College of Natural Science
MICHIGAN STATE UNIVERSITY

Departments: Biochemistry and Molecular Biology, Plant Biology and the Molecular Plant Sciences Program

BMB 960 Sect 301 "Plant Biotechnology Research Forum"

Credit Hours Total Credits: 1 Discussion and presentation: 1.5 hours
Course meeting day and time: Wednesdays 1:00-2:20
Course location: MPS 3220
Course website address: https://d2l.msu.edu/d2l/home/2068955
Course Modality: In person

Instructors

Instructor Information

Instructor(s)
Rob Last Danny Ducat Björn Hamberger
Office: MPS 3230, or by Zoom Personal meeting ID 585 243 9276 https://msu.zoom.us/j/5852439276
Office hours: Please contact the instructors by email for arrangements. 24 hours may be needed to respond to student emails.
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Course Information, Objectives and General Course Information

This is an advanced seminar focusing on primary scientific literature in the broad topic area of plant biotechnology. Student-led presentation and discussions related to selected materials are a major component of the course. The course is tightly integrated with an Annual Symposium (Plant Biotechnology for Health and Sustainability) that will next be held on October 18, 2024 on MSU campus in East Lansing, MI. Students are expected to attend this Symposium (no registration cost) and a primary goal of the course is to enhance the value of student's participation in this event. For examples of past Symposium events, see: https://plantmetabolism.natsci.msu.edu/events/past-symposia-agendas/index.aspx.

Plant biotechnology is a broad topic area that can encompass many scientific fields and disciplines. Topic areas for classroom discussion are generally aligned with current research related to the use of photosynthetic organisms to address modern problems in human health and environmental sustainability. Topic areas in past years of this course have included: boosting lipid productivity in oleaginous microalga; synthetic biology and microbial biosynthesis from industrial perspective; plant abiotic stress tolerance as agronomic trait and its quantification; electronically controlled microorganisms; the organization, function and evolution of plant metabolism, and synthetic biology as it relates to food/oxygen production in future of long-range space exploration.

This year, students who are participating in a NIH T32 graduate training program in plant biotechnology '*Plants for Health and Sustainability*' (https://plantmetabolism.natsci.msu.edu/) selected the topic areas that will be the focus of both BMB 960-301 and the accompanying Symposium. These topic areas are related directly to PBHS relevant research and the students, and whenever possible, their mentors will co-deliver the MSU research talks at the symposium, after joining the classroom discussion of related research from the field. This is an excellent opportunity to explore research in the departments, build networks and learn about new technologies. The primary goals of BMB 960-301 are to improve the breadth of knowledge of students working in plant-related fields, increase critical thinking skills through evaluation of the scientific literature, improve oral scientific communication skillsets, and to enable students to be able to fully engage with the affiliated Symposium.

Format: The class will meet once a week. During periods, a student participant will deliver a 30-40 minute presentations with focus on the selected papers and lead the class members through detailed discussion based upon the assigned topics. The topics and papers will be selected based upon the topics contributed by PBHS students (see above), and relevant for the background of Symposium speakers. Therefore, topics vary each year. A single paper will be assigned for all students, but background information will be provided in the form of review articles. Students are encouraged to broaden the discussion beyond the boundaries of the paper itself - please feel free to include background papers papers, book chapters or online resources in your reading and for the preparation of the presentation. Active questions and discussion of the material is encouraged during the presentation period.

Suggested format for student presentations is: 5' of introduction, suitable for students familiar with molecular techniques but approachable for students with a variety of backgrounds. 25' of discussion of key experiments of the selected article, making sure to highlight both basic biological insight and applications when appropriate. 10' of conclusions including ideas for future experimental and engineering approaches, insights and ideas for your research that the work gave you or anything else that might be of interest to the class members. Approximately 15'+ of additional discussion with the class are budgeted for each class period.

Prerequisite: If you are not a declared Biochemistry graduate student, you will need to submit the online override request form (http://bmb.natsci.msu.edu/undergraduate/override-request-special-permissions-form/) and then contact the course coordinator (Danny Ducat; ducatdan@msu.edu for permission to enroll. Enrollment will be limited to 14 students.

Course Philosophy/Structure: A core value of this course and the affiliated PBHS Training Program is to continuously reiterate activities based on the changing needs and interests of emerging young scientists in the area of plant biotechnology. As such, this course can best serve the students if there is an invested interest and feedback cycle from students to the administrators (e.g., Course Coordinator, Danny Ducat). Each semester, the last class period will be reserved for a discussion and evaluation of the course and the associated Symposium. We expect that each student will actively participate in the symposium.

Grading: Grades are based upon class participation (30%) and the research presentation (70%). Course materials will be made available to enrolled students at D2L.msu.edu.

Ethics policy: The use of AI, e.g., chat-gpt is not prohibited but will need appropriate indication in the documents, checking of facts and of references and resources given.

