Bios 4620 Syllabus

**[Aquatic Chemical Ecology, 3 Credits]**

**[Tu Th, 1335-1455h, Who Knows??]**

**Instructor Information**

|  |  |  |
| --- | --- | --- |
| Instructor | Email | Office Hours & Location |
| [Mark Hay] | [mark.hay@biology.gatech.edu] | [EST 2102, 1300-1500h, Wed; and by appointment] |

**General Information**

**Description**

## Most organisms have neither eyes nor ears and so sense the world via chemical cues and communicate via chemical signals. This course focuses on understanding how chemical signals and cues (especially in aquatic systems) produce both direct and cascading effects on behavior, population regulation, community organization, and ecosystem function. In summary, chemistry is ‘the language of life” – our goal is to learn more about ecology and evolution by better understanding that language.

## Pre- &/or Co-Requisites

BIOL 2335 or BIOL 2337 or BIOS 2300 or BIOS 2310 are pre-requisites, but a number of students, primarily engineering students, with strong interests in aquatic systems, chemistry, or ecology, but without these pre-requisites have petitioned me to wave the pre-requisites and have done well in the course. If you are interested, discuss your interests and background and I’ll consider making an exception.

## Course Goals and Learning Outcomes

[Goals include:

* Learn how organisms use a “chemical language” to sense their environment and communicate both within and among species.
* Understand the complex biotic interactions that are mediated by chemical cues and signals and the consequences of this for populations, communities and ecosystems.
* Learn the fundamentals of how good science is conducted by using strong inference and multiple working hypotheses.
* Become comfortable and proficient at reading, evaluating, and challenging the primary literature (i.e., we will not use a book, but will read and evaluate the primary literature related to each lecture topic).

**Course Requirements & Grading**

|  |  |  |
| --- | --- | --- |
| Assignment | Date | Weight (Percentage, points, etc) |
| Pop Quizzes | Throughout the course | 5% |
| Exam 1 | 10th class meeting | 15% |
| Exam 2 | 20th class meeting | 17% |
| Exam 3 | The final | 18% |
| Oral presentation and discussion leading | Varies by student | 10% |
| Final paper | Self-scheduled, but before mid-April | 15% |
| Primary literature critique | Self-scheduled, but before mid-April | 10% |
| Class participation/ discussion |  | 10% |

**Extra Credit Opportunities**

None

There is no textbook. Required readings will be made available on Canvas and students are encouraged to use library databases and the scientific literature to pursue topics in more detail. Since there is no textbook and classes involve discussion as well as some lecture, attendance and class participation are required.

**Surprise quizzes** can come anytime, and involve simple questions about the day’s readings that you should always get full points if you read the paper and show up to class on time. I’ll drop one quiz grade, but if you miss or do badly on more than one, then it will affect your grade. There will be no make-up exams for pop quizzes. **I give these in the first 2-3 min of class. BE HERE**. This class will involve considerable discussion. If you did not read the assigned papers, you will not be ready to contribute and you will be letting down the others in the class. Thus, these quizzes are to “encourage” you to read the assigned papers and be a positive contributor (or to punish you for not reading the paper and for “sponging” off the discussion of others – feel free to interpret this as you wish).

The **primary literature critique** will be a short paper written by each student (maximum 2 pages single spaced, 12 point font), reporting on a recent article from the scientific literature that you choose by conducting your own literature search (it cannot be a review paper – it needs to be an experimental paper – and IT CANNOT BE ONE I ASSIGNED YOU FOR CLASS READING). I want you to cover a paper reporting an experiment so you can comment on its strengths and weaknesses of approach and interpretation. It should be one that you found particularly interesting and important; it can focus on any area of chemical ecology – BUT YES, IT DOES NEED TO BE ON CHEMICAL ECOLOGY. In this paper, you should: 1) present a brief overview of the topic of focus, 2) report the important findings of the chosen article, 3) argue why this article represents an important contribution (or why it does not), and 4) critically evaluate its strengths and weaknesses. For both this and the final paper, submit by email, and *remember to put your name and email address on the paper itself*. **You can turn this in anytime before 15 March.**  A good way to find papers for this is to look for papers cited on topics of interest cited in some of the broader review papers I’ve assigned early in the course. Look up those papers, newer papers that cite those papers, or newer papers citing the reviews I’ve assigned. Journals that often have better papers include *Science, Nature, Proceedings of the National Academy of Sciences, Ecology, Ecology Letters, Proceedings of the Royal Society B, Oecologia*, and numerous other journals.

