ABSTRACT

The model moss species, *Physcomitrium patens* (*P. patens*), provides a unique system for investigating plant development, evolution, and physiology and also serves as an excellent chassis for synthetic biology. Because of the unique phylogeny of *P. patens* as a bryophyte, and sister to the vascular plants, allows opportunity for understanding shared traits among embryophytic life, early terrestrialization of plants on land 500 million years ago, and the divergences/convergences of plant traits since then. The high prevalence and global distribution of plants and fungi today can in-part be attributed to their long-standing relationship which predates early terrestrialization, and who's early collaboration likely reduced the initial barriers for both kingdoms to thrive on land. Here, the interaction between *P. patens* and fungi in the Mortierellaceae family are cocultured together to characterize their physiological and transcriptional responses. These analyses are used to explore possible long-standing interactions between plants and fungi, identify essential traits in plant-fungal communication, and provide foundational exploration into coculturing these systems for metabolite production. *P. patens* is an effective system for the production of heterologous metabolites, particularly diterpenes, because of its relatively low chemical diversity, many developed synthetic biological tools, and similar machinery/compartments to vascular plants. The large pool of diterpene chemodiversity and bioactivity known today affords these compounds with high humanitarian and economic value, making it an excellent metabolite to develop for expression in *P. patens*. Work presented in this dissertation focuses on evaluating the effectiveness of a coculture system with *P. patens* and Mortierellaceae, explores long-standing relationships among plants and fungi, provides schematic and initial testing of novel synthetic biological tools for improving *P. patens* as a chassis, and evaluates complexities among the total diterpene landscape to-date.