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# Something Old, Something New: Lessons Learned from Pivoting an REU Site during the COVID Pandemic

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## Overview

The objective of the "BME Community of Undergraduate Research Scholars for Cancer (BME CUReS Cancer)," REU Site is to encourage future engineering/quantitative science researchers to focus on cancer-related problems by building a diverse community of undergraduate research Scholars. The National Cancer Institute (*1*) has identified barriers to achieving progress in cancer research and strategic actions needed to overcome those barriers. Our Site introduces Scholars to these key challenges in cancer research using an engineering approach (Figure 1).

**Imaging and image processing**

- Improve imaging to give clinicians better information on tumor size, shape, and growth rate.
- Combine optical imaging with interferometry to detect subtle changes in cells deep within the body.
- Determine how to measure blood flow to tumors, e.g., changes in VEGF therapy.
- Create new software algorithms to process imaging data to detect subtle changes in tumor activity.

**Biomaterials, biomolecular engineering, and drug delivery**

- Develop methods to determine how much drug is getting into the target organ/tumor.
- Develop new methods to administer drugs other than intravenously.
- Develop nanotechnology methods to overcome hydrostatic pressure that blocks delivery of drugs.
- Use nanoparticles to study cell internalization pathways to improve drug delivery.

**Multi-scale approaches to studying, modeling, and testing cancer**

- The heterogeneity of tumors and their microenvironment require quantitative measurements.
- There is not a firm understanding between stochastic and deterministic events in cancer.
- There is a gap in understanding the spatial aspects of cancer.

**Figure 1.** Scientific organizational themes of the Site.

Due to the safety risks and potential for program disruptions posed by the on-going COVID pandemic, our REU Site transitioned to a fully virtual offering for summer 2021. Figure 2 is a diagram illustrating the organization of the online REU experience into educational "vines" and research "pods." In this paper, we share our experiences in offering our REU Site online, with an emphasis on lessons learned that can benefit our Site and others post-pandemic.

A key consideration of the transition to the online format was providing didactic instruction, which we refer to as "vines," to replace the informal learning in the lab that is difficult to replicate in the online format as well as to maintain didactic instruction on topics that had been provided in person in prior offerings of the Site. For example, a strength of our Site is our extensive professional development support, with a particular emphasis on communication skills, and regular community-building activities. We leveraged the faculty experience of online teaching during the pandemic and engagement of several graduate students with complementary experience to transition our programmatic goals of professional development and community-building to the online format. We shipped experimental kits for Scholars to engage in hands-on activities at home, e.g., to learn about cell culture, microscopy and bioassays, as well as approaches that focused on computer-based activities, e.g., to learn about molecular modeling. The didactic instruction component intentionally emphasized data analysis and modeling skills that would be needed for research projects that had to be conducted at a distance and so could not rely on experimental methods.

Another important design change that was made to accommodate the online format was moving from mentoring triads to mentoring "pods." Typically, we have formed mentoring triads consisting of an undergraduate research Scholar, a graduate student mentor, and a faculty mentor. For the online offering, we first paired faculty where one typically uses experimental research methods and the other typically uses computational research methods in order to facilitate the planning of a rich set of Scholar projects that could be completed fully online. Each faculty member identified a graduate student mentor from their lab to join the mentoring pod. Then, we matched 2-3 undergraduate research Scholars with each mentoring pod. Each mentoring pod pursued one or more projects depending on the evolving interests and skills of the Scholars.

