

MIT EJ-UROP Summer of 2023

Prof. Bevin P. Engelward (Biological Engineering)

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UROPs: Summer ELO



Proposal:

An Experiential Learning Opportunity that leverages ongoing research to provide hands-on laboratory experiences, as well as additional experiences, to create an impactful opportunity for MIT undergraduates that we believe will permanently shape their career.

Students who participate in this program will:

- Gain a deeper understanding of environmental justice
- Have a heightened sense of social responsibility
- Be exposed to real-world opportunities for tackling challenges associated with environmental justice
- Learn by engaging with community members in impacted communities
- See first-hand how their research can make a meaningful difference to real-world problems

Student Experience:

- Hands-on research in an MIT laboratory that focuses on public health and environmental health related research
- Journaling: reflect on lab experiences
- Experiential learning enhanced by:
 - Workshops
 - Interactive discussions
 - Hands-on water collection in collaboration with community members
 - Interview/learn from leaders in the public health arena
- Mentored by a GS or PD from lab, as well as their faculty advisor



June 5 –
July 28
2023

Questions?

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We created an Experiential Learning Opportunity that leveraged ongoing MIT research to provide hands-on laboratory experiences.

Students also benefited from a myriad of additional experiences that created an impactful opportunity for MIT undergraduates.

Feedback from students show both quantitatively and qualitatively that the program has had a significant impact on the following:

- understanding of environmental justice
- research skills
- knowledge of public health organizations and their impact
- career development
- wellness
- awareness of the experiences of community members impacted by hazardous chemicals

Students gained a heightened sense of responsibility, and they were exposed to real world opportunities for tackling challenges associated with environmental justice.

UROP Students

Lillian Bluestein



Sanjana Mupparaju



Matilda Swanson



Safiyyah Ogundipe



Michelle Wang



Jad Abou Ali



Evan Kowal



Kyra Shutt

Graduate Student and Postdoc Mentors



Chyna Mays



Aimee Moise



Lee Pribyl



Melanie Gut



Alec Agee



Sohyun Park



Barath Baskaran



UROPS from left to right: Michelle Wang, Lillian Bluestein, Jad Abou Ali, Matilda Swanson, Evan Kowal, Kyra Shutt, Safiyyah Ogundipe, Sanju Mupparaju. Dr. Bevin Engelward (center).



At the field trip, students gather in a public building to learn about the region that was contaminated. Dr. Kathy Vandiver (Community Engagement Leader) and Martha Stevenson (Community Member) share a map showing the extent of the contamination.



Field Trip to see from a distance the region of Wilmington that is heavily contaminated with a carcinogen.
Suzanne Sullivan (green shirt) is explaining the history of the site.



Students learn about the contaminated site from Martha Stevenson (community member).



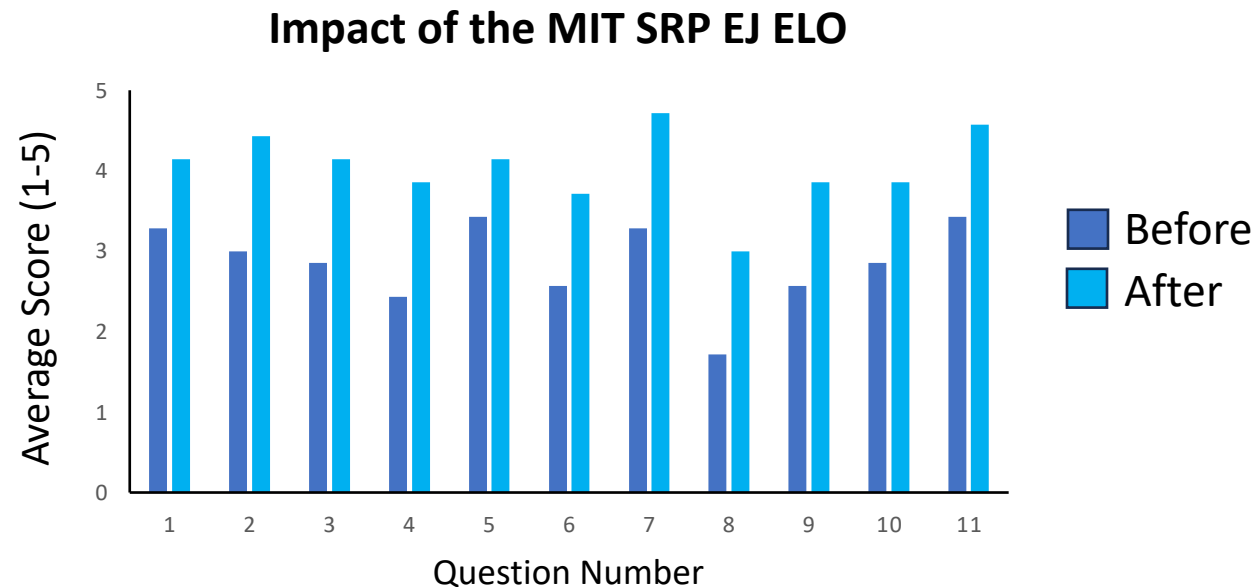
The enormous region that is contaminated is contained under black plastic and surrounded by a high fence.