Course Outline/Schedule

August 28: Welcome to the class, goals and assignments

September 4, Max
Topic: Metabolic engineering and precursor pools (related to the symposium presentation by Lucas and Bjoern)
Title: Metabolic engineering of tomato fruit for optimized terpenoid production.
(Papers were selected that investigate the impact of the pathways upstream of the engineered target compounds and how their engineering can improve productivity by providing boosted precursors.)

Assigned reading: Gutensohn et al., 2021, Overcoming Bottlenecks for Metabolic Engineering of Sesquiterpene Production in Tomato Fruits https://www.frontiersin.org/journals/plant-science/articles/10.3389/fpls.2021.691754/full
Other paper examples:
Chen et al., 2023, Plastidial engineering with coupled farnesyl diphosphate pool reconstitution and enhancement for sesquiterpene biosynthesis in tomato fruit https://www.sciencedirect.com/science/article/pii/S1096717623000393?via%3Dihub
Kruse et al., 2024, Improved production of the antidiabetic metabolite montbretin A in Nicotiana benthamiana: discovery, characterization, and use of Crocosmia shikimate shunt genes https://onlinelibrary.wiley.com/doi/10.1111/tpj.16528

September 11, Asia
Topic: Central carbon metabolism, especially photosynthesis and related processes, under diverse and challenging environmental conditions (related to the symposium presentation by Anne and Berkley)
Assigned reading: "Rubisco is evolving for improved catalytic efficiency and CO2 assimilation in plants" – Bouvier et al. 2023 PNAS (https://doi.org/10.1073/pnas.2321050121).
Other papers:
For students who would like some background in photosynthesis: "Cell biology of photosynthesis over geologic time" - Flamholz and Shih 2020 Current Biology (https://doi.org/10.1016/j.cub.2020.01.076).
Anne specifically plans to present about her work on the carbon-concentrating mechanism of the extremophilic alga Cyanidioschyzon merolae and she recommends this "primer" article to help explain relevant background to the students in the course with little background in photosynthesis.
If you are interested in metabolic compartmentation: "A repeat protein links Rubisco to form the eukaryotic carbon-concentrating organelle" – Mackinder et al. 2016 PNAS (https://doi.org/10.1073/pnas.1522866113).

September 18, Elliot
Topic: Biosynthesis and regulation of maize phenolic compounds (related to the minisymposium presentation by Lina and Erich)

Assigned reading: Zhou et al. 2019, Metabolome-Scale Genome-Wide Association Studies Reveal Chemical Diversity and Genetic Control of Maize Specialized Metabolites (https://pubmed.ncbi.nlm.nih.gov/30923231/)

Background reading:
Reviews:

Tibbs Cortes, L., Zhang, Z., and Yu, J. 2021, Status and prospects of genome-wide association studies in plants. Plant Genome 14, e20077 - https://acsess.onlinelibrary.wiley.com/doi/epdf/10.1002/tpg2.20077
Vogt, T. (2010). Phenylpropanoid biosynthesis. Mol Plant 3, 2-20. - https://www.cell.com/action/showPdf?pii=S1674-2052%2814%2960394-4

Tibbs Cortes, L., Zhang, Z., and Yu, J. 2021, Status and prospects of genome-wide association studies in plants. Plant Genome 14, e20077 - https://acsess.onlinelibrary.wiley.com/doi/epdf/10.1002/tpg2.20077

Medeiros, D.B., Brotman, Y., and Fernie, A.R. 2021, The utility of metabolomics as a tool to inform maize biology. Plant Comm 2. https://www.cell.com/plant-communications/fulltext/S2590-3462(21)00065-1

An earlier and broader maize metabolism GWAS paper:
Wen et al. 2014, Metabolome-based genome-wide association study of maize kernel leads to novel biochemical insights. Nat. Comm. https://www.nature.com/articles/ncomms4438

September 25, Grace
Topic: microbial physiology and functions (related to the minisymposium talk by Imani)
Assigned reading: Herpell et al. 2023, Phyllosphere symbiont promotes plant growth through ACC deaminase production https://www.nature.com/articles/s41396-023-01428-7

Other papers:
Moon and Ali, 2022, ACC deaminase review https://link.springer.com/article/10.1007/s40626-022-00237-1
Ali et al., 2014, Amelioration of salt stress
https://www.sciencedirect.com/science/article/pii/S0981942814001375?via%3Dihub

October 2, Luke
Topic: How microbiome organisms promote root growth and plant physiology (related to the minisymposium talk by Kevin)
Assigned reading: Castrillo et al., 2017, Root microbiota drive direct integration of phosphate stress and immunity, https://www.nature.com/articles/nature21417

Other papers:
Finkel et al., 2020, A single bacterial genus maintains root growth in a complex microbiome, https://www.nature.com/articles/s41586-020-2778-7
Bhosale et al., 2018, A mechanistic framework for auxin dependent Arabidopsis root hair elongation to low external phosphate, https://www.nature.com/articles/s41467-018-03851-3

