Undergraduate Biotechnology Research Fellowship Program

Available Projects (2024-25)

This is the list of company-based and faculty-led biotechnology projects available for students applying to participate in the Undergraduate Biotechnology Research Fellowship Program. As more projects are recruited, this list will be updated.

In order to apply to the summer research program, review the list of projects and identify and rank your top 3. If you are selected to participate in the program, we will match you to a project based on your indicated preferences.

NOTE: If you are already working with a mentor on a biotechnology related project, you may apply to continue working with that mentor. In this case, you are not required to select from these listed programs.

Biotechnology Companies

Project #1. ***Taguchi materials and printer technique for calibration-DoE***

Company name and description: Skyphos (www.skyphos.tech)

Skyphos is a top 100 lab-on-a-chip and diagnostics company, a top 5 worldwide 3D printing company, and a top Virginia startup. We research and design microfabrication techniques for clients in the life sciences. Our main focus is clear, biocompatible u3DP processes to enable startups to graduate from the lab and get to market.

Research project description: Individual would be mentored by Skyphos engineering team to run calibration design of experiments, validate results for different cure scenarios, plan the next experiment, review and make final adjustments. The current calibration SOP is in place but we expect we will need to make changes as we progress through new materials. The culmination of the project wild be completing 2-3 base designed LOC devices with 5 new materials.

Research goals for student(s): Full on design of experiments for process optimization. This will run the gamut from microscopy to materials characterization and potentially ISO FDA cell work for 13485 approval.

Required skills: Professionalism.

Restrictions: NDA in place, lab safety

Number of positions available: 2-3. There may be other projects

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Project #2. *Biomedical Research Intern*

Company name and description: CytoRecovery (www.cytorecovery.com)

Cell sorting is a critical tool for all stages of disease diagnosis, research, and therapy development. As we continue moving towards more personalized medical treatment plans and therapies, understanding individuals' cells will continue to be critical.

Our label-free platform provides the unique ability to recover living cells in a much faster and gentler way, without changing or biasing the cells, allowing their use in "downstream" research studies, including single cell genomic analysis, growth behavior studies, CAR T-cell therapies, drug dose testing, and many more, all critical for personalized medicine.

Our exclusively licensed technologies were invented at Virginia Tech and the University of Virginia, bringing together a cross-commonwealth collaboration.

Research project description:

We will have three projects available that can be flexible pending candidates. They span engineering and life science areas.

Project A: Chip Quality Control Processing

This biomedical research intern (hints of software, EE, mechE, BME) will work on implementing impedance-based analysis and automated imaging analysis to expedite and improve CytoRecovery's microfluidic device quality assurance and control processes. Using our developed techniques, the intern will test "good" and "bad" devices to determine the limits of detection and implement an faster quality test on our produced devices for improving customer satisfaction with our product lines.

Project B: Manufacturing Optimization & Design of Tools

This biomedical research intern (hints of BME, MSE, ISE, MechE) will work to design and integrate tools into our microfluidic manufacturing processes. Our devices require many hands-on processes with incredibly tight tolerances. The intern will continue evolving a chip cutter, bonding press, and alignment tools to continue increasing the quantity and quality of CytoRecovery's product lines.

Project C: Cell Viability & Phenotype Preservation on the CytoR1

This biomedical research intern (hints of BME, biology, biochemistry) will work on testing several cell lines of interest to CytoRecovery's current customer pipeline (e.g. T cells). They will characterize and expose them on the CytoR1 Platform to determine the cells' bioelectrical signature. Post exposure, we will grow the cells and analyze them to ensure they are healthy and remaining true to their original behaviors (e.g. Western blot, protein expression, growth curves).

Research goals for student(s):

All of our interns will achieve several things during their time with us. To kickoff their summer, all interns will rotate through the various aspects of our small company (microfluidic device manufacturing, engineering design/prototyping, on platform cell sorting experiments, cell culture/analysis, lab safety/procedures). Following the rotations, interns will choose from the projects listed above and be assigned a direct report mentor to achieve the goals outlined. They will be given a experimental design templates and ideas, receive mentoring guidance, and be given freedom to explore their project (and to fail!). At the end of the summer, we hold an internal showcase of their projects (which will help them prepare for the VT summer symposium), and they complete report documentation so the company can learn from their work and continue developing next steps. Their project report and presentation at our internal showcase are their final objectives to successfully complete their internship with us.

Required skills/experience:

- Basic biology, mathematics, and critical thinking skills.
- Strong curiosity and desire to ask questions.
- Computer programming skills are a plus.

Restrictions: Interns must be US citizens/legal to work in the US due to active federal grants.

Number of positions available: 3 (maybe 4)

Faculty-led Projects

Project #3: *Engineering and Understanding Agricultural through Synthetic Biology*

Faculty name (department): Dr. Clay Wright (Biological Systems Engineering)

Research project description: A hands-on introduction to the fundamental concepts of recombinant DNA technology and how it can be used to engineer cellular and organismal systems particularly crop plants. In this project using engineering design cycles of learn->design->build->test->learn, we will clone genes into yeast or plant expression vectors and characterize the expression and function in yeast or plants. This project will apply recombinant DNA technology, quantitative and synthetic biology, and automation and data analytics.