At the fence that surrounds the Superfund Site, Lillian Bluestein asks questions of Dr. Kathy Vandiver (Community Engagement Leader).

Feedback from UROPs Before and After the ELO

- 1) Awareness of Environmental Justice challenges and related ethical considerations.
- 2) Knowledge of how to work in a lab.
- 3) Knowledge of how to work on a team in a lab setting.
- 4) Knowledge of career options in public health.
- 5) Interest in public health.
- 6) Confidence in career path.
- 7) Knowledge of the research being done in your host laboratory.
- 8) Ability to write a primary research manuscript.
- 9) Knowledge of steps that can be taken to protect people from hazardous chemicals.
- 10) Confidence in ability to network and to benefit from mentors.
- 11) Knowledge of concrete steps that can be taken to increase happiness/wellbeing.



Graduate Student and Postdoc Mentor Feedback

Average score for all questions was rated as “*Significantly Enhanced*” for all criteria!

- 1) Awareness of Environmental Justice challenges and related ethical considerations.
- 2) Knowledge of career options in public health.
- 3) Interest in public health.
- 4) Confidence in career path.
- 5) Knowledge of concrete steps that can be taken to increase happiness/wellbeing.
- 6) Confidence in mentoring junior lab members

Workshops and Activities

1) Orientation. Students learned about the program and expectations and also about how chemicals in the environment can affect health and steps that can be done to prevent this. They specifically learned about the MIT Superfund Research Program and how this program uses a multidisciplinary approach to tackle a complex real-world problem. (June 7, 2023)

2) Visit from Community Members Affected by Contaminated Environment. Martha Stevenson and Suzanne Sullivan joined via zoom. Students learned about the history of a Superfund Site (a location with an extremely high degree of contamination) and how community members had to work hard to get steps taken to clean up the site. (June 8, 2023)

3) Strategies for Reading Papers. This workshop introduced different strategies both for how to learn from a manuscript and also how to find manuscript and organize them so that they can be referenced in future publications. (June 14, 2023)

4) Visit from Environmental Protection Agency Representative. David DeMarini, former leader in the EPA. Joined via zoom, gave a formal presentation, and participated in discussion. He shared two examples where EPA made a difference (reducing indoor air pollution and preventing skin cancer caused by tanning beds). The history of the indoor air pollution work was an important example of the need for public health officials to work toward environmental justice. (June 15, 2023)

5) Career and Degree Options Workshop. Students learn about different careers related to public health and environmental justice and they learn about the process for applying to graduate school. One key lesson-learned for students was the importance of strong letters of support. (June 21, 2023)

6) Wilmington Field Trip. Students benefited from a site visit to see a Superfund Site and learn about its consequences from community members while there. Students had the opportunity to fully appreciate the vastness of the contamination problem by looking at the site through a barbed wire fence. This trip was organized by Dr. Kathy Vandiver. (June 27, 2023)

7) Lessons Learned on the Road to Environmental Cleanup. Students learned from Community Engagement Leader Kathy Vandiver about strategies for solving problems of environmental contamination from multiple viewpoints of different stakeholder groups. Issues related to environmental justice were discussed. (June 28, 2023)

8) Happiness and Wellness. Productivity and creativity in science cannot happen without wellness. This workshop provided concrete steps that can be taken to increase happiness and wellness. Managing thoughts and meditation were discussed. (July 5, 2023)

9) Networking and Professional Development. This workshop emphasized the importance of relationship-building and active steps that one can take as a mentee. (July 12, 2023)

10) Visit by Silent Spring Representative. Dr. Jennifer Kay, former MIT postdoc, shared her work and that of her organization. Silent Spring is a not for profit organization that works on environmental justice issues. (July 13, 2023)

11) Final Presentations by UROP Students (July 26, 2023)