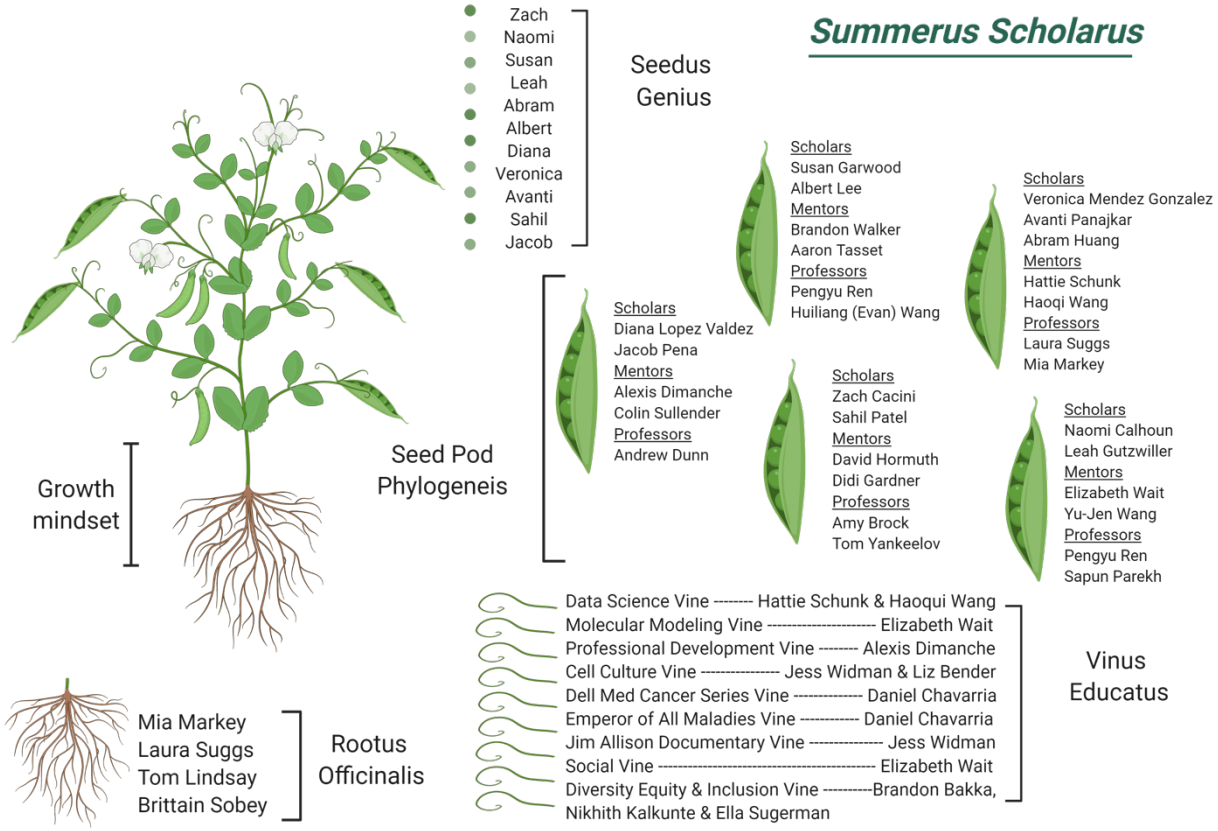


**Figure 2.** Diagram illustrating the organization of the online REU experience into educational "vines" and research "pods."

## Vines: Didactic Instruction

### Data Science Vine

*Brief Description:* Training emphasized familiarity with data science and machine learning techniques such as cluster analysis and neural networks. The experience featured hands-on experience with data mining tools such as Orange. Scholars performed mini data analysis projects in small groups under advisement of CUReS graduate student mentors.

*Lessons Learned:* Even in the online format, we observed some synergy between the research projects and the didactic instruction in data science. However, the evaluation process revealed that the Scholars suggested that the data science vine should be more interactive and connected more closely to the work being done in research pods. Moving forward, we believe those goals would be easier to achieve in person during an on-campus experience.

**Molecular Modeling Vine**

*Brief Description:* One way to categorize computational methods is as data-driven vs. physics-based. This vine familiarized Scholars with physics-based methods such as multiscale physical modeling of molecules, multi-scale biophysical models of tumor growth, and computational drug discovery. The experience featured hands-on experience with modeling tools such as TINKER FFE, guided by CUReS graduate student mentors.

*Lessons Learned:* Similar to the data science vine, we found that online instruction in molecular modeling was feasible, but that the Scholars reported in the evaluation that they had difficulty connecting it to their research projects. Again, graduate student mentors and Scholars prefer that these activities take place in-person.

