CHEMICAL ECOLOGY

BIOL 7800/
2-4 credits, Spring 2025

Course Instructor

Dr. Jordan Dowell
Email: jdowell@lsu.edu
Office: LSA 210A
Office Hours: TBD

Course Description

- This course investigates the role of chemistry in mediating interactions among various organisms alongside developing practical analytical chemistry skills and intuition. We will discuss the diversity of species interactions and chemical compounds in terrestrial and aquatic systems and the methods used to detect those compounds. We will cover defensive and offensive chemistry mediating antagonistic interactions, the evolution of defenses, chemicals mediating mutualisms, competition, and sociality, and the physiology of chemical production and recognition. This course will include paper discussions of relevant recent literature and exposure to laboratory techniques for analysis of small molecules relevant to chemical ecology and comparative biochemistry.

Course Goals and Learning Objectives

Upon completion of the course, students will be able to:

1. Categorize ecological interactions.
2. Infer potential chemical mechanisms by which ecological interactions are mediated.
3. Discuss these chemically mediated mechanisms in light of evolutionary theory.
4. Construct potential agricultural/industrial/conservation applications based on principles of chemical ecology.
5. Recognize the general structures of organic molecules.
6. Recognize the relationship between structure and function in chemically mediated interactions.
7. Apply several analytical, behavioral, and experimental techniques to analyze chemical compounds that mediate ecological interactions.
8. Synthesize findings from original scientific research in chemical ecology considering primary literature.

Prerequisites

As this is a graduate course hosted through the biology department, there is an expectation of exposure to courses required of an undergraduate biology major, e.g., A grade of "C" or better in one majors-level biology and ecology or evolution course, one semester of analytical chemistry or organic chemistry for majors or nonmajors or equivalents. If students feel that they do not meet these expectations, please see Dr. Dowell for links to external resources to help you get up to speed.

Class Meetings

Classroom meetings twice per week (80 minutes each). The first classroom meeting per week will be a traditional lecture from Dr. Dowell. In contrast, the second classroom meeting will begin with a ~15-minute student-led presentation of a primary source relating to topics covered in the previous lecture, followed by an in-depth discussion.

Moodle Site

There is a course website available through Moodle (https://moodle.lsu.edu) that will be used to post materials for the course, including the syllabus, lecture slides, and grades.

Course Text

This course will use the primary source reading materials (e.g. journal articles) provided by the instructor through Moodle.

Methods of Evaluation and Grading System

Grades will be assigned on the following scale without rounding or the use of plus/minus grades:

A: 90-100% B: 80-89% C: 70-79% D: 60-69% F<60%

The grade for this course will be based on the following components:

(1) **One take-home midterm exam** (15%). The first exam involves creating short consulting research plans based on situational prompts.

(2) **Take-home final exam component** (30%) The final exam will consist of writing a full **Division of Environmental Biology (DEB) STAR (Special Targeted Awards for Research)** style proposal to address a question of their choice incorporating chemical ecology. Proposals with total budgets of $400,000 or less may be identified with the designation "STAR. STAR Grants may address any topic appropriate for DEB core programs: Ecosystem Science, Evolutionary Processes, Population and Community Ecology, and Systematics and Biodiversity Science. They could include various important research activities that entail a narrower scope and/or reduced costs (< $400,000 total budget including direct costs) (e.g., analysis of existing data (including NEON data), theoretical research, synthesis projects, fieldwork projects, etc.). The STAR track should not be used predominately to collect preliminary data. If funds for educational supplements are requested, those can be in addition to the $400,000 funding limit for STAR projects. **Students are only expected to produce a budget with justification (using the supplied template), a 10-page maximum project narrative, and a one-page project summary.** See associated resources for formatting and other prompts. The professor must approve the chosen topic. If one wishes to use an alternative structure in line with a funding agency that the graduate student is more likely to seek funding from, seek approval from Dr. Dowell first. However, this is very encouraged for graduate students. Submissions will be due May 9th at noon.

