Guidelines and Advice for SURF Program Proposals

Requirements

In the electronic application, applicants are asked to outline their research proposals and goals in the following ways.

1. **Title**
2. **Description (4500 characters max.).** You are asked to *"Outline your purpose and goals in terms that a scientifically literate generalist would understand. (Think of someone in another field or who has not studied science for a few years.) But, don't dilute the science! Satisfy your supervisor(s) that you've described your proposed research in a suitably rigorous way!"*
3. **Explain why you have selected this particular project (2000 characters max.).** You are advised that "*There are many ways to answer this question, but, basically, this is an opportunity to catalog your relevant strengths. Explain some of the reasons that the particular project fits your experience. Explain some of the assistance you may be able to provide your supervision on an existing or future project. Perhaps you might explain some of the reasons that you are a suitable candidate to be chosen by your supervisor for this particular project."*
4. **What you hope to learn from the whole experience of SURF.** You are asked to "Explain the three most important things that you hope to learn through completing this project of summer undergraduate research." While your project description should address the goals of the research project itself, you may wish to define what you hope to learn more holistically here: for example, learning how to put theory into practice, learning how to become a more independent learner, learning how to work in a team or a lab, learning how to link areas of knowledge, learning how to interpret experimental data, learning how to present a research report, and many, many more!

General advice

- Describe your project in a way that is clear, concise, and free of grammatical and spelling errors.
- Demonstrate your knowledge of the subject and the research to be conducted.
- Outline a clear timeline for the research or otherwise demonstrate the project's feasibility and the consistency of your research goal with the time available.
- Explain *in your own words* both the connection between your project and the supervising faculty member's area of expertise.
- Explain the aspects of the project where you will operate with most independence or take most responsibility.
- List appropriate scholarly citations and references to demonstrate your understanding of the field. References should be formatted in the style appropriate to your discipline. If you refer to a grant proposal made by your mentor, please cite the grant proposal as one of your sources.

Resources:

- Jacobson Center, Writing Process Series, Smith College
- UCONN Office of Undergraduate Research
- Duke University Undergraduate Research Support Office
- Carnegie Mellon University
- webGURU Guide for Undergraduate Research

Matters to Address in a Research Proposal and Suggested Order or Headings

1. *Title*
    - Your title should be clear, descriptive, and specific.
2. *Motivation for the research*
    - Give context for your research project and/or question(s): why is this an important area to study?
    - Provide a few references to the most important and relevant peer-reviewed scientific literature and if appropriate, policy documents that will motivate and guide your research.
3. *Overall research goal*
    - What do you want to find out?
    - If you have a project that is already well defined:
        1. What is your guiding research question?
        2. What specific questions or hypotheses will you test in order to answer the overall question (be explicit about what these are)?
        3. What is the state of scientific knowledge in this area, and how will your research question advance that knowledge?
4. *Approach* (methods, e.g. field experiments, economic surveys, meta-analysis of existing data, that you will employ to gain a better understanding and set of tools to pursue research in your chosen area or, if you are further advanced in your research, test the hypotheses laid out in part 3)
    - What will you do to answer the overall research question?
    - What data will you collect? Where will you do the research?
    - What equipment or technical resources will you need?
    - How long will the research take?
    - How will you analyze and interpret your data?
5. *Anticipated results* (based on your knowledge of related and previously conducted research in this area)
    - What do you predict that the results of your experiments, surveys, etc. will yield in terms of data? Why?
6. *Significance of the proposed research* (to the scientific community and society)
    - Why are you excited about the proposed research, and why should the reader be as well?
    - How does the proposed research relate to what has already been done in this area?
7. *Literature cited*

(adapted from "Suggested Format for a Research Proposal," Office of Biology Undergraduate Education, Brown University)

Examples of SURF Project Proposals from 2016

Example 1: Using DNA Origami To Understand Motor Ensemble Motility

Just as a bird might see cars and trucks loaded with people and cargo coursing across a city grid, with the aid of a microscope, our cells appear much the same to the human eye. In order to function properly, intracellular cargoes – such as organelles and vesicles – need to be transported to specific places in the cell at particular times. Motor proteins called dyneins and kinesins are the microscopic UPS delivery system that facilitates this transport. These bipedal motor proteins walk down molecular tracks called microtubules delivering cargoes essential to proper cellular functioning.

To investigate the underlying biophysical mechanisms of how this remarkable transport occurs, the Derr lab created a controlled experimental system that allows us to measure how these motors work in teams to collectively haul large cellular cargo. To do this, we've built synthetic cargo structures that attach to motor proteins. We build these structures out of DNA origami – essentially like building with molecular Legos – which allows for a high level of design control. DNA origami is well-suited for creating nanoscale 3-D shapes: the resulting structures allow us to explore how cargo geometry and the number of motors impact cellular transport.