**Professional Development Vine**

*Brief Description:* The professional development vine emphasized instruction in technical communication. Resources were selected and developed from several sources, including Michael Alley's *The Craft of Scientific Writing* (*2*). Scholars developed knowledge and skills necessary to (i) analyze their audience, purpose, and context; (ii) read research articles efficiently and critically; (iii) write effective research abstracts; (iv) create effective research posters; (v) engage general and expert audiences in conversations about research; and (vi) give peers constructive feedback on research communications. The Scholars read and discussed instructional materials, including examples of research abstracts; drafted, presented, and revised their own research communications; and gave, received, and applied feedback. With support from the professional development vine, the Scholars prepared abstracts for the undergraduate research poster session of the Biomedical Engineering Society (BMES) annual conference (**Figure 3**). We also helped the Scholars prepare oral presentations to accompany their posters. Students were surveyed about their levels of confidence in their ability to do science using a 22-item scale with 5 response options (1=very insecure, 2=insecure, 3=neither confident nor insecure, 4=confident, 5=very confident). Each item was tested individually pre- to post- program. While students reported an increase in each of the 22 items in the scale, the increase in 6 of these items was statistically significant after adjusting for multiple t-tests. The evaluation demonstrated significant gains in the Scholars self-assessments of their scientific writing skills: "Deal with a lack of mentor support in scientific writing" ($p < 0.001$, Pre $2.42 \pm 0.79$; Post $3.60 \pm 0.66$); "Write and submit an abstract to a scientific meeting" ($p < 0.001$, Pre $3.36 \pm 0.81$; Post $4.50 \pm 0.92$); "Write a first draft of a manuscript intended for publication by yourself" ($p < 0.05$, Pre $2.42 \pm 1.00$; Post $3.56 \pm 0.96$); "Write using correct grammar" ($p < 0.05$, Pre $4.25 \pm 0.45$; Post $4.80 \pm 0.40$); "Continue to revise a manuscript multiple times after receiving negative feedback from your mentor or reviewers" ($p < 0.001$, Pre $3.58 \pm 1.03$; Post $4.60 \pm 0.49$); and "Write

with minimal help because your skills are strong enough" ($p < 0.05$, Pre $3.17 \pm 1.03$; Post $4.00 \pm 0.77$)

*Lessons Learned:* Due to faculty experience of online teaching during the pandemic, the professional development vine was highly impactful despite the transition online for summer 2021. In future offerings of the Site, we aspire to follow up on in-person summer activities of this vine with online activities in the subsequent fall to increase value for the Scholars.

- **Albert Lee**, **Susan Garwood**, Brandon Walker, Aaron Tasset, Pengyu Ren, Huiliang Wang, "Predicting transfection rates of poly(β-amino ester) compounds via machine learning methods," presented at BMES 2021.
- **Naomi Calhoun**, **Leah Gutzwiller**, Elizabeth Wait, YuJen Wang, Pengyu Ren, Sapun Parekh, "Investigating serum albumin interactions: fatty acid complexes and fibrinogen explain abnormal clots," presented at BMES 2021.
- **Avanti Panajkar**, **Abram Huang**, **Veronica Mendez-Gonzalez**, Hattie Schunk, Haoqi Wang, Laura Suggs, Mia K. Markey, "Pattern recognition of proteases using multiplex peptoid arrays," presented at BMES 2021.
- Diana Lopez-Valdez, Samuel Mihelic, Shaun Englemann, Annie Zhou, Andrew Dunn, "Analyzing the morphology of the neurovascular network through two-photon imaging over time," presented at BMES 2021.
- **Sahil H. Patel**, **Zachary Cacini**, Andrea Gardner, Amy Brock, Thomas E. Yankeelov, David A. Hormuth II, "Image-driven modeling of cellular microenvironment habitats in a pre-clinical model of glioma," presented at *BMES 2021.*
- **Jacob Pena**, Alexis Dimanche, Andrew K. Dunn, "Improving intraoperative laser speckle contrast imaging hardware via ray optics simulations," presented at BMES 2021.

**Figure 3.** Citations for the Scholars' poster presentations at BMES 2021. The names of Scholars supported by any source are underlined with the NSF REU supported Scholars additionally in **bold**.

## Cell Culture Vine

*Brief Description:* We shipped experimental kits for Scholars to engage in hands-on activities at home about cell culture, microscopy, and bioassays. Scholars were provided with detailed written directions and video demos. A CUReS graduate student mentor provided synchronous support via videoconferencing.