(3) **Oral final exam component** (20%) Most graduate students in this course must take an oral exam to complete their degree. Before taking one, I want to give you a sense of what that looks like. During finals week, all students must create a 1-hour meeting time with Dr. Dowell using the provided calendar link. During this time, you will give a chalk-talk-style talk about your

proposal, reviewing aspects of relevant background, aims, experimental design, pitfalls/mitigation strategies, etc. You will be given 15 minutes of uninterrupted time to begin your presentation, after which I will ask questions as I see fit. I will continue to ask you questions on your proposal and other relevant topics from the course.

(3) **Paper presentation** (25% total). The student(s) will prepare an introductory presentation, a paper relevant to the previous discussion, with approximately 15 minutes of content detailing the conceptual framework and methodology. I have listed a suggested paper, but feel free to pick a different one that fits your specific interests and get approval. After the presentation, the student(s) will provide a set of discussion points posed to the class to facilitate discussion about the conceptual framework, methodology, and conclusions presented. Dr. Dowell will lead the discussion for week one.

(4) **Class participation & discussion** (10% total). Students will actively engage in discussion in class, or the submission of a ~2-page summary and critical analysis (based on the presenter's discussion points) of the research paper presented will be accepted in place of participation.

Course Schedule

The course schedule is an approximation and subject to change at any time by the instructor. Papers posted are suggestions for presentations; feel free to pick a different one that fits your interests or system preferences.

Week	Meeting	Description
1	Lecture 1/14	Course Introduction – Chemical Ecology
	Presentation 1/16	The lost origin of chemical ecology in the late 19th century Thomas Hartmann DOI:10.1073/pnas.0709231105
Section 1: Tools of the Trade		
2	Lecture 1/21	Spectrophotometry & Hyperspectral Analysis
	Presentation 1/23	Couture, J.J., Singh, A., Rubert-Nason, K.F., Serbin, S.P., Lindroth, R.L. & Townsend, P.A. (2016) Spectroscopic determination of ecologically relevant plant secondary metabolites. *Methods in Ecology and Evolution*, 7, 1402–1412.
3	Lecture 1/28	Mass-spectrometry & Ambient ionization
	Presentation 1/30	Fowble, K.L., Teramoto, K., Cody, R.B., Edwards, D., Guarrera, D. & Musah, R.A. (2017) Development of "Laser Ablation Direct Analysis in Real Time Imaging" Mass Spectrometry: Application to Spatial Distribution Mapping of Metabolites Along the Biosynthetic Cascade Leading to Synthesis of Atropine and Scopolamine in Plant Tissue. *Analytical Chemistry*, 89, 3421–3429.
4	Lecture 2/4	Gas-Chromatography
	Presentation 2/6	Aparicio-Ruiz, R., García-González, D.L., Morales, M.T., Lobo-Prieto, A. & Romero, I. (2018) Comparison of two analytical methods validated for the determination of volatile compounds in virgin olive oil: GC-FID vs GC-MS. *Talanta*, **187**, 133–141.
5	Lecture 2/11	Liquid-chromatography
	Presentation 2/13	Haghi, Ghasem, and Alireza Hatami. "Simultaneous Quantification of Flavonoids and Phenolic Acids in Plant Materials by a Newly Developed Isocratic High-Performance Liquid Chromatography Approach." *Journal of Agricultural and Food Chemistry* 58, no. 20 (October 27, 2010): 10812–16. https://doi.org/10.1021/jf102175x.
6	Lecture 2/18	Untargeted vs. Targeted frameworks + Metabolomics core field trip
	Presentation 2/20	Proposal Pitch Discussions ** **One-page Project Summary due** **
Section 2: Ecology		
7	Lecture 2/25	Intraspecific interactions
	Presentation 2/27	Glassmire, A.E., Hauri, K.C., Turner, D.B., Zehr, L.N., Sugimoto, K., Howe, G.A., *et al.* (2024) The frequency and chemical phenotype of neighboring plants determine the effects of intraspecific plant diversity. *Ecology*, **105**, e4392.
8	3/4	Mardi Gras
	3/6	Midterm exam due via email on Monday 3/10
9	Lecture 3/11	Making a Budget & Grant Submissions Led by Biology's Proposals and Award Coordinator Calin Veal

