

Plant Synthetic Nanobiology Center

Strategic Plan Theme: Stewardship and Sustainability

Funding Level: More than \$5 million

Facility Needs: New facilities will be needed

Submitting Unit: PRL/BMB/PLB

Collaborating colleges/departments/units involved with this proposal.

Colleges: CNS CANR, EGR; Departments: HRT PRL BMB PLB PSMS MMG PRI CEM ECE CHEMS
CMSE BME ME

What is the proposal's big theme or idea?

We propose to build a center around the topic theme of Plant Synthetic Nanobiology that will emphasize the development and application of a number of cutting-edge technologies for the control and enhancement of model plants and crop species from the nanoscale to the holobiont. Center development goals will cover topics from delivery of nanoparticles and associated cargo into plants (Phytonanotechnology), tailored engineering of plant cells to make new functionalized nanostructures inside living photosynthetic tissues and organelles, methods for effective transfer of modules of specialized metabolism into plants (Plant Synthetic Biology) or into soil, compartmentalization of beneficial metabolic processes in the microbiome associated with surface tissues (e.g. the rhizosphere) and associated impacts/risks to the quality of soil, food, and environment. The Plant Synthetic Nanobiology Center will capitalize upon recent revolutionary advances in the application of microbiome engineering and micro and nano-scale technologies for the manipulation, control, and enhancement of biological systems, but which have been underutilized for plant engineering.

What is the proposal's goal?

Establish first-in-kind Plant Synthetic Nanobiology Center. The proposed Center would be well-positioned to leverage existing strengths in the leadership, expertise, and facilities at Michigan State University. Center activities would be focused around catalyzing new, cross-disciplinary initiatives for cutting-edge research for technologies related to the strategic themes of Stewardship & Sustainability and Sustainable Health. The Plant Synthetic Nanobiology Center will capitalize upon existing expertise and activities on campus and provide a level of foundational organization and support to synergize efforts across a diverse group of MSU scientists ranging from synthetic biologists, plant biochemists, biophysicists, computational scientists, microbiologists, structural biologists, advanced imaging scientists, phenomics initiatives, and soil and materials sciences.

Define the significance, or impact of your big idea.

To our knowledge, there is no comparable effort of integrating plant synthetic biology, soil science, microbiology, biotechnology, and nanotechnology being pursued in a concerted manner in the United States, perhaps globally, providing an opportunity for MSU to take a leadership role. The Plant Synthetic Nanobiology Center will increase the impact of MSU researchers by coordinating research efforts across multiple disciplines including those outlined above, but can also leverage these multi-disciplinary teams for ambitious and high-reward projects outside of the scope of individual laboratories. For example, compartmentalization tightly controlled at a developmental and tissue-specific levels can provide a potentially ideal environment to protect and improve delicate metabolic processes such as nitrogen fixation. Through engineering and delivery of specialized compartments to plants (e.g., bacterial microcompartments, symbiotic microbial partners),

processes that are normally incompatible with plant metabolism (e.g., the sensitivity of nitrogen fixation to oxygen that is produced by photosynthesis) can be protected and operated simultaneously. The capacity for plants to fix atmospheric nitrogen that is sufficient for their needs has huge implications for reducing energy-intensive crop inputs, reducing pollution from agricultural practices, and improving sustainability. Similar benefits of compartmentalization on the micro-to-nano scale can be leveraged towards the production of sustainable compounds important for human nutrition and therapy.

Who will be impacted?

We anticipate that the Plant Synthetic Nanobiology Center would provide opportunities for student training and engagement through formal programmatic efforts and by supporting research opportunities for undergraduate and graduate students across a diverse range of university departments and units. The Synthetic Biology CMB symposium to be held on campus October 21, 2022 provides an illustrative example: this student-driven scientific event that will include Plant Synthetic Biology and emphasize different careers in STEM is a model that the Center could support/emulate to make the effort enduring in future years. To align Center goals with the University priorities in DEI, preliminary discussions on engagement of students from tribal colleges have been explored. We propose to expand upon existing faculty connections and engagement efforts, particularly those initiated through BMB, with these institutions to specifically exchange ideas with, and provide opportunities for, underrepresented individuals from Native/Indigenous communities should this proposal be considered for Phase Three.

What does sustainability for your proposal look like?

To our knowledge, there is no other serious concerted effort in the country/world in this focal area. MSU is both well-positioned with existing faculty to take the lead, and the presence of the Plant Synthetic Nanobiology Center would increase the competitiveness of the University to recruit world-class scientists with complementary expertise. Because of existing expertise on campus, it is likely that efforts organized under the Plant Synthetic Nanobiology Center could make rapid progress and be competitive for external funding to sustain these efforts after an initial investment. The impacts of the Plant Synthetic Nanobiology Center align well with multiple Strategic Plan Objectives, including Staff & Faculty Success, Stewardship & Sustainability, and Sustainable Health. Integration of graduate and undergraduate students into the Center will also provide opportunities to target the Objective of Student Success.