## Undergraduate Student, Graduate Student, and Postdoctoral Training Plans:

The ***Doctoral student*** in the Biomedical Sciences Program will work with Dr. Britton and Dr. Greathouse to learn how to setup, run, and maintain the MBRA system. For the first two weeks of the project, Dr. Greathouse and the doctoral student will work with Dr. Britton at his lab at Baylor College of Medicine to learn how to setup and use the MBRA system. This training will include education on each apparatus contained within the MBRA, followed by observation of staff/students in their use of the MBRA to conduct experiments, and finally conducting test experiments on our own with supervision. Following this training, Dr. Greathouse and the doctoral student will setup the MBRA system at Baylor University. Dr. Greathouse will train the doctoral student in microbial DNA extraction, sequencing, bioinformatic analysis, and statistics. Dr. Britton will provide training in using the MBRA system and conducting bacterial invasion experiments. During the second and third years, the doctoral student will work part time with Dr. Lavado to learn how to perform fatty acid extraction and analysis. Further, all mentors will provide training in grant writing, manuscript preparation, presentation skills, and opportunities to travel to present at national conferences. Dr. Greathouse, Dr. Lavado, and Dr. Britton will continue to co-mentor the BMS doctoral student throughout his/her research until completion of their degree.

The ***Postdoctoral fellow*** will work with Dr. Greathouse and Dr. Chia to learn how to use the MBRA system in a similar manner to the training of the doctoral student. For the first year, the postdoctoral fellow will utilize the microbial sequence data for bioinformatic analysis. They will also work with Dr. Lavado to integrate microbial metabolite data with the sequencing data. In the last 2 years of this research project, the postdoctoral fellow will work with Dr. Chia to integrate the microbial and metabolite data to construct an interaction landscape from response to dietary prebiotics. Next, they will use the interaction landscape to identify which prebiotic fibers can support the microbes capable of evicting or preventing *C. difficile* or ETBF engraftment. Dr. Greathouse and Dr. Chia will also provide training in grant writing, manuscript preparation, presentation skills, and opportunities to travel to present at national conferences.

## Impact on transformational undergraduate education

*Background*

Beginning in 2009, the Department of Biology began developing course-based undergraduate research experiences (CURES) to transform the ways in which our students learn. In line with transformational learning, we believe that the world needs a new generation of trained biologists to solve the “Grand Challenges” of our world. These challenges include understanding the organism’s role in the environment, assembling the “Tree of Life”, developing tools and models to understand the dynamic interconnected systems of life, understanding genomes and how they produce organisms, and understanding the paradox of stability and change in evolutionary history. These challenges are applicable for global health, sustainable agriculture, clean air, water, and energy. These initiatives have continued to grow and currently include approximate 25% of our introductory biology lab sections and several upper-level courses. **The MBRA will**

**enrich these courses by allowing students to design creative and relevant experiments and to analyze large genomic data sets.**

*Summary of Research Topics*

1. BIO 1406: Analysis of soil microbial communities for types and concentrations of bacteriophage or specific host organisms related to various locations or conditions.
2. BIO 1106: Analysis of soil microbial communities and experimental design using additions of different types of ciliates, microbes, or pollutant.
3. Independent projects: This technology will provide the opportunity to have large data sets generated in several research labs. Current examples include water samples and sewage effluent samples. The data could also be generated in labs studying cancer or the human microbiome. This technology is a powerful tool that students can use to analyze many different types of samples. The end result of these experiments is a DNA sample that needs bioinformatic analysis. The BIO 1105/1106 curriculum is primed to include this large-scale research analysis, as well as the undergraduate researchers that are mentored in the Department of Biology each year.

*Description*

1. There are at least 2 research questions that we would address in the undergraduate lab courses in the Department of Biology with this MBRA technology. **First, students in the SEA-PHAGES program (a program first initiated through a Science Education Alliance grant from Howard Hughes Medical Center) could use a soil lysate to not only search for individual bacteriophages, but with the use of the MBRA, students could ask sophisticated questions about what happens to the bacterial community with the addition of certain phages or when the environmental parameters change (e.g. pH or temperature). This program has achieved success in training undergraduates in microbiology and bioinformatics.** The interesting questions concerning how the phage population changes over time and under different conditions could also be addressed. Community interactions are important in the soil, and known to be important in soil health and plant growth. Baylor undergraduates have archived 168 Arthrobacter phage samples and published 15 phage genomes. **This research has generated dozens of publications within the SEA-PHAGES community, many with undergraduate authors.** Having access to this bioreactor would allow for further experiments and increase the research experience and productivity of our undergraduate students. Phage genomic research holds promise for new innovations in human health and ecology. From the early days, phage biology has led the way to discovery and advances in molecular biology and modern biotechnology. For example, the study of just one type of phage (phage lambda), led to discoveries of DNA binding proteins, basic mechanisms of gene regulation and regulatory networks, the

mechanism of site-specific recombination, and much more. Early genetic engineering used phage lambda vectors to clone DNA fragments and many new technologies followed. Phage are the most abundant biological entities on Earth and their diversity is bound to reveal many more discoveries. Phage have the ability to lyse (kill) their bacterial host and this genetic mechanism has led to the development of phage therapy, a method used to treat infections. **This bioreactor would allow students to model the effect of phage therapy in addition to other treatments, such as antibiotics.** These advanced experiments allow for creative experimental design and a true ownership of a research project. Both of these characters are important for a transformative education. Reports indicate that CURE-like programs result in a higher retention in the sciences. Overall, having the MBRA to process student samples for this course would provide a tool for us to use to scale-up, serve more students, and make more discoveries.

2. **The second introductory lab course that will benefit from the MBRA is focused on the global challenge of soil.** In terms of food security for our planet, soil is the limiting factor. It is a grand challenge to determine how to recognize, produce, and maintain healthy soil. Soil is also a reservoir for carbon and therefore plays a fundamental role in determining the outcomes of another grand challenge, climate change.

   One of the areas in soil research that is not well-understood are the soil microbial ecosystems. We do not know which organisms are present in our soils or the roles that they play in nutrient recycling. Using this challenge, we are training introductory biology students to think like scientists and develop research skills that will address the soil microbiome. The recycling of nutrients and the health of the soil determines the health of plants and ultimately all animals which rely on plants for the basis of the food chain. Baylor students focus on the biology of a large and diverse group of single celled organisms, the ciliates. Ciliates are known to play an essential role in the soil ecosystem as predators of bacteria and other microorganisms. Due to the difficulty of culturing and classifying the ciliates, only around 3500 species have been described, but their specific role in the ecosystem is unclear. As next generation metagenomic techniques have improved, interest has grown in determining "who" is in the soil and ultimately what role are they playing in the ecosystem. The mini bioreactor will allow students to explore multiple samples and work on the most challenging questions by analyzing the environmental DNA on a large scale. The opportunity to provide this level of research to our students is exciting and will open doors for more transformational learning experiences.

3. Over 100 undergraduates participate in research under a mentor in the Department of Biology. **Almost every area of research has a bioinformatic component and this MBRA would allow undergraduates to participate in this community level of analysis.** It is a perfect system to consider for examining the

biological component of water quality, sewage effluent, and the dynamic microbiota of any system.