	Presentation 3/13	Budget & Proposal Discussions
10	Lecture 3/18	Interspecific and multi-trophic interactions
	Presentation 3/20	Martini, X., Pelz-Stelinski, K.S. & Stelinski, L.L. (2014) Plant pathogen-induced volatiles attract parasitoids to increase parasitism of an insect vector. *Frontiers in Ecology and Evolution*, **2**.
Section 3: Evolution		
11	Lecture 3/25	Evolution of novelty and enzyme promiscuity
	Presentation 3/27	Heidel-Fischer, H.M., Kirsch, R., Reichelt, M., Ahn, S.-J., Wielsch, N., Baxter, S.W., *et al.* (2019) An Insect Counteradaptation against Host Plant Defenses Evolved through Concerted Neofunctionalization. *Molecular Biology and Evolution*, **36**, 930–941.
12	4/1	Spring Break
	4/3	
13	Lecture 4/8	Population diversification **** First Draft of Project Narrative Due ****
	Presentation 4/10	Gloss, A.D., Vergnol, A., Morton, T.C., Laurin, P.J., Roux, F. & Bergelson, J. (2022) Genome-wide association mapping within a local Arabidopsis thaliana population more fully reveals the genetic architecture for defensive metabolite diversity. *Philosophical Transactions of the Royal Society B: Biological Sciences*, **377**, 20200512.
14	Lecture 4/15	Macroevolution
	Presentation 4/17	Volf, M., Leong, J.V., Lima Ferreira, P. de, Volfová, T., Kozel, P., Matos-Maraví, P., *et al.* (2023) Contrasting levels of β-diversity and underlying phylogenetic trends indicate different paths to chemical diversity in highland and lowland willow species. *Ecology Letters*, **26**, 1559–1571.
Section 4: Future Directions and Current topics in Chemical Ecology		
15	Lecture 4/22	Synthetic Biology
	Presentation 4/24	Fuentes, P., Zhou, F., Erban, A., Karcher, D., Kopka, J. & Bock, R. (2016) A new synthetic biology approach allows transfer of an entire metabolic pathway from a medicinal plant to a biomass crop. *eLife*, **5**, 1–26.
16	Lecture 4/29	Climate Change
	Presentation 5/1	Farré-Armengol, G., Peñuelas, J., Li, T., Yli-Pirilä, P., Filella, I., Llusia, J., *et al.* (2016) Ozone degrades floral scent and reduces pollinator attraction to flowers. *New Phytologist*, **209**, 152–160.
Final Week	Final exam 5/5-5/10	Research proposal due + Oral Exams

Course Policies

1. Attendance is vital to success in this course. A large portion of the course grade will be based on laboratory research and class participation, which cannot be made up, and exams will cover material not available outside of class.
2. The final exam is the only in-class exam, and a make-up exam will be given only with valid documentation of illness, mandatory religious observance, or required participation at an authorized

university activity before the absence or within 24 hours of the exam. Make-ups for laboratories cannot be provided.

3. Students are highly encouraged to discuss any and all portions of this course with the instructor and teaching assistant. If you are struggling, please do not wait until you fall behind to meet with me. I am available during my weekly office hours or by appointment and will always be happy to discuss the course.
4. Written communication with the instructor should be sent via LSU email. Note that I will not be able to respond to course inquiries sent from third-party email addresses (e.g., Gmail) where student identity cannot be confirmed in order to comply with FERPA regulations.