*Lessons Learned:* Critical aspects of chemical and biological experiments were unsurprisingly challenging to replicate outside of the laboratory environment. At the same time, the experiments themselves were scientifically more trivial than what Scholars would learn in person. In the evaluation process, the Scholars discussed difficulties of doing the cell culturing activities from home, though some Scholars expressed informally that they did gain an understanding of basic cell culture and biochemical assays. For example, one Scholar shared with us in a follow up email that, "little did I know, culturing cells in my basement lab this summer would prove to be so important in my junior year" as she became an undergraduate assistant to a graduate student doing cell culture in fall 2021.

## Dell Med Cancer Series Vine

*Brief Description:* The Livestrong Cancer Institutes at Dell Medical School are advancing care and improving health outcomes through a patient-centered strategy developed in partnership with

the Central Texas cancer care community. The Livestrong Cancer Institutes have created multiple educational programs for students of different ages. The Scholars in our REU Site participate in the weekly cancer research seminar series developed by the Livestrong Cancer Institutes for undergraduate students. The seminar series spans basic science (e.g., Studies in Experimental Models); Prevention, Diagnosis, and Screening (e.g., Cancer Screening in Primary Care); Social Science & Community Based Research (e.g., Health Disparities Research); Cancer Sub-specialties (e.g., Colorectal Cancer); and Translational and Clinical Research (e.g., Immunotherapy). While this series of talks was designed with undergraduate learners in mind, we enhanced the Scholars' participation in the seminar by engaging them in corresponding themed discussion sessions led by a CUReS graduate student mentor.

*Lessons Learned:* In the program evaluation, Scholars expressed disappointment with the cancer lectures because they found it hard to stay engaged, lacked background context for understanding, and struggled to relate it to their experience in the lab. Going forward, we think this aspect of the Site needs to be in person to facilitate more discussion to engage the Scholars and help them make connections to other program activities.

**Emperor of All Maladies Vine**

*Brief Description:* Each Scholar is provided with a copy of the Pulitzer Prize winning book, The Emperor of All Maladies: A Biography of Cancer by Siddhartha Mukherjee (*3*). Discussions associated with this reading, which were led by a CUReS graduate student mentor, utilized the companion materials developed by PBS (videos, lesson plans, etc.).

*Lessons Learned:* Book discussions were effectively delivered in an online format. In addition to the DEI vine and the social vine, the book club vine was mentioned by name as one of the most important parts of the program by students in the program evaluation. Scholars appreciated the book club for applying a human aspect of cancer to their research perspective. In future offerings of the Site, we aspire to conduct these book discussions online in the fall after the on-campus summer research experience to help the Scholars place their REU learning experiences in historical context.

**Jim Allison Documentary Vine**

*Brief Description:* In 2019, Uncommon Productions released Bill Haney's inspiring documentary *Jim Allison: Breakthrough* which chronicles Dr. Allison's scientific quest that ultimately led to a 2018 Nobel Prize for discovering the immune system’s role in defeating cancer. While Dr. Allison's career has taken him many places over the years, he grew up in Texas, earned both his BS and PhD degrees from UT Austin, and is currently a faculty member at The University of Texas MD Anderson Cancer Center. Thus, in addition to providing a platform for reinforcing technical concepts about immunology and cancer, watching and discussing this documentary helped Scholars identify as UT Austin researchers and as part of the broader cancer research community. The Scholars' experience of the documentary was enriched by corresponding themed discussion sessions led by a CUReS graduate student mentor.

*Lessons Learned:* The Scholars reported that they enjoyed the documentary, and we feel that it was a valuable addition to the Site. However, given the technical issues that can arise when coordinating watching a feature-length video online, we would prefer to implement this aspect of the program in-person for future offerings of the Site.

**Social Vine**

*Brief Description:* A CUReS graduate student mentor creatively engaged the Scholars via Slack and Zoom. Conversation starters included sharing pet photos, embarrassing childhood photos, and silliest fears. Synchronous sessions included shared experiences, such as making pancakes using a mix from an Austin-based restaurant.

*Lessons Learned:* Along with DEI vine and the book club vine, the social vine was mentioned by name as one of the most important parts of the program by students in the program evaluation. Scholars appreciated the social vine for network development. However, the Scholars reflected that they wished they had more social/informal interactions with peers and lab mates, and they also wanted to learn more about what other pods/ research groups were doing. We conclude, not unexpectedly, that that social aspects of the REU experience are hard to reproduce in an online setting. Going forward, we hope that online social programming will be a supplement to, not a replacement for, rich in-person interactions in our Site.