In the past, we've built several variations of linear cargoes, all with different levels of overall rigidity. During the SURF program last summer and continuing into this academic year, we've discovered how these varying levels of rigidity within linear cargos directly impact ensemble motility.

In one exciting discovery last summer, we observed teams of dynein moving the completely non-rigid linear cargo structure faster and further than teams carrying either a very rigid or a semi-rigid structure. The varying behaviors of the ensembles carrying the different structures can be explained by the concept of "negative interference." On a rigid cargo, for a system of seven motors to move at the same speed as a single-motor system, all the motors would have to be perfectly synchronized. If just one is out of step, or pauses asynchronously, then when the others try to take a step the outlier serves as an anchor tightly bound to the track. The hindering force caused by these motor asynchronies and pauses is known as negative interference. We believe there is a differential degree of negative interference between the various synthetic cargo structures. Specifically, the flexible nature of our non-rigid linear cargo structures prevents motors from negatively interfering with one another because the structure is less sensitive to motor-pauses.

To further test this hypothesis, we are intentionally chemically-inducing the motors to pause and then observing the differential responses between teams carrying either rigid or flexible cargos. Currently, we are comparing their emergent behaviors in response to the chemically-induced change in the frequency and duration of pauses.

My results have shown that the physical properties of the cargo have a direct effect on the behavior of the dynein ensemble (manuscript in preparation). We now want to create a volumetric synthetic cargo structure that more closely mimics cargoes within the cell, such as spherical vesicles. With DNA origami techniques, we can now do this with a high level of control. The aim will be to create a spherical cargo structure that pushes further the complexity and biological relevance of this experimental system.

Inside the cell, there are complicated cargo hauling and cargo transport dynamics which likely relate to how multiple dyneins and kinesins on the same cargo interact with one another. There are bidirectional motions, pauses and varying velocities among these ensembles. With that as context, the ultimate goal will be to test the new spherical cargo structure with a mixed motor ensemble, using both dynein and kinesin motors.

The linear cargoes in our experimental system directly positions the motors on top of the microtubule tracks upon which they walk. In contrast to our linear cargoes, our hypothesis is that a spherical cargo would orient the motors very differently with respect to the microtubule track, which may affect overall ensemble motility. We aim to push the boundaries of what DNA origami allows us to do by creating more complicated structures, ultimately testing the hypothesis that shape and geometry matters in cargo transport dynamics.

Amalia Driller-Colangelo, ’18, Neuroscience Major
686 words [3722 characters]

Example 2: Precious Metal Recovery from Electronic Waste: Technological Challenges and Socio-economic Considerations

An ongoing project of Paramjeet Pati involves a novel protocol to recover gold from nanomaterial waste at room temperature. The protocol involves selective complexation of gold facilitated by a benign and low-cost carbohydrate, cyclodextrin. For the summer research project, I want to explore the feasibility of applying such a method to separate, concentrate and recover precious metals from the electronic waste. In particular, I will focus on the environmental systems modeling and life cycle assessment of e-waste recycling scenarios.

The rapid change of technology and the increase dependence on electronic devices result in an increasing amount of electronic waste. It was estimated in late 2000s that 20-25 million tons of electronic waste were produced each year. With the nature of circuit boards and other electronic components, electronic waste contains concentrated amounts of precious metals. The amount of gold in electronic waste ranges from 10-350 ppm and that of silver 100-1400 ppm, depending on different electronic devices (Khaliq et al., 2014). An estimated 320 tons of gold and more than 7500 tons of silver are used each year in electronics production, summing up to around $21 billion of expense (Bonn, 2012). Under such status quo, the needs for recycling and for understanding comprehensive environmental analysis of global e-waste flow are highly crucial. The EPA’s Border 2020 Program has identified that e-waste flow across national boundaries is an important research challenge in sustainability.

Recycling e-waste not only reduces our dependence on resource-limited materials, but also mitigates the environmental impacts of toxic e-waste. Hazardous metals are also present in electronic waste and are a threat to the environment if not formally treated. E-waste recycling prevents metals such as mercury, cadmium and lead from leaking into soil and water while through normal disposal they would by landfill or combustion.

The goal of this research project is to determine the feasibility of recycling e-waste by using cyclodextrin facilitated gold complexation. Collecting data about e-waste and conducting life cycle assessment on the recovery process will provide insights in the potential of recovering precious metals. As the use of gold and silver in producing printed circuit boards is also overwhelming in a socio-economic perspective. The research will also couple environmental challenges with social impacts.

The use of gold and silver in producing printed circuit boards is also overwhelming in a socio-economic perspective. In modeling and life cycle assessment, I will couple social life cycle assessment with environmental analysis as environmental challenges are intimately intertwined with socio-economic issues. Besides technological solutions, sustainable e-waste management requires the mitigation of social impacts associated with global e-waste traffic and trade.

Catherine Keqin Ding ’18, Engineering Major
429 words [2489 characters]