1) Orientation. Students learned about the program and expectations and also about how chemicals in the environment can affect health and steps that can be done to prevent this. They specifically learned about the MIT Superfund Research Program and how this program uses a multidisciplinary approach to tackle a complex real-world problem. (June 7, 2023)

Evan Kowal

“During the welcome orientation it was fascinating to hear about the other UROP students’ projects. I had been mainly thinking about the issue of NDMA contamination in terms of the physiological effects of NDMA. My own lab’s work examines how NDMA causes cancer through DNA damage and how the body repairs the damage. But this is just one part of the issue. It was extremely interesting to hear how other labs were working to build sensors to detect NDMA or building devices to destroy it. Even if my own lab finds out exactly how potent of a carcinogen NDMA is and how DNA damage plays a role in its toxicity, we would still need to be able to detect and treat contaminated water. It was a great reminder that the DNA damage side of the NDMA issue is only one facet.”

2) Visit from Community Members Affected by Contaminated Environment: Martha Stevenson and Suzanne Sullivan. Students learned about the history of a Superfund Site (a location with an extremely high degree of contamination) and how community members had to work hard to get steps taken to clean up the site. (June 8)

3) Strategies for Reading Papers. This workshop introduced different strategies both for how to learn from a manuscript and also how to find manuscript and organize them so that they can be referenced in future publications. (June 14)

Lillian Bluestein

“I learned a lot during the Reading Papers Workshop. As someone who is new to research, I find reading scientific papers very daunting. This workshop was the first time that I was formally instructed about how to read a paper. It was informative to learn about different ways people read papers, from chronological reading to just looking at the figures. I learned that it is not always necessary to read the whole paper. When reading a paper, it is important to identify what you hope to acquire from reading this paper. Then, you can determine what sections are necessary for you to read. I also enjoyed our discussion of whether doing community-oriented research increases bias in scientific findings, as avoiding bias when doing research is a very important ethical priority.”

Safiyyah Ogundipe

“The workshop on interpreting and publishing papers with Prof. Plata was quite interesting. It was helpful to think about the different ways to approach reading papers. When Prof. Plata mentioned the "album" vs. "single" style of reading, I realized that I have used both styles for different reasons. When I'm still in the early phases of learning a new topic and want to get a sense of what's out there, I tend to attempt to read a paper from the beginning. In contrast, last summer while working on a project, I was working on creating a mathematical model, so I would hop to the results and figures first because actual data was more important (then I would look at the methods, etc and make sure the conditions used disqualified the data from use in the model). I also took 7.003 this past semester, and the paper-drafting portion was one of the more challenging parts for me. I learned a lot about how to make my writing more succinct and clear, but I know I still have room for improvement.”

4) Visit from EPA Representative: David DeMarini. He shared two examples where EPA made a difference (reducing indoor air pollution and preventing skin cancer caused by tanning beds). The history of the indoor air pollution work was an important example of the need for public health officials to work toward environmental justice. (June 15, 2023)

Lillian Bluestein

“My biggest takeaway from David DeMarini’s talk is that scientific research is not adequate on its own for addressing public health issues; informing legislators and industrial leaders is necessary to ensure that issues discovered in scientific research are addressed via policy and industry changes. As someone who has interned the policy sphere before and hopes to further engage with this sector in the future, this talk was especially interesting for me, as it provided greater context for the role of regulatory bodies in addressing public health issues.”

Jad Abou Ali

“Learning about the work that David’s team did was very interesting. I was shocked by all the results that they collected, especially the study they did on tanning beds. I can relate to that the most as I know a lot of people, including two of my cousins, who use tanning beds every summer, unaware of all the health risks associated with that. I did not know how they worked, but after the meeting I was able to understand why it is bad for people’s health.”

5) Career and Degree Options Workshop.
Students learn about different careers related to public health and environmental justice and they learn about the process for applying to graduate school. One key lesson-learned for students was the importance of strong letters of support. (June 21, 2023)

Kyra Shutt

“This workshop made me think more critically about what I want to do after graduation. I knew I wanted to further my education by pursuing a higher degree, but I did not have plans beyond that. Discussing the pros and cons of a Master’s program vs a Doctoral program was very enlightening. Further, I did not know what exactly was required in an application package before this. Now I know I need to really focus on building relationships to get a strong letter of recommendation and otherwise continue to build my resume while maintaining good grades.”