**Diversity, Equity, and Inclusion Vine**

*Brief Description:* The Diversity, Equity, and Inclusion (DEI) vine offered opportunities for Scholars to deepen their understanding of DEI through readings and media excerpts, discussing perspectives with fellow Scholars, and acting through scenarios Scholars may encounter. CUReS graduate student mentors led sessions on Defining Diversity, Equity, and Inclusion; Understanding and Responding to Microaggressions; Anti-Black and Anti-Asian Narratives in Academia; Allyship to the LGBTQ+ Community; Disability Justice; and Bystander Intervention. In the 2021 program evaluation, more than half of the students cited the DEI vine as one of their favorite parts of the program claiming that it helped them get to know other scholars, and provided a space to talk about important issues among scientific peers.

*Lessons Learned:* Given the success of the DEI vine when offered online in summer 2021 and the fact that Scholars' feedback in the evaluation identified this as a topic they would like to have expanded, in future offerings of the Site we aspire to engage Scholars in DEI conversations online in the spring before and the fall after the on-campus experience as well as in-person during the summer.

**Pods**

*Brief Description:* In prior offerings of the Site, we formed mentoring triads consisting of an undergraduate research Scholar, a graduate student mentor, and a faculty mentor. For the summer 2021 online offering, Scholars were mentored by faculty and graduate students in a laboratory pod. We first paired faculty where one typically uses experimental research methods

and the other typically uses computational research methods in order to facilitate the planning of a rich set of Scholar projects that could be completed fully online. Each faculty member identified a graduate student mentor from their lab to join the mentoring pod. Then, we matched 2-3 undergraduate research Scholars with each mentoring pod. Each mentoring pod pursued one or more projects depending on the evolving interests and skills of the Scholars. As with prior offerings, in summer 2021 the graduate student mentors took a course, based on the *Entering Mentoring* curriculum (*4*), that opens dialogue about the nature of mentoring, sets expectations for mentors, and discusses how to establish a good relationship with one's mentee.

*Lessons Learned:* In future offerings of the Site, we hope to keep the pod structure to promote more organic experiences based on this larger, collaborative organization. The evaluation process revealed that the Scholars enjoyed the pods as a more facilitated and scaffolded way to learn about research and graduate structures. In prior offerings of the Site, we 'front loaded' the mentoring course schedule to give more information early in the summer. Based on positive feedback to changes in the pacing and duration of the mentoring course in summer 2021, future offerings of the Site will ensure that the graduate student mentors have substantive discussion time in the course about the day-to-day mentoring experience throughout the summer.

**Conclusions**

From our experiences, when the pandemic necessitated that our Site be conducted fully online in summer 2021, we learned that the research opportunity was greatly enhanced by the addition of didactic instruction in foundational technical topics beyond the one-week "Research Bootcamp" and project-specific training that had been standard in our Site for years. Based on our experiences, we think that most technical instruction would probably be better implemented in-person. For example, it was difficult to teach cell culture at home with a kit or to adequately engage Scholars in data science projects over videoconferencing. On the other hand, discussion orientated activities were well-received in the online format. For example, in the program evaluation, Scholars noted that they appreciated the Emperor of All Maladies "book club" for applying a human aspect of cancer to their research perspective. In future offerings of the Site, we hope to add an online program in the fall after the on-campus summer research experience to provide more opportunities for discussion of Emperor of All Maladies. Likewise, the addition of discussions about diversity, equity, and inclusion in the summer 2021 offering was very well received and effective in the online format. Thus, in future offerings of the Site we aspire to engage Scholars in DEI conversations online in the spring before and the fall after the on-campus experience as well as in-person during the summer. It is also interesting that the program evaluation revealed that the Scholars felt that the didactive instruction "vines" helped simulate the graduate student experience of classes.

We emphasize that training in technical communication remained a very strong element of our Site, even with the transition to the online format in summer 2021. In future offerings of the Site, we aspire to extend this professional development activity through an online component in the fall after the on-campus summer experience. We believe that extending the technical communication training beyond the summer will enable us to multiply the impact of Scholars' participation in the BMES conference (October) through supporting their preparation in the weeks leading up to the conference and guided reflection after the conference.

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