sub- angstrom (1×10^{-10} m) resolution to capture the chemical reactions as they were happening. This allowed Zewail to view transition states and intermediates occurring within a reaction. A transition state is a period in a reaction where bonds are between formed and broken.

This state is incredibly unstable and so passes very quickly. An intermediate occurs when a reaction has more than one step. The chemical bonds between intermediates are still fully formed, but intermediates are less stable than the final product, and so also are short lived. These interactions between molecules are called elementary steps which are the simplest steps that can occur, and there are multiple types. A unimolecular step occurs when the reactant is only one molecule, there are also bimolecular processes (two molecules) and trimolecular processes (three molecules). Since femtochemistry is looking at such small amounts of sample and such small timescales, generally elementary processes are observed. The first reaction characterized by Zewail, the decay of ICN, is a unimolecular reaction that was characterized with a timescale of 40 femtoseconds.

In order to study such fast reactions, Zewail needed to be able to look at very small timeframes. Similar to slow motion in movies and sports, Zewail used lasers to look at the changes in molecules every few femtoseconds (1×10^{-15} s). This was performed using a technique called pump-probe spectroscopy. In this experiment a high-energy laser is used to excite electrons to a higher energy level, and a lower-energy laser is followed soon after to monitor any changes occurring in the sample. This allows for humans to be able to “see” on the femtosecond timescale as each of these laser pulses can act like a frame in a movie.

Ahmed Zewail has forever changed the way the world

understands chemical reactions. Ahmed Hassan Zewail's discovery of femtochemistry sparked not just interest, but an entire new field of chemistry. His expertise was not just noted by his peers and he was even appointed as an advisor to the president due to his prestigious work.

6

ROSALIND ELSIE FRANKLIN

John Kaiser; Alex Meier; Liz Collins; Jacob Parker; Angel Singhal; and Shuai Sun



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<https://opentext.ku.edu/deichemistry/?p=41#h5p-6>

Rosalind Elsie Franklin was born in London on July 25th, 1920. As a child, she attended St. Paul's School for Girls, where she showed an aptitude for science, language,

and mathematics. After graduating in 1938, she attended Newnham College, where she acquired a bachelor's degree in physical chemistry and met her close friend Adrienne Weill.

After finishing her undergraduate degree, Franklin began working as a researcher for the British Coal Utilization Research Association (BCURA). While working at BCURA, Franklin researched the relationship between the microstructures of coal and the permeability of coal. She graduated from Cambridge in 1945 with a Ph.D., having already successfully published five articles. By the end of World War II, Franklin's friend Weill introduced her to Jacques Mering, a scientist specializing in X-ray diffraction. Mering later hired Franklin to work with him at the Laboratoire Central des Services Chimique de l'Etat in Paris in Paris, where he taught her the process of x-ray diffraction analysis in which she became quite skilled.

In 1950 she earned a three-year Turner and Newall Fellowship at King's College in England, working for John T. Randall's lab. While there, Franklin was tasked by Randall to investigate DNA structures utilizing X-ray diffraction. As a result of her x-ray diffraction on the DNA samples, Franklin discovered that DNA structures had both a "wet" and dry" state which produced very different results from each other. Initially, Franklin could only hypothesize that the "wet" state shared a helical structure with the "dry" state, but she eventually confirmed that

both were helical. However, her identity as a Jewish woman made her feel unwelcome as Christian men at King's College constantly surrounded her. Thus, Franklin ultimately decided to abandon her work and relocated to Birkbeck College instead, where she analyzed the structure of the tobacco mosaic Virus.

In the fall of 1956, Franklin was diagnosed with ovarian cancer; while not undergoing surgeries or a period of remission, she continued to work in her lab at Birkbeck. Sadly, Rosalind Elsie Franklin died from ovarian cancer on April 16th, 1958, at the young age of thirty-eight.