October 9, Maddie
Topic: Impact of genetic interaction definitions on predictions of fitness and co-function in yeast and Arabidopsis (related to the minisymposium talk by Kenia)
Assigned Reading: Costanzo et al. 2016, A global genetic interaction network maps a wiring diagram of cellular function: https://doi.org/10.1126/science.aaf142

Other papers:
Highly recommended background reading in Machine Learning:

Azodi et al. 2020, Opening the Black Box: Interpretable Machine Learning for Geneticists https://doi.org/10.1016/j.tig.2020.03.005
Background on genetic interactions: Mani et al. 2008, Defining genetic interaction. https://doi.org/10.1073/pnas.0712255105

October 16, Jacob
Topic: Leveraging natural genetic variation to decode plant specialized metabolism (related to the minisymposium talk by Miles)
Assigned reading: Brachi et al., 2015, Coselected genes determine adaptive variation in herbivore resistance throughout the native range of Arabidopsis thaliana. https://doi.org/10.1073/pnas.1421416112

Other papers:
A review:
Li et al., Decoding plant specialized metabolism: new mechanistic insights. https://doi.org/10.1016/j.tplants.2023.11.015

Another primary research article:
Shirai et al., Positive selective sweeps of epigenetic mutations regulating specialized metabolites in plants. https://www.genome.org/cgi/doi/10.1101/gr.271726.120

Mini-Symposium Friday, 1-5 PM Oct 18, 2024.
Natural Sciences Building Classroom 116 (north side of building, nearer to Grand River Avenue).

October 23, Sepideh
Topic: Plant Biosynthetic Gene Clusters
Assigned reading: Yang et al. 2024, Variation in a Poaceae-conserved fatty acid metabolic gene cluster controls rice yield by regulating male fertility. Nature Communications volume 15, Article number: 6663 (2024) https://www.nature.com/articles/s41467-024-51145-8

Two relatively recent reviews:
Smit and Litchman 2022, Plant biosynthetic gene clusters in the context of metabolic evolution. Nat Prod Rep. https://pubs.rsc.org/en/content/articlelanding/2022/np/d2np00005a
Polturak et al. 2022, New and emerging concepts in the evolution and function of plant biosynthetic gene clusters. Curr. Opin. Green and Sustainable Chem. https://doi.org/10.1016/j.cogsc.2021.100568

A recent research paper on BGC evolution in Solanaceae:
Kerwin et al, 2024, Tomato root specialized metabolites evolved through gene duplication and regulatory divergence within a biosynthetic gene cluster. Sci Advances https://www.science.org/doi/full/10.1126/sciadv.adn3991

Other Course Policies

Disability Access:

Students must inform the instructor of any accommodations needed. Information related to disability access is available on the Resource Center for Persons with Disabilities (RCPD) website. Students: to make an appointment with a specialist, call: (517) 353-9642 Or TTY: (517) 355-1293 or visit the RCPD website.

Americans with Disabilities Act Accommodations:

"Michigan State University is committed to providing equal opportunity for participation in all programs, services and activities. Requests for accommodations by persons with disabilities may be made by contacting the Resource Center for Persons with Disabilities at 517-884-RCPD or on the web at rcpd.msu.edu. Once your eligibility for an accommodation has been determined, you will be issued a verified individual services accommodation ("VISA") form. Please present this form to me at the start of the term and/or two weeks prior to the accommodation date (test, project, etc.). Requests received after this date will be honored whenever possible."

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Syllabus Signature Page

Instructors: Rob Last, Danny Ducat, Björn Hamberger

Course: BMB 960 Sect 301 "Plant Biotechnology Research Forum"
Semester: Fall Semester 2024

I _____ acknowledge that I received and even read a copy of the course syllabus for the class mentioned above. For this I am aware that I can and should inform the instructor that I earned ice cream from the MSU dairy store for the next meeting. I will let the instructor know if I have any dietary restrictions.

I understand the course requirements and the policies entailed in this document. I further understand that my participation and conduct in this course is a key contributor to my success and the success of this course.

I pledge to come to class prepared and to always conduct myself respectfully.

_____
Print Full Name

_____ _____
Signature Date

We collectively acknowledge that Michigan State University occupies the ancestral, traditional, and contemporary Lands of the Anishinaabeg – Three Fires Confederacy of Ojibwe, Odawa, and Potawatomi peoples. In particular, the University resides on Land ceded in the 1819 Treaty of Saginaw. We recognize, support, and advocate for the sovereignty of Michigan's twelve federally-recognized Indian nations, for historic Indigenous communities in Michigan, for Indigenous individuals and communities who live here now, and for those who were forcibly removed from their Homelands. By offering this Land Acknowledgement, we affirm Indigenous sovereignty and will work to hold Michigan State University more accountable to the needs of American Indian and Indigenous peoples.