Michelle Wang

“It was very nice to also have the mentors here at the workshop. I found it very informative to have our questions answered by graduate students who are currently experiencing graduate school and have recently experienced some of the questions and fears we have about continuing to graduate school. I learned a lot about different options of graduate school and now knowing that gap years are common and helpful, it has relieved some stress. While I still have a couple years of undergrad, it is helpful to start thinking about graduate school and what I would like to do.”

6) Wilmington Field Trip: Site visit to see a Superfund Site and learn about its consequences from community members. Students had the opportunity to fully appreciate the vastness of the contamination problem by looking at the site through a barbed wire fence. (June 27)

Lillian Bluestein

“The Wilmington site visit was a very educational and enjoyable experience. Seeing the superfund site that has been discussed in this environmental justice program was very enlightening; it was interesting to see the various water sources in the town, as well as the major contamination site. I saw that the major contamination site was contained with a tarp-like material.

I also enjoyed talking with the community leaders in this environmental project. Learning about their experiences advocating for their town’s public health was very interesting to me. As someone who comes from a town that has somewhat similar water-based pollution problems, I found very valuable to hear about their efforts in raising this concern, as well the steps that they took to address this problem. They explained that regulatory bodies in the area were not quick to recognize the water problem in their town; this was likely due to industrial and monetary forces involved in the political decision-making. Learning this was very concerning, as it further emphasized ethical issues with regulatory bodies.”

Matilda Swanson

“I found the Wilmington fieldtrip to be incredibly informative. I was able to learn so much more about the superfund program and Wilmington in general which was amazing, and I think will really help me motivate my research. I also feel like I was given a new window into the ethics of the situation. The women in the town had to put a lot of work in to get anything done. They were amazing for this, but it was also lucky. These women had the resources to take the time away from any jobs and family time to work on this problem. In many communities, people would not have the resources to stop working or stop taking care of their kids. It makes me worry for the communities where people do not have the resources to do this kind of work. It's important to consider while we go forward to make sure we try to pay equal attention to communities who can't advocate for themselves as to those who can.”

Kyra Shutt

“This field trip was incredibly enlightening. I was not aware of the situation in Wilmington but it was incredibly interesting to hear about and see the important areas. Learning about the reactions from the health department, certain community members, the plant owners, and others to the situation was kind of frightening. People were willing to turn a blind eye to the prevalence of children with cancer and attack the character of these women; I don’t understand how you can put profit or complacency over kid’s lives. This was generally a very eye-opening experience for me.”

7) Lessons Learned: Learning from Community Engagement Leader Kathy Vandiver about strategies for solving problems of environmental contamination from multiple viewpoints of different stakeholder groups. Issues related to environmental justice were discussed. (June 28, 2023)

Evan Kowal

“The environmental cleanup in these situations is complex for a number of factors. For one thing any situation in which chemicals are dumped into the environment are difficult due to the fact that the universe is predisposed to entropy and things disburse. Chemicals leach into the groundwater....When toxic substances are released they do not stay in the place they were initially put in, making it hard to round them up after the fact. Furthermore, large amounts of these contaminants were released for many years before it was stopped. The examples in the modules were large scale issues. Lastly, many stakeholders play a role in these cleanups, complicating things. Companies responsible want to pay as little in cleanup fees as possible. Some of the people of the surrounding areas are worried about their health. Some of the other people are worried about their town looking bad or property values going down or jobs leaving if projects are shut down....All these factors and competing stakeholders make solutions for environmental cleanup extremely complicated.”

8) Happiness and Wellness.

Productivity and creativity in science cannot happen without wellness. This workshop provided concrete steps that can be taken to increase happiness and wellness.

Managing thoughts and meditation were discussed (July 5, 2023)

Safiyyah Ogundipe

“The happiness and wellbeing workshop was very interesting. I've been thinking a lot about what I want to do after MIT; so, it was helpful to get some general advice. I think what really stuck with me was the discussion about health....I want to focus on some yoga moving forward. It's always good to be reminded of one's health.”

9) Networking and Professional Development. This workshop emphasized the importance of relationship-building and active steps that one can take as a mentee. (July 12, 2023)

Michelle Wang

“I found this workshop to be very helpful. The charts and flow charts are great exercises to do to get us thinking about people in our lives that are able to help us meet these needs either personally or professionally. I think one big issue I have is meeting new people and putting myself out there because of how shy my personality is. I feel like this hinders the purpose of networking and trying to develop relationships.”