One unfortunate aspect of Franklin's story is the fact that it was her work that ultimately led to the discovery of the helical nature of DNA. However, Franklin's role in discovering the double-helical nature of DNA was not revealed until long after her death. The reason for the suppression of Franklin's role in the discovery of the nature of DNA is commonly attributed to her status as a Jewish woman, as her work would long be ignored in favor of the contributions made by two cisgender heterosexual white men. In January of 1953, Francis Crick and James Watson were shown Franklin's "Photograph 5f" by Maurice Wilkins. Crick and Watson were also shown a copy of the Medical Researcher's Report by Max Perutz, which contained a summary of Franklin's work at King's College. This allowed Crick and Watson to "discover" the double-helical shape of DNA. However, they failed to credit Franklin, who took the X-ray diffraction

photograph when they wrote their paper. Watson, Crick, and Wilkins would eventually receive the 1962 Nobel Prize for Physiology or Medicine. However, none of them mentioned Franklin's enormous contributions to this research. Franklin's Double Helix contributions would only become public knowledge after Watson included her in his 1968 memoir in which he would defame her; this libel caused Franklin's friend Anne Sayer to publish a rebuttal to Double Helix, in which she revealed the importance of Franklin's contributions.

Franklin specialized in X-ray crystallography and X-ray diffraction. By shining X-rays through a sample of a compound, the light diffracts, leading to what looks like spots of darkness on the detector. By determining the pattern and distance between these spots it is possible to calculate the position of every atom within a given sample. This is how Franklin was able to determine the structure of DNA as well as study RNA and the poliovirus. The X-rays used for X-ray crystallography have extremely short wavelength, approximately 0.1 nm, which means that the light is extremely high energy. In modern day experiments, the most effective way to generate X-rays of sufficient energy is by use of a synchrotron, massive buildings that are miles across in order to increase the energy and abundance of X-rays for crystallography. Franklin did most of her work at both King's College London, and later Birkbeck college was performed with a

single X-ray tube, which makes the data she acquired all the more impressive.

Franklin's most well-known work is her determination of the double helix structure of DNA, however, due to her expertise in X-Ray work, she made other incredible discoveries as well. After moving to Birkbeck college, Franklin started her research on viruses. She used the same X-ray diffraction skills to determine the Tobacco Mosaic Virus (TMV) structure, which targeted plants and destroyed tobacco crops. Using these diffraction images, other scientists were then able to figure out the genetic code and finally experience breakthroughs in treatments after decades of only knowing the miniscule size of the virus. With the structure of TMV figured out, Franklin would then study other plant-related viruses and help provide essential information for viruses that targeted critical agricultural crops such as potatoes, peas, and tomatoes.

In 1957, Franklin started researching the poliovirus, which was structurally similar to one of the mosaic viruses that Franklin had studied earlier. One year after her death, her collaborators published the paper on the poliovirus structure and dedicated the paper to her memory. Aside from her research, Franklin was also an essential player

on the global stage of scientific research. Her love for traveling and making connections with other scientists around the globe helped connect researchers in the early days of virus research, making the findings and communications much more available.

Franklin was one of the preeminent researchers in X-ray crystallography, and the field has since become one of the most powerful techniques to determine structures of any biological systems such as protein, DNA, RNA, and viruses. Although at the time her work was hidden, and she died at a young age due to cancer, her work paved the way for many to follow.

YOUYOU TU

John Kaiser; Alex Meier; Thanh Nguyen;
Anaya Parikh; Varun Udayar; and Shuai Sun



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<https://opentext.ku.edu/deichemistry/?p=46#h5p-8>

Youyou Tu is a preeminent malariologist, famous for her discovery of artemisinin. Born in the city of Ningbo, a city on the east coast of China, Ningbo grew up with her

father, mother, and four brothers. Tu's family highly valued education, and she would attend several prestigious schools over the course of her schooling. At one point during her early education, Tu would contract tuberculosis, forcing her to take several years off from her studies. Inspired rather than dissuaded by this bout of illness, Tu became determined to pursue a career in medicine. Tu would eventually be accepted into the medical school at Peking University, and graduated with a pharmacology degree in 1955. She would then go on to attain a research position at the China Academy of Medical Sciences, an academy centered around the research and development of Chinese medicines.

