1. **Project:** Plant/microbe/soil interactions
   Mentor: Chuck Hyde | **Faculty member:** Wendy Yang
   Location: University of Illinois Urbana-Champaign
   Virtual or in-person? In-person if permitted

This project centers on the interactions between plants, microbes, and the soil surrounding them, specifically how annual (sorghum) and perennial (miscanthus) grasses change the soil around them. The student will help collect, process, and characterize soil and root samples from field sites around central Illinois to understand nutrient cycling and greenhouse gases.

2. **Project:** Analyzing emissions data from crop production
   Mentor: Dalton Stewart | **Faculty member:** Jeremy Guest
   Location: University of Illinois Urbana-Champaign
   Virtual or in-person? Virtual (computer and internet connection required)

This project focuses on quantifying field-level emissions of crop production using real-time data collected with remote sensors. The student will help collect data on emissions standards (the allowable amount of air pollutants) and organize and coordinate these standards to combine with emissions data for environmental impact determination. Time permitting, the student will also assist with writing code to convert emissions data to environmental impacts according to the information provided by the standards.

3. **Project:** Analyzing farmers' willingness to adopt perennial energy crops
   Mentor: Pan Yang | **Faculty member:** Ximing Cai
   Location: University of Illinois Urbana-Champaign
   Virtual or in-person? Virtual (computer and internet connection required)

This project focuses on analyzing farmer's survey data about their willingness to adopt perennial grasses. We will analyze survey data using advanced data analytic tools to identify the roles of various socio-economic factors in affecting farmers' crop adoption decisions. The student will be taught data analytic tools such as regression and basic machine learning algorithms.

4. **Project:** Biorefinery simulation for citramalate production
   Mentor: Emma Brace | **Faculty member:** Jeremy Guest
   Location: University of Illinois Urbana-Champaign
   Virtual or in-person? Virtual (computer and internet connection required)

Citramalate is a high-value bioproduct that can be made via the conversion of glucose by engineered *E. coli* bacteria. This project includes tasks related to design and simulation of a biorefinery to evaluate how a process to make citramalate could work (design), how much it would cost (techno-economic analysis), and what kind of environmental impacts it might have (life cycle assessment). The student will learn how to review scientific literature, code using object-oriented programming (Python), and contribute to some portion of the overall project (potentially a specific unit operation of interest in the biorefinery design, or a portion of the life cycle assessment).

5. **Project:** Applying machine learning to synthetic biology
   Mentor: Michael Volk | **Faculty member:** Huimin Zhao
   Location: University of Illinois Urbana-Champaign
   Virtual or in-person? Virtual (computer and internet connection required)

In this project, an existing machine learning tool, Automated Recommendation Tool (ART), will be used to make predictions for synthetic biology by applying it to CABBI datasets or data from scientific papers. In synthetic biology, organisms are engineered to have new useful purposes. The student will be introduced to basic concepts in metabolic engineering and data science and taught some of the basic tools from both disciplines. Part of the research experience will focus on identifying datasets where the ART method gives meaningful results. If time permits, we can begin looking into how to improve the machine learning method to make better predictions.

6. **Project:** Creating biorefinery process design software tools
   Mentor: Sarang Bhagwat | **Faculty member:** Jeremy Guest
   Location: University of Illinois Urbana-Champaign
   Virtual or in-person? Virtual (computer and internet connection required)

The overall project goal is to create a software tool to assist in the process design of biorefineries, and then to integrate the tool with BioSTEAM (the Biorefinery Simulation and Techno-Economic Assessment Modules). The mentor will introduce the mentee to BioSTEAM and the biorefineries developed using it and guide them through literature related to biorefinery design and separations. The mentee will summarize the data flow needed between the proposed process synthesis tool and BioSTEAM and aid in the parallel development (in Python) of the process synthesis algorithm. The mentee will also help collect data from previously implemented biorefineries to generate a development dataset as well as a validation dataset (for qualitative and quantitative comparisons between design decisions that were used in those biorefineries and those recommended by the process synthesis algorithm). Although there are no firm prerequisites, the mentee will be well placed for these tasks with an ongoing bachelor-level degree in a chemical engineering/technology major and prior participation in at least one project (academic or industrial) that involved some form of chemical engineering design.

