Signaling and Interactions in the Phytobiome
Information for Spring Semester 2021

PP 590/790

3 Credit Hours

Prerequisites. The course is intended for graduate students and provides an understanding of biochemical interactions between plants, microbes, and environment. Undergraduate students can be admitted but are required to demonstrate a general understanding of principles in plant biology, microbiology, or biochemistry (e.g., MB 351 and BCH 451 or by instructor permission, contact Dr. Oliver Baars, obaars@ncsu.edu).

Meeting Time and Place. Mon/Wed 10:15-11:30 AM, Room TBD

Instructor: Dr. Oliver Baars
Department of Entomology and Plant Pathology,
Center for Integrated Fungal Research
Email: obaars@ncsu.edu
Office Location: 223 Partners III or by Zoom
Office Hours: By Appointment

Course description. The course teaches signaling and metabolic interactions involved in symbioses between plants and their microbial and arthropod partners. Lectures cover concepts (e.g., evolution related to environmental constraints and drivers of symbiosis, growth-differentiation-balance hypothesis, impact on agriculture and environment), specific examples of well-studied interactions, and approaches and methods based on recent publications. A section of the course is dedicated to current developments in analytical methods, including metabolomics, and experimental approaches.

Learning Outcomes
The overall goal of the course is to provide students with an understanding how phytobiome communities can affect and enhance plant production based on an exchange of signals/cues, competition, and nutrients. After successful completion of the course, students will be able to:

1) Identify limitations on biological productivity related to soil chemistry and resource availability and provide examples of how this can affect phytobiome interactions
2) Describe how soil microbiota and activity change from bulk soil to the rhizosphere and intimately root-associated microbes
3) Discuss how microbial metabolic functions can impact plant productivity, pathogen resilience, and biogeochemical cycles
4) Discuss how communication between plants and their microbial or animal partners occurs on a molecular basis and how these communication mechanisms can be hijacked during competition
5) Provide specific examples of metabolic interactions in the rhizosphere

6) Identify classes of various secondary metabolites produced by plants, fungi, and bacteria
7) Suggest analytical and experimental approaches to study selected phytobiome interactions and discuss advantages and limitations inherent to different methods
8) Review and critique current research papers in the field of phytobiome interactions
9) Identify major functions of arthropods and their plant interactions on a molecular level. Discuss communication systems involved in plant-arthropod cross-talk.

Course Structure. Course contents will be taught in two lectures per week. The class will read a research paper or review in preparation for a set of upcoming lectures during which the course teaches major concepts, approaches, and questions introduced in or related to these papers. In addition, there will be student lead presentations of selected recent research papers and opportunities to revisit and expand on the lecture contents in a workshop format. Selected guest lecturers will speak on specific aspects, such as agricultural application of biologicals and biological engineering. Depending on the number of students, the course will include an experiment shown in class or done by the students, for example to improve plant growth in pot experiments under nutrient or drought stress.

Grading

Component	Weight	Details
Participation	50 pts	Active participation during lectures
Midterm exam 1	50 pts	Covers topics from beginning to Midterm exam 1
Midterm exam 2	50 pts	Covers topics from Midterm exam 1 to Midterm exam 2
Final exam	100 pts	Covers all topics
Student presentation	Optional 50 pts – can be used by the student to improve grade	Review and discuss a recent publication related to the lecture topics in a student-led presentation
Research proposal	100 pts only for PP790 students	Students will write a 1-2 page research proposal for a topic of their choice related to the lecture contents

Tentative Course Schedule

Lectures take place in the spring semester of each year. The schedule shows the specific dates during for the spring semester 2021.

Date	Subject
M 01/11	**Lecture 1:** Overview and introductory concepts • Primary production and limitation / co-limitation • Functions of exudates and secondary metabolites • Genotype and phenotype • Resource Use Efficiency and Growth-Differentiation-Balance hypothesis
W 01/13	**Lecture 2:** How do beneficial microbes work? • Plant growth promoting mechanisms • Biocontrol mechanisms • Abiotic stress resilience
M 01/18	**Lecture 3:** How do plants influence the rhizosphere microbiome and how are signals perceived? • Rhizosphere effect • Signal reception • Signals and cues
W 01/20	**Lecture 4:** Critical signaling events in the rhizosphere • How microbes find their host • Importance of quorum sensing and biofilms • Indirect Biocontrol: Induced Systemic Resistance
M 01/25	**Lecture 5:** Soil chemistry effects on plant-microbe interactions • Nutrient and pH buffering capacity of soil • Water availability • Role of soil organic matter
W 01/27	**Lecture 6:** Disease suppressive soils
M 02/01	MLK day – no classes, university is closed
	Questions and exercises, Mid-Term Exam 1
W 02/10	**Student presentations 1 & 2**
W 02/03	**Lecture 7:** Nitrogen fixation symbiosis

	• Nutrient exchange and the common SYM pathway • Evolution of symbioses • Biogeochemical impacts
M 02/08	**Lecture 8:** Mycorrhizae, agricultural products • AM fungal symbiosis vs. N-fixing symbiosis • Environmental and agricultural importance of mycorrhizae • Commercial development and use of Ag-Biologicals
M 02/15	**Lecture 9:** Examples of biocontrol and plant growth promoting fungi and bacteria - Trichoderma and Pseudomonas spp.
W 02/17	**Lecture 10:** Plant endophytes • Plant hormones and abiotic stress resilience • Endophytes vs epiphytes • Effect of endophytes on plant stress regulation
M 02/22	**Questions and exercises; Experiment**: Improving plant growth in a low nutrient soil / allelochemicals
W 02/24	**Guest lecture:** Agricultural products and field applications
	Student presentations 3 & 4
M 03/01	**Lecture 11:** Bottom-up vs top-down control; plant-protist interactions
W 03/03	**Lecture 12:** Arthropods – Herbivory • Constitutive defense • Herbivory signals and response • Direct defense response
M 03/08	**Lecture 13:** Arthropods – Alliances and Cheaters • Pollinators • Carnivorous or parasitoid arthropods • Cheaters
W 03/10	**Lecture 14:** Plant-plant interactions • Perception of other plants • Competition: confront, avoid, or tolerate • Cooperation: stress cues, resource sharing

M 03/15	Spring Break
W 03/17	Spring Break
M 03/22	**Questions and exercises; Mid-term exam 2**
W 03/24	**Student presentations 5 & 6**
M 03/29	**Lecture 15:** Natural product structures, gene organization and genome mining for secondary metabolites
W 03/31	**Lecture 16:** Classes of plant secondary metabolites and high molecular weight compounds in interactions
M 04/05	**Guest lecture 2:** Engineering approaches
W 04/07	**Lecture 17:** Metabolomics – how to detect molecules and data analysis
M 04/12	**Lecture 18:** '-omics' methods for analysis of plant-microbe interactions
W 04/14	**Lecture 19:** Experimental approaches • Combining -omics approaches • Metabolomics approaches • Hypothesis driven vs discovery research Question-specific experimental approaches and assays
M 04/19	**Workshop: metabolomics data analysis**
W 04/21	**Questions and exercises**
M 04/26	**Final exam**
W 04/28	**Lecture 20:** Discussion of experiment outcomes and summary