Having completed a training program in Chinese medicine, complete with a Western-based medical background, Tu aimed to develop treatments that applied both styles of medicine. Tu's model was not without its criticism – it drew the ire of people who saw Chinese and Western medicine as two separate and exclusive entities. Tu, however, believed that the two systems could complement each other. This unique fusion of medical tradition was revolutionary at the time. For older generations more skeptical of modern medical developments, the traditionalist approach provided the familiarity essential for a patient's trust and amenability. Having developed her novel traditional Chinese–Western fusion model of medicine, Tu began to her medical research career. In particular, Tu's research focused on

phytochemistry (applied plant chemistry) and how the processing of various herbs could be used for treatment and to alter their function.

Just as Tu's career began taking off, the Chinese Cultural Revolution began. Launched under the authoritarian rule of Mao Zedong, this Cultural Revolution sought to restore Communist and socialist ideologies as the hegemonic structure of the People's Republic of China. This movement made a point of targeting groups that deviated from the Communist and Maoist beliefs, collectively referred to them as "Stinking Old Ninths". These included anti-Marxists, right-winged ideologists, and intellectuals. Since capitalism hadn't firmly rooted itself in China, the Cultural Revolution also targeted landlords and rich agrarians, attempting to steal back their lands and put them under state control.

The impact of China's Cultural Revolution led to the widespread closure of schools and educational institutions. Tu was forced to hide her research, as its Western influence potentially made her a target of fervent Maoists. Although scientific research in China was halted, military research continue. In particular, work into infectious disease and warfare-based medical advancements were developing at an unprecedented rate. One particular health problem facing East Asia at the time was the rise of chloroquine-resistant malaria, which was sweeping across many populations during the Vietnam War.

To combat this, the Chinese government funded projects aimed at finding treatment and cures against these particular strains of malaria. In 1969, Tu was appointed head scientist for Project 523. The goal of this project was to create an antimalarial drug based in traditional Chinese medicines. Thousands of compounds had already been screened, but none had been identified as possible cures. Tu fully invested herself in this project. However, Tu's participation had a huge impact on her personal life. She was forced to prioritize research over family. Despite her efforts to find a cure, Tu's family was targeted by the government. While continuing to run Project 523, Tu would see her husband detained and sent to a labor camp for "re-education".

Despite multiple adversities, Tu's commitment to the project and her research was unwavering. She and her team scoured traditional Chinese medical treatments, collecting thousands of herbal, animal, and mineral prescriptions, in their search for viable candidates for an antimalarial drug. They tested the substances on the rodent malaria parasite *Plasmodium berghei*. This approach of *in vivo* rodent research was effective in modeling human malaria due to "genetic and physiological similarities between the species"⁸. After numerous trials and errors with extractions from different plants, Tu discovered how applying the general chemistry concepts of solubility and boiling points could allow one specific plant to achieve near 100% antimalarial inhibition.

Upon re-analyzing Chinese medical literature, Tu found that Qinghao or sweet wormwood (*Artemisia annua*), an herb in the *Artemisia* family, showed effective but inconsistent results in alleviating malaria symptoms (see Figure 3). *Artemisia annua* had been used as a remedy for some malaria symptoms for millennia, and had traditionally been used as a tea. Tu followed this by extracting the leaves of *Artemisia annua* in boiling water. The extract showed efficacy towards inhibition of malaria, but the extract was not consistent, and the amount of inhibition varied between samples. Tu found a reference to the use of *Artemisia annua* from a philosopher named Ge Hong wherein the *Artemisia annua* was simply submerged in water without heating. Because of this, Tu thought that the heat might be destroying any active compounds within the *Artemisia annua*, and after performing the solid-liquid extraction at a lower temperature, her hypothesis was confirmed. Tu performed the extraction at lower temperatures and also changed the solvent to a compound called diethyl ether. This not only boils at a lower temperature, but also Artemisinin has higher solubility in diethyl ether than in water. This is because Artemisinin is only moderately polar. It contains several hydrophilic (water-loving) areas, but also contains hydrophobic (water-fearing) areas. The extract in diethyl ether showed nearly 100% inhibition for the rodent malaria parasite that Tu had been using as a model.