The three **tests** will be based on material covered in lectures, class discussions, and readings since the previous test (i.e., none are cumulative). There is no final test, there is a final paper.

**Oral presentation and discussion leading** – After the first few class periods, individual students will present on a general topic of their choice (after getting it OKed by me). This will involve 1) choosing a good, exemplary paper on that topic for the class to read, 2) preparing a 12-15 min powerpoint on that topic (not on just the assigned paper but on that general topic – thus requiring the reading and information from numerous papers), and 3) then leading a 15-18 min discussion on that topic. Your grade will be based on the depth, clarity, and overall quality of your presentation, and on being able to interest and motivate your audience as evidenced by questions and the general level of discussion that your topic and presentation generate. The graduate students will go first.

For the **final paper,** you will write a proposal to get funding to conduct research related to a new idea that you want to test dealing with chemical ecology (no – don’t put in budgets, or worry about justifying costs, just write a compelling proposal on the ideas, why they are important, and describing the experimental design by which you will be able to address the questions you pose). The paper is to be no more than 5 single-spaced pages (not including references, which should be used extensively, in the format of the journal *Ecology*), 12 point font. **Due at the latest by April 12 (before is always a good option). GRADUAT STUDENTS GET 10 PAPGES INSTEAD OF 5.** This can be a good practice effort for the written portion of your Ph.D. exam. Several students have go on to do there dissertations on the project they proposed here, so doing this well can profit you well beyond the course itself.

**Class participation** will be judged by the degree to which each student participates in discussions (by asking questions during others’ presentations, answering questions, offering ideas, opinions, critiques of readings, and by connecting the current discussion to previous class discussions). If you sit like a lump and never make a mistake because you never open your mouth, you get 0 points. If you say enough and it is always insightful and brilliant, you get 10 points. If you participate fully, asking insightful questions when you have them but also ones you think may be stupid (if you have it, others may as well – someone has to ask….), that’s also worth 10 points. If you talk incessantly until you think of something worth saying… well, none of us value that very much….

**Grading Scale**

I grade rigorously and expect you to do well. Your final grade will be assigned as a letter grade according to **roughly** the following scale. However, given that I’m a rigorous grader, it is not uncommon for there to be few students with 90%+ grades. I commonly curve the grades and it is not unusual for 86%+ to be in the A group. As we progress through the tests, I’ll show you the class distribution on each and you can see your placement within the class distribution

A 90-100%

B 80-89%

C 70-79%

D 60-69%

F 0-59%

**Course Materials**

**Course Text**

We will read the primary literature (i.e., real scientific papers) for each lecture. There is no text book. Papers for each lecture are listed below and will be available on Canvas or its equivalent.

## Additional Materials/Resources

## If you are interested in specific topics within chemical ecology and want additional information, come discuss this with me and I can lead you to specific texts or suggests searches focused on especially impactful researchers, etc.

## Course Website and Other Classroom Management Tools

Readings, schedules, etc. will be posted on Canvas

**Course Expectations & Guidelines**

## Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit http://www.catalog.gatech.edu/policies/honor-code/ or <http://www.catalog.gatech.edu/rules/18/>.

Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

## Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or <http://disabilityservices.gatech.edu/>, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. See me or e-mail me to discuss your learning needs and we will find a way that is fair and works.

## Attendance and/or Participation

## Lectures and discussions will cover aspects of the papers, but will be broader in scope so as to better cover the general concepts and studies that the assigned papers represent one aspect of. YOU