**Undergraduate research in the Anderson Lab** 7/13/23

*Introduction*

Thank you for taking an interest in the Anderson Lab. Since Dr. Anderson's postdoctoral training started in 2014, we have hosted undergraduates in the lab. Undergraduates have presented their science at symposiums, won research awards (Mary Gate Research Scholarship), co-authored papers with us (*Journal of Experimental Medicine, Cancer Immunology Research, Journal for Immunotherapy of Cancer*), secured competitive jobs in the biotech sector, and gone on to enroll in top graduate programs (University of Washington Pharmaceutical Bioengineering, Rutgers Biomedical Engineering). However, scientific research is challenging, and it is important to understand what to expect when considering undergraduate research.

Your success is entirely dependent on your commitment to learning about scientific research. We have established a culture in the lab, which resonates with some undergraduates and overwhelms others. To help decide whether the Anderson Lab is for you, we collectively drafted this document to give a sense of what it takes to become a successful undergraduate lab member.

*Eligibility*

Undergraduate students must have a GPA > 3.2 to be considered eligible for work in the Anderson Lab. Research is a supplemental activity that should complement academic work, and individuals who have not yet posted a strong semester have not demonstrated that they are ready to supplement their academics.

*Purpose*

One of the most important components of any relationship is a common set of shared expectations that both parties understand before entering the relationship. Our research group has agreed upon the following list of objectives for supporting undergraduate research in the Anderson Lab:

1. To help undergraduates determine whether they can or should pursue a career in scientific research, and to catalyze the trajectory of those who chose a scientific-research path.
2. To enable graduate students and postdocs to gain experience with mentorship and personnel management.
3. To accelerate research progress in the lab.

The following are unacceptable goals when considering this lab: to add an extracurricular activity to my resume, to win a research award, to get courtesy authorship on a paper.

*Step 1: Lab shadowing (probationary period)*

Lab shadowing is the requisite first step for anyone interested in joining the lab. Before shadowing in person, a volunteer form must be completed, signed by the undergraduate, and returned to the shadowing contact. Kara Cummings (klc6c@virginia.edu) is the Lab Manager and current Anderson Lab shadowing contact. You are in charge of making and maintaining contact throughout the lab shadowing period; we will always answer your emails, but you are responsible for independently managing your schedule.

During lab shadowing, you will visit the lab 1–2 times per week for several weeks. Ideally, your class schedule will also permit you to attend a few of our lab meetings, which are held on Tuesdays from 1-3pm in MR6 3501. The goals of lab shadowing are:

1. To listen to an overview of the current research directions in the group and ask questions about specific projects.
2. To observe multiple laboratory techniques and get a sense of types of experiments we do, what they accomplish, and how they work.
3. To try your own hand at some basic experiments and experimental troubleshooting.

The key thing that we evaluate during the lab shadowing is your level of engagement. When you are in the lab, we expect you to be in the lab: not just your body, but your mind and its undivided attention. Half listening, scrolling social media, showing up late, overlooking scheduled meetings, etc. is a surefire way to get excluded from Step 2.

*Step 2: Critical literature summary (probationary period)*

Engaged shadowers who remain interested in joining the group will next be asked to write a brief (1-2 single-spaced pages) summary of a facet of research related to the Anderson Lab. This literature summary will synthesize information from our published (or preliminary) work along with the published work of others. The document will be evaluated by the most-relevant individuals in the lab and will undergo at least one round of revision. The objectives are:

1. To gauge your ability to evaluate and organize information from the primary literature.
2. To assess how you handle an unstructured responsibility with high implicit expectations but no explicit deadline.
3. To obtain a glimpse of your baseline competency for technical communication.

Many undergraduates will drop out before the completion of Step 2, as they will be unable to make progress on the assignment amidst the competing demands on their time from classes and other responsibilities. For dedicated undergraduates who prioritize research, Steps 1 and 2 should not require more than one semester.

*Step 3: Volunteer research*

At this time, you will be partnered with a predoctoral, postdoctoral, or staff mentor who will supervise your day-to-day activities in the lab. Undergraduates may work individually or in pairs with a shared mentor, depending on the undergraduate research project that we are envisioning. Undergraduate projects could fluctuate on a semester-to-semester basis depending on the needs of the lab.