When discussing inhibition, most often it is used to

mean the inhibition of enzymes. Enzymes convert substrate into products as shown in Figure 3. An enzyme will bind to a substrate and through a chemical reaction will convert it to the product. Inhibitors can interrupt this process in three different ways. The first is called competitive inhibition. In competitive inhibition, the inhibitor and the substrate bind to the same location in the enzyme, and they directly compete to try and bind. This reduces the total amount of substrate that can bind and so it increases the amount of substrate required. However, competitive inhibition is not favored for medicines as it is very reliant on the concentration of the inhibitor as well. The second type of inhibition is called non-competitive inhibition. In this type of inhibition, the inhibitor binds to a different part of the enzyme and once the inhibitor is bound to the protein, the substrate cannot bind anymore. This reduces the speed at which the enzyme can convert substrate to product. The final type of inhibition is called uncompetitive inhibition. In uncompetitive inhibition the inhibitor only binds to the enzyme while the substrate is bound. This slows the speed of the conversion of substrate to product and also requires more substrate. In modern medicine, derivatives of Artemisinin are used to treat malaria, and they can comprise all three types of inhibition.

After creating a sample that showed near full inhibition of malaria samples, the next step was to evaluate the safety of Artemisinin before use in a clinical trial but there were

debates about the results from the animal trials and whether the compound would be safe for humans or not.

With very little time before the end of the malaria season, Tu and two others from the lab volunteered to test the compound on themselves. This vastly expedited the process, and the first full-scale clinical trials were able to be held that same year.

While Tu did find a cure for malaria in the 1970s, it was not until decades after that she was truly recognized for her work. Before being awarded the Nobel Prize in Physiology or Medicine in 2015 as the first Chinese woman, Tu was “completely forgotten by the people” before this point.¹ She is said to be regarded as the professor of three no’s—no postgraduate degree, no study abroad experience, and no member status of Chinese national academies. It is astonishing to see that despite her evident contributions, her title remained “the professor of three no’s.”

Today, artemisinin and artemisinin-based combination therapies are the main treatment against chloroquine-resistant malaria, further affirming the significant and lasting contributions Youyou Tu has made to the fields of chemistry, biology, public health and the military. Tu was a visionary whose work not only contributed to the malaria crisis in the 1970s but also to global health crises around the world today.

GERTY THERESA CORI

John Kaiser; Alex Meier; Hannah Darron;
Charitha Lakkireddy; Heaven Getahun;
Siwar Abu-Saymeh; Sophia Hill; and Shuai
Sun



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online here:

<https://opentext.ku.edu/deichemistry/?p=52#h5p-9>

Gerty Theresa Cori was born on August 15, 1896, in

Prague. She came from a Jewish family and her father was the chemist Otto Radnitz. Influenced by her father's passion in the sciences, as well as her uncle, who was a professor of pediatrics, Cori decided to pursue medicine. However, Cori's aspirations wouldn't be met without tribulation. Given the time period and her being a woman, Cori wasn't academically prepared to attend medical school. At the time, she had only received an education through home tutoring and had graduated from a girl's finishing school. To compensate for this she had to spend two years making up her academic shortcomings in a concentrated study. This allowed her to matriculate into the medical school of the German university in Prague at 18 years old. She was one of the few women to enter into this program. During her first year, she met Carl Cori, who would eventually become her husband and scientific collaborator. World War I interrupted her medical education, forcing her to spend the following two years as a medical school assistant. Despite this, she was able to earn her medical degree.