7. **Project:** Connecting Sustainability models
   Mentor: Yalin Li | **Faculty member:** Jeremy Guest
   Location: University of Illinois Urbana-Champaign
   Virtual or in-person? Virtual (computer and internet connection required)

This project will lay the groundwork to connect BioSTEAM (the Biorefinery Simulation and Techno-Economic Assessment Modules) with biogeochemical and economic models (e.g., FUN-CORPSE, DayCent, BEPAM) to include the impacts of feedstock when evaluating the sustainability of biofuels and bioproducts. The mentor will introduce BioSTEAM to the student and guide them through literature related to the models on feedstock impacts. The student will summarize the required inputs, outputs, and fundamental methodologies of CABBI's existing models related to feedstock impacts (in-field and potentially logistic systems) and propose a path for integrating BioSTEAM with these models. There are no prerequisites for the mentee, but basic knowledge of life cycle assessment (LCA) will be helpful.

8. **Project:** Biological nitrification inhibition
   Mentor: Sierra Raglin | **Faculty member:** Angela Kent
   Location: University of Illinois Urbana-Champaign
   Virtual or in-person? In-person preferred if permitted but can arrange virtual

Sustainable agriculture strives to maximize productivity without depleting soil fertility and plant-microbe interactions play vital roles in achieving this goal. One of these beneficial interactions is biological nitrification inhibition (BNI). In order to investigate how beneficial traits like BNI capacity are lost through the domestication and crop breeding process, we will use sorghum as a model crop species to grow in greenhouse conditions. We will then sample rhizosphere soils and conduct potential nitrification assays in our lab. Students will gain experience in experimental design, greenhouse experiments, soil microbiology, laboratory analyses, and data collection and analysis.

9. **Project:** Investigating polyhydroxy alkenoates with synthetic biology
   Mentor: William Cordell | **Faculty member:** Brian Pfleger
   Location: University of Wisconsin at Madison
   Virtual or in-person? In-person preferred if permitted but can arrange virtual

Polyhydroxy alkenoates (PHAs) are polymer subunits produced from microbes that have potential applications in biodegradable plastics. PHA copolymers, made of two different PHA subunits, have unique biocompatible, biodegradable, and flexible properties making them suitable for more advanced applications like medical device components. Our research direction is twofold, optimizing the production and quantification of PHA monomers and designing novel PHA production pathways for production of PHA copolymers in *E. coli* from a single carbon source. The student project will begin with the planning of the desired PHA copolymer pathway. Virtually the student will research the needed genes and prepare a file for gene synthesis. If in-person research is allowed, the student will clone the genes into a plasmid expression vector for production cultures. The primary virtual component for the student in this process will be to design a code for easy analysis of the PHA products.

10. **Project:** Nitrogen cycling in miscanthus
    Mentor: Di Liang | **Faculty member:** Angela Kent
    Location: University of Illinois Urbana-Champaign
    Virtual or in-person? In-person preferred if permitted but can arrange virtual

Bradyrhizobium is a diverse bacterial genus harboring versatile biogeochemical functions related to nitrogen and carbon cycling such as N_2 fixation, photosynthesis, nitrification, and denitrification. The overall goal of this project is to understand the role of *Bradyrhizobium* in N cycling and sustainability of miscanthus cropping systems. We will extract endophytic and soil DNA from parts of the plant, rhizosphere and bulk soils of miscanthus. We will then characterize *Bradyrhizobium* community composition by targeting the *nifH* gene using Illumina MiSeq for sequencing. To isolate *Bradyrhizobium*, endophytes and soil bacteria cell extracts will be plated and the isolates will be confirmed on 16S rRNA gene sequencing using Sanger sequencing. Students will gain experience in experimental design, microbiology, laboratory analyses, and data collection and analysis.