Please communicate with your mentor about your preference for experimental vs. computational projects. Experimental projects require tactile dexterity ("good hands"), extreme attention to detail, and many continuous hours at the bench in the lab. Volunteer experimentalists are strongly encouraged to read the laboratory copy of Kathy Barker's *At the Bench: A Laboratory Navigator* (Cold Spring Harbor Press, 1998) during incubation and washing steps. This book nicely summarizes the implicit expectations of being a good lab citizen and the steps to becoming a competent experimentalist.

Computational projects work well for undergraduates who enjoy self-teaching, debugging, and the discontinuous-time flexibility provided by structured programming. Volunteer computationalists are strongly encouraged to read Ten Simple Rules for Effective Computational Research. This Editorial touches on many of the common mistakes made by beginning coders. Note that computational researchers will have less day-to-day oversight from mentors compared to experimental researchers.

Both experimental and computational research projects call for meticulous recordkeeping. Although there is not a strict prescription for how individual records should be maintained, in 2023 the NIH implemented new expectations for data sharing, and all labs receiving NIH funding must properly document protocols, data and analyses to

comply with these new directives. Therefore, the Anderson Lab operates on the "Five-minute Rule"—you must be able to provide any detail about any experiment or simulation from any time in the past within five minutes of being asked. Breaking the Five-minute Rule will prompt a reimplementation of your recordkeeping practices. Prof. Janes in the UVA Biomedical Engineering Department recorded a lab meeting on recordkeeping practices and shares examples of thorough lab notebook records. There is also editorial advice on Ten Simple Rules for a Computational Biologist's Laboratory Notebook. The NIH recorded a webinar that covered some "best practices" for keeping a lab notebook, and *Science* interviewed many scientists for their advice about best notebook practices. In the Anderson lab, we strongly encourage learning and using Benchling, a digital laboratory notebook.

The first goal of volunteer research is to gain mastery of a skill or technique that is useful for the lab. Mastery does not mean successfully executing an analysis once or attempting an experiment many times with variable success. Mastery means that you have accumulated an in-depth understanding of how a skill or technique works and can execute it perfectly to yield publication-quality results every time. First skills are selected to be fundamental, in that they are used routinely in the lab and can serve as a launching point for more-advanced methods once mastery has been achieved. The only thing that puts a ceiling on an undergraduate research project in the Anderson Lab is the ambition, talent, and work ethic of the undergraduate.

Starting undergraduate projects are typically straightforward, with a clear sense that useful results should be obtainable if the experiments or simulations are done properly. Successful completion of a first project will often lead to a second project that is more challenging. We may not know what results, if any, can be obtained, and the project may involve facets that neither the mentor nor Prof. Anderson are deeply familiar with. The purpose of a more-difficult second project is to achieve Objective #1—every worthwhile graduate thesis requires a predoctoral student to dive into unfamiliar, high-risk territory. You must see how you handle this challenge (as well as the long string of failures that typically ensues) and decide whether you want to face it again in graduate school. We take pride in challenging our undergraduates with activities similar to those encountered in graduate school so that they are truly prepared when applying for Ph.D. programs.

As a volunteer activity, the time commitment is flexible, and expectations can be adjusted to account for exams or other busy times. However, keep in mind that progress in research moves slowly, even when dedicating one's entire effort.

Undergraduates who have reached Step 3 and above will take on additional expectations. First, you should make every effort to arrange your class scheduling around the lab meeting on Tuesdays from 1-3pm in MR6 3501. (Alumni have shared that lab meeting is among the most valuable aspects of volunteering.) Second, you will be assigned a simple-but-important lab task (cleaning the water baths, verifying $CO_2$ and water levels in the incubators, scraping the –80ºC doors, etc.) that must be completed regularly without reminder. The tasks give undergraduates a sense of the shared responsibility of working in a research environment.

*Step 3a: Summer research (optional)*

The summer can be an outstanding time to gain a sense of what full-time research is about. The Anderson Lab makes every effort to support motivated undergraduates with stipended summer research opportunities after mastery has been achieved with at-least one skill or technique. The default summer stipend rate is $12/hr assuming a 40 hr/wk. During summer work, you are expected to apply your mastered skill(s) to generate publication-quality data for an ongoing project in the lab while also learning new, time-intensive skills that can be leveraged in future semesters. To keep track of research progress, 20–30 minute one-on-one-on-one meetings will be scheduled weekly with you, your mentor, and Prof. Anderson. You will also be expected to give a research update at lab meeting in mid-to-late August, which summarizes your results from the summer.