After receiving their medical degrees, the Coris married and moved to Vienna to begin their careers. Carl received an opportunity to work at the University of Vienna's medical clinic and Pharmacological Institute. Despite having the same qualifications as her husband, Gerty would only work at the Karolinen Children's hospital because she was a woman. In 1922, the Coris immigrated to the United States, citing widespread

antisemitism as their motivation to leave. Gerty was a Jewish woman who had converted to Catholicism upon marrying Carl in order to appease his family, but her identity would continue to make her a target. Again, like what happened in Vienna, although Gerty had the same background as her husband, she was forced into a lower-level job as an assistant pathologist. The continuing trend of gender discrimination would continue into their next job, when the Cori's moved to Washington University in St. Louis. In 1931, Gerty was given a research assistantship there at a nominal salary in contrast to Carl being given a chairmanship at the Pharmacology Department in the same year. In 1936, Gerty gave birth to son, Thomas Carl. While they maintained their university careers, Gerty and Carl collaborated together for their research. Between 1922 and 1931, the Cori's published close to 80 research papers. During this time of collaborative research, the Cori's were able to identify an important biochemical process that would be named after them – the Cori Cycle.

The discovery of the Cori cycle, and the proliferative nature of the Cori's research efforts led to Gerty being promoted to a full professor. The Cori Cycle also led to a far better understanding of, and the treatment for, diabetes. The discovery of the Cori Cycle won the Cori's the Nobel Prize in Physiology or Medicine in 1947. With this, Gerty became the third woman to win a Nobel Prize in Science, and the first American woman to do so.

Despite this huge milestones, the Cori's would soon be

faced with tragedy. The same year that she was awarded the Nobel Prize, Gerty was diagnosed with myelosclerosis, a cancer of the bone marrow. Cori passed away on October 26, 1957, when she was only 61 years old. Cori's Jewish identity played a defining part in her life. Stemming from the unbridled antisemitism in Europe, she had to immigrate to the United States. Cori also faced major setbacks due to her being a woman. Gerty rarely received the same opportunities as her husband, despite being just as qualified as him. She had difficulty in finding work, and was compensated much less whenever she did secure a job. She was also excluded from much of the recognition for the work that she pioneered. Despite their work being a collaborative effort, Gerty wasn't elected to the National Academy of Science for an entire eight years before her husband was.

Cori's Nobel Prize was due to her work discovering the Cori cycle. This cycle describes how energy is produced from glucose anaerobically (without Oxygen). Many students in biochemistry classes still learn about the Cori cycle along with the Krebs cycle, which is the process of generating ATP which we use for energy aerobically, or in the presence of Oxygen. What makes Cori's work even more impressive is that the Cori cycle was formulated in 1929, 8 years before the Krebs cycle was discovered. Cori was the first scientist to document the formation of ATP by determining the cycles used within our body.

Another interesting point of the Cori cycle is that the

cycle is reversible. When energy is needed in the muscle, glucose is brought to muscles from the liver, which is broken down into Adenosine triphosphate, or ATP, and lactic acid in a process called glycolysis. This provides energy quickly, and so is the primary method of energy creation when performing anaerobic exercises such as weightlifting. It was also originally thought that the buildup of lactic acid in muscles is what caused muscle soreness, but this has since been proven to be incorrect, and the prevailing theory is that micro-tears in the muscle account for the soreness. It was shown that lactic acid buildup could not be responsible for muscle soreness, because the lactic acid created from the Cori cycle was transported back to the liver, where the cycle would work in reverse. The liver would take lactic acid and use energy to regenerate glucose molecules that could be stored for later energy in a process called gluconeogenesis which completes the cycle.

The glucose that is created within the liver by gluconeogenesis is stored as glycogen, which is a long string of connected glucose molecules. However, in some people, this storage can be problematic. In some people, formation of glycogen is not performed correctly, and in some, glycogen is not broken down correctly. Cori also studied these cases of glycogen storage disease, which is now also called Cori disease. Cori discovered four different forms of glycogen storage disease and managed to tie each form to a defect in a specific enzyme. Cori was

the first person who was able to link defects in a specific enzyme to a genetic disorder within humans. Thanks to her work we have now identified 14 different types of glycogen storage disease, and almost all are treatable.