Research goals for student(s):

- Develop a basic understanding in molecular biology workflows.
- Learn how to use protocols and perform molecular cloning tasks.
- Learn basic molecular cloning techniques such as cloning plasmids into E. coli
- Build and test yeast strains or plants expressing proteins of interest
- Develop a basic understanding of data analysis and get acquainted to Git through software carpentries lessons (https://softwarecarpentry.org/lessons/).
- Practice public speaking by presenting research results and knowledge gained at a lab group meeting.

Required skills/experience:

- Basic biology, mathematics, and critical thinking skills.
- Strong curiosity and desire to ask questions.
- Computer programming skills are a plus.

Restrictions: None

Number of positions available: 1

Project #4: *Engineered Armor Biomaterials for Extreme Space Operations*

Faculty name (department): Dr. Anna Duraj-Thatte (Biological Systems Engineering)

Research project description: The engineered microbes and biotechnological processes will play crucial role in development of technologies for human exploration of space. It could include pharmaceutical synthesis, air and soil bioremediation, biomining and construction materials. However, to make this vision a reality, we need to provide a controlled environment for microbes to survive and conduct their programmed functions in extreme extraterrestrial environments. To

address these challenges, we will develop resilient nanofiber hydrogels produced by genetically engineered microbes to create radiation shielding materials for microbes. Microbial cells will be embedded into armor hydrogel matrix and exposed to UV-C radiation (comparable to UV-C sanitizers) and tested at various time points for the viability and metabolic activity of cells. The aim of this project is to investigate the relationship of protein nanofiber structures that form hydrogels and radiation resistance that will provide fundamental knowledge to develop radiation resistant materials for biotechnological applications in space.

Research goals for student(s):

- Microbial production of nanofibers
- Hydrogel Production by established filtration technology
- Embedding E.coli cells into produced hydrogels
- Design experimental plans for testing viability and metabolic activity of cells after UV-C exposure

Student Learning Outcomes:

- Learning basic microbiology techniques
- Production of protein-based hydrogels
- Develop basic understanding of physicochemical properties of biomaterials
- Learning experimental design, analysis of data and conclusion of results

Required skills/experience: It is preferable (but not a limiting factor) that student have experience with basic microbial culture.

Restrictions: None

Number of positions available: 1-2

Project #5: Development of an Archaeal Vitamin Production Process

Faculty name (Department): Dr. Biswarup Mukhopadhyay (Biochemistry)

Research project description: Vitamins are used as supplements in animal production and human health management. Many of these are produced via microbiological means where microorganisms are cultivated in large-scale bioreactors under controlled conditions and the desired vitamins are recovered from the cells. Such processes utilize either bacteria or fungi (eukaryotes) and here archaea have rarely been considered. The student will determine the levels of major B vitamins in several methanogenic archaea which are strict anaerobes and produce methane as part of their

energy metabolism. Select hyperthermophilic, thermophilic, and mesophilic methanogens that grow at 85, 65 and 37 °C, respectively, will be studied. Starting from serum bottle-based small culture systems, the effort will include bioreactor or fermenter systems for nutritional and physical (temperature, pH, and mass transfer) parameter manipulations to increase the levels of production. Theoretical metabolic models will be developed based on available omics data and used to design nutritional and genetic engineering manipulation strategies for improving the yield, production rate and productivity of desired vitamins. The student will be introduced to the genetic anaysis systems as applicable to targeted organisms. The last two activities will open the avenues for leveraging synthetic biology and genetic engineering approaches towards the stated goals in the future. An opportunity of interacting with an industry partner exists.

Research goals for student(s):

- Master the skills for the cultivation of strictly anaerobic microorganisms that grow on gaseous substrates and at high temperatures.
- Learn the required analytical methods, including thin layer and high-performance chromatography (TLC and HPLC) and chemical and enzymatic assays.
- Employing these skills determine the levels of vitamins in selected methanogens.
- Learn to use a bioreactor and scale-up one of the production system to 1–10-liter bioreactors
- Learn *E. coli* based molecular biology techniques that facilitate genetic manipulation of a methanogen (*).
- Learn to analyze genomic, transcriptomic and metabolomic data for devising strategies for nutritional and genetic manipulations of targeted organisms (*).
- Develop the plan for genetic engineering of one of the targeted organisms for overproducing one of the B vitamins (*).
- Learn to plan experiments, document results, prepare reports and make presentations of the outcomes for both basic and applied science goals in the laboratory meetings.
- Survey the status of the microbiological vitamin production industry and the research and process development opportunities in this field

(*) These goals could be pursued in the following semesters. The student will work in a team science environment with an ample scope of independence.

Required skills/experience:

- Basic biology, chemistry, and microbiology, and mathematics (open to science and bioprocess and chemical engineering majors)
- Interest in a bioprocess industry career or a bioprocess industry facing academic career

Restrictions: None

Number of positions available: 1-2