Summer research is not an automatic opportunity but one that must be negotiated with the mentor and Prof. Anderson early in the spring semester. If you are planning to take a lab or seminar course, the GRE or MCAT, etc. over the summer, then you should not inquire about stipended summer research during that time. Anyone who has made it to Step 3 is welcome to continue volunteering over the summer on a relaxed time expectation

that is commensurate with other summer activities.

*Step 3b: Research for credit (optional)*

Research for credit (BIOL 4910 or HBIO 4950) is an opportunity for undergraduates to work on a project during the semester (and/or summer) with a reduced credit load. As with summer research, research for credit is possible only after mastery has been achieved with at-least one skill or technique. BIOL4910 must be the 13th, 14th, and 15th credits for the semester, meaning that you must take no more than four classes when considering research for credit in the Anderson Lab. Research for credit carries with it an explicit time commitment of 10–15 hours per week throughout the semester (regardless of exam weeks and other competing priorities) along with many additional responsibilities:

1. Before the start of the semester, write a 1–2-page research proposal containing the following headings: Background, Objective and Hypothesis, Research Plan, Milestone(s) for the Semester. This document will undergo at least one round of revision with your mentor and then with Prof. Anderson. For all sections, be as specific as possible. The approved revision must be sent to Prof. Kawasaki (mk3u@virginia.edu).
2. Before the start of the semester, fill out the appropriate program application (e.g. BIOL4910 Research-for-credit application)
3. During the semester, 20–30 minute one-on-one-on-one meetings will be scheduled weekly with you, your mentor, and Prof. Anderson to monitor research progress.
4. Before the end of final exams, write a detailed research summary (typically 5+ pages) that reintroduces the problem, describes and interprets your results obtained during the semester, self-evaluates the progress you made on the project, and discusses future work that you think should be done. This document will undergo at least one round of revision with your mentor and then with Prof. Anderson. As with the research proposal, for BIOL4910 the research summary must be sent to Prof. Kawasaki.

Up to 3 semesters of research for credit (BIOL4910) are permitted to count towards graduation requirements in the Biology BA major. However, it should not be considered an easy grade in the Anderson Lab, because there is more accountability with research for credit and thus consequences for poor or mediocre performance. The final BIOL4910 grade is assigned by Prof. Anderson after direct consultation with your mentor about the strengths and areas of opportunity displayed during the semester.

Research for credit is not an automatic continuation from volunteer research. Anyone who has made it to Step 3 is welcome to continue volunteering or engaging in stipended research on a per-semester basis through their third or fourth year.

*Step 4: Biology Distinguished Majors Programs and/or Capstone Thesis Research*

The Biology Distinguished Majors Program and Human Biology Distinguished Majors Program offer an opportunity for students who are seriously committed to research to present their independent research and receive a degree with distinction. We only consider Distinguished Majors projects for undergraduates who have made it to Step 3 by the end of their third year.

The expectations for Distinguished Majors are similar to research for credit (Step 3b), especially with respect to the explicit time commitment, the biweekly one-on-one-on-one meetings, and the urgency to make meaningful progress. The major differences are that students must 1) participate in weekly Distinguished Majors seminar, 2) write a formal thesis and 3) give a podium presentation of their work at the Richard D. Katz Undergraduate Research Symposium at the end of Spring term.

*Lab do's and don'ts*

Do:

- Ask questions in the lab, in lab meetings, etc.
- Pay close attention to details
- Take ownership over your project
- Leave shared lab spaces cleaner than you found them
- Put temperature sensitive reagents back as soon as possible
- When learning something new, take detailed notes on the protocol as it is being shown
- Be on time and keep commitments with your mentor and Dr. Anderson
- Alert the lab if anything seems out of the ordinary (centrifuge making odd noise, freezer alarming, etc)
- Read and understand the IBC Biosafety Handbook
- Understand the responsibilities of the last person to leave the lab

Don't:

- Assume that work in the lab is like taking a class
- Expect to have a dedicated desk or lab bench
- Take anything for granted with your experiments or your algorithms
- Interrupt others at the bench if they are clearly in the middle of something; it is best to wait for acknowledgement and a 'safe' time to distract the individual
- Touch "clean" surfaces (door handles, elevator buttons, your phone, your face) with gloves on, even if they are "fresh" gloves
- Use your phone at the bench or in the cell culture hood.
- Wear your lab coat outside of the 2nd floor secure hallway