Gerty Cori's work on glycogen and glucose greatly changed our understanding not only of how energy is produced in humans, but also the problems that can occur within the process. Her work was largely overshadowed by her husband during her time alive, but later in her life and after her death, her work was recognized for what it was. The Cori cycle has been proven to be true, and is still taught to undergraduate students to understand how we generate energy without the benefit of oxygen, and Cori's work with glycogen storage disease has helped us not only treat those individuals, but also taught us that defects in enzymes are the major cause of human genetic disorders. Now, studies into genetic disorders and mutated enzymes is an entire field of medicine. Cori's diagnosis with myelosclerosis was not even enough to stop her, and Cori continued her work until the last few months of her life. Her advancements in the understanding of human metabolic pathways are unmatched to this day.

John Kaiser

When I think about what DEI means to me, I've always seen it inherently rooted in the ethos of intersectionality. Everyone is positioned at a unique place in social space. Your views and relationships to politics, gender, religion, sexuality, class, and science afford you a specific place in the world. It not only affects how much agency you have to exercise your ambitions and will, but also how you see the world. One of the team's main goals was to have students research more about this for minority chemists – to have the students not only learn about the chemist's scientific contributions, but also how their backgrounds and histories helped them make these discoveries. That's why the unique experiences of minority chemists are so important.

With this project, our team set out to revel in the pioneering success of these chemists, but also to investigate how each of these chemists rose to overcome the distinct challenges and obstacles that faced them. Science doesn't happen in a vacuum: it's an institution

baked into the fabric of society. From academia and education to the medication and discoveries that better your life, science affects the way we view, learn, and harness knowledge. Yet science is also susceptible to prejudice, bias, and discrimination. This is where the power of sociology can help us learn more about the natural sciences.

In reading through the biographies created by the students, it's clear that many recognized the struggles facing minority chemists within science. Many of these chemists faced the aforementioned prejudice, bias, and discrimination. Students were able to pick up on these dynamics, showcasing that we can be cognizant of these social forces when awareness is brought to them. My analyses simply added an additional sociological element to concepts that were either alluded to or implied.

During the project, I collected survey and interview data from the students to learn about their experiences in creating these biographies. Many students, particularly those from marginalized or minority backgrounds, found the project really resonating. Since the minority chemists were chosen by the students, many empathized with the chemists' stories. The struggles brought on by distinctions in class, race, and gender rung a little too true.

Throughout this book, we've tried to focus not only on the scientific discoveries of the chemists but also on the experiences that positioned the chemists to make their discoveries. Inherent obstacles that were purposefully

baked into the institutions of chemistry have posed innumerable problems to aspirant chemists from various backgrounds. The minority chemists that you've read about in this book overcame these problems and found solutions. They made discoveries when others (including those from more privileged backgrounds) couldn't. The importance of DEI comes from the ability to revel in these different viewpoints – to build solidarity in spaces where only a few limited worldviews had been allowed to flourish.

It's likely that you've heard about DEI before. You will also probably continue to hear about it in places far beyond this classroom. However, as the ideas of DEI continue to become more ubiquitous, they've also come under attack. But without such clearly identifiable incentives and analyses related to the dispersion of social power, privilege would continue to be largely limited to very specific groups of people. As powerful or compelling as the stories of the chemists that you've read in this book have been, the world of chemistry has largely been limited to a Eurocentric worldview. As interdisciplinary work continues to happen where chemistry, education, and the social sciences intersect, hopefully this can be curtailed.

Whether it's successfully completing a chemistry assignment, studying for a standardized test, or just to learn more about minority chemists, I hope you've gotten something out of reading this book. At the same time, I hope this book has given you insight into the importance

ALEX MEIER

of different worldviews and the value that minority voices can give. I hope that you've seen the importance of DEI in chemistry.