Evan Kowal

“I thought this workshop was very interesting. I liked thinking about what person in my life filled each different mentorship role. I had never really evaluated mentorship or support in my life from a macro scale. Thinking through it for the first time I definitely have a great support network of mentors and friends around me who support me in many different aspects of my life. I’ve always been very appreciative of each of the individual people, but never thought about how lucky I am to have people who can fulfill all of these different and distinct roles. The talk also made me think about how I can be a better mentor to the people in my life. As the captain of the water polo team here at MIT and the former president of my fraternity it’s always been super important for me to mentor the younger guys in both groups as well as younger people from any other organizations or groups I’ve been a part of. Mentorship has been so important for my development and happiness and so I always want to give back. It was useful to hear about different roles I can play as a mentor that I hadn’t considered.”

10) Visit by Silent Spring Representative. Dr. Jennifer Kay, former MIT postdoc, shared her work and that of her organization. Silent Spring is a not-for-profit organization that works on environmental justice issues. (July 13, 2023)

Michelle Wang

“This workshop was led by Jenny Kay from Silent Spring Institute. It was very nice to hear her talk about the non-profit organization she works for and how she got there after doing her academics with Prof. Engleward. My favorite part of the talk would be when she talked about the app she and others developed that can tell you the dangers of product ingredients and just overall safety and accessibility to that knowledge.”

Evan Kowal

“This was one of my favorite talks during the ELO. The talk made me think a lot about how we gauge risk in our daily life. We obviously can’t prevent all exposure to carcinogens, and probable carcinogens are so common in our life. It is so hard to weigh risk versus convenience in our own lives especially when conclusive data about cancer risk is so hard to actually get. At the very least it is fantastic that people like Dr. Kay are working to help people make more informed decisions, even though (as she acknowledged) they will always be imperfect decisions. It was also interesting to think about how to balance advocacy with staying impartial as a scientist. It definitely seems unique that the Silent Spring Institute combines the two and I’m curious how they ensure that their advocacy and goal of serving their community doesn’t bias their work.”

Concluding Thoughts by Matilda Swanson

Final Summary by Matilda Swanson

Through this program I have been able to learn a great deal about environmental justice and the ways we are all impacted by public health issues. There has been a lot of benefit to being involved in the program, such as new understanding of public health issues, lab experience, and a greater appreciation for community involvement in health issues.

In the workshops from David DeMarini from the EPA and Jenny Kay from the Silent Spring institute I learned a great deal about public health issues. David DeMarini told us about some of the public health issues he had dealt with during his career, and the way these issues had been handled by the governments of the people affected by the health issues. There's a lot of benefit to knowing about this as it provides you with knowledge about what is behind government policies, which is something important to know as a voter. Jenny Kay presented on the hazards that have become common in American homes. This is also something that's been great to know as it gives me and others the opportunity to take accountability for our health and the ways we should consider health in the products we buy.

During this program I have gained a great deal of lab experience which will be of significant benefit as I move forward in my career. I have learned to stain and image slides for various targets, collect mice, perform pup checks, prepare protein for western blots, extract RNA, and prepare comet chips. I have greatly enjoyed learning all of these skills and believe they have been of great benefit to my education at MIT.

The other amazing part of this program was the engagement with superfund sites and with the members of the Wilmington community. When studying these chemicals, it is so important to consider what matters to the people who were directly affected. There was so much benefit gained from meeting with the women who had fought for Wilmington. They had to work so hard to get their community the help it needed, and it's so good to see that, and be able to know that while you study things that hope to help them down the line.

Research Activities of Students

Matilda Swanson

- Western blots – We will perform a series of western blots using liver tissues from four groups of mice. The four groups will be the mice treated with CCl₄, the mice treated with just Lr and olive oil, the mice treated with olive oil, and the mice treated with Lr and CCl₄. On the western blots we will stain for proteins marking for DNA damage responses and inflammation. This experiment will tell us the quantities of these proteins present in the liver allowing us to draw more conclusions about the differences between the four groups of mice.
- Comet chips – We will perform a series of comet chip assays to determine how much DNA damage was done by comparing the four groups of mice. We will use samples of liver tissue to extract DNA and we will treat it so that we can see all kind of damage in the form of breaks. These breaks will then make the tails of the comets longer which will show more damage. By comparing the the DNA damage across the four groups we will be able to see the effects of the CCL4 and the Lr on the mice.
- Histology image analysis – Using a time course of images of mice of different genotypes treated with NDMA or saline we will be able to analyze how the portion of cells that show proliferation and DNA damage markers changes over time.

JadAbou Ali

The research I am working on uses yeast to extract Lithium from mining water to purify the unused mining water and give it a second life (especially to underprivileged communities that do not have enough safe water availability) and to also use the Lithium extracted to create more batteries (and thus an increase in the usage of renewable energy and electric cars because there is not enough Lithium currently to solve the energy problem). It focuses on engineering yeast to be halotolerant to the uptake of Lithium. The biggest challenge of this research is finding ways to let yeast actually store Lithium inside the vacuole or just within the cell by knocking out some (or all) group 1 metals efflux channels.

Lillian Bluestein

For sensor design, the main task is to create a structure on which current produced by *Shewanella* can be detected. Taking inspiration from existing literature, the projected structure will include an electrode with cuts. *Shewanella* and an assisting carbon-based conductive material are deposited in these cuts. (*Shewanella* does not conduct current well on its own, so the carbon-based material is used to assist the cells in moving current from the anode to the cathode.) The experiments involved in creating this sensor must determine the following:

- best electrode polymer
- ideal cut depth and size for current flow
- best carbon material for current flow
- best method of depositing carbon material and *Shewanella* onto electrode
- ideal qualities of carbon and *Shewanella* to be deposited

Safiyyah Ogundipe

Current remediation methods are limited to inefficient capture. The lab's proposed technology utilizes low-energy, scaffolded whole cell-enzyme materials to move beyond simple capture to degrade these hazardous pollutants. Specifically, degradation of PFAS can occur through a radical-initiated mechanism, so efforts are being made to produce radicals in PFAS-contaminated environments using proteins expressed on the surface of genetically modified *E. coli*.

Michelle Wang

Pitcher-scale devices containing activated carbon or ion exchange technology are not efficient for NDMA removal. This premise is based off the fact that the NDMA's polar and neutral nature enables it to evade classical treatment technologies. However, recent commercially available options adopt technologies such as UV-C irradiation for disinfection that may simultaneously enable improved NDMA removal. I will evaluate the performance of commercially available filters for NDMA removal, in conjunction with aiding in the optimization of the electrochemical device.

Traditional plastic materials, especially polyesters, pose challenges due to their slow degradation rate. This is because they are highly stable compounds, which is favorable when it comes to their lifetime use, but problematic when it comes to disposal. Enzymatic degradation using esterase enzymes, such as lipases and cutinases, has emerged as a promising approach for accelerating polyester degradation. This research aims to optimize the enzymatic degradation process of polyesters using esterase enzymes and LC-HRMS spectrometry to gain valuable insights for sustainable polymer design.

To achieve that goal, we will focus on identifying lipase and cutinase enzymes that show high activity for degrading polyesters. Then, we will try to optimize enzymatic conditions using independent variables like temperature, pH, enzyme concentration, and reaction time. To analyze our results, we will use LC-HRMS (Liquid Chromatography-High-Resolution Mass Spectrometry). The LC-HRMS data will provide an insight into how the enzyme mechanistically degrades the plastic which can then allow for a better understanding of how to approach the design and development of sustainable polyesters.

Evan Kowal

We will be running many different experiments to build better detectors of DNA damage caused by nitrosamines. First off, I will be helping grow cell lines for use in our experiments, as well as check how well the cells are growing using a cell counting machine. We will be exposing our cells to different PARP inhibitors that stop single stranded breaks caused by removal of bulky adducts in the NER pathway from being repaired. This means that when our cells are exposed to the different nitrosamines we want to test, damaged DNA will be trapped in a single stranded break state, which can be seen in our comet chip. We will be testing many different types of nitrosamines that are used in industry, as well as testing different PARP inhibitors at different concentrations to see what is most effective for the assay.

We also will be using CRISPR to knock out different NER pathway proteins in our cells. We will be knocking out the XRCC1, ERCC1, and Pol Beta proteins. We will do this to try to make even more effective sensors of the DNA damage than the cells treated with PARP inhibitors. Using CRISPR requires a lot of planning and steps. I will use different software to design sgRNAs that can target our genes of interest, doing both knock outs and knock ins. The sgRNAs need to be designed so off-target effects are minimized and our genes of interest are optimally targeted.

Opportunities for Improvement going Forward

Next time:

It would be good to have more social engagements. For example, a movie hour to watch “A Civil Action.”

Having events specifically for the mentors would strengthen their experiences. Furthermore, mentors should be formally required to attend all the events.

It would be helpful if mentors provided feedback to the UROPs on their Journals.

Having all of the trainees present their work to the program leaders prior to the group presentations would be a plus.

The research experiences of the students were highly valuable and the feedback from the students shows that the workshops and activities were also of great benefit.

Overall, all of the major objectives were achieved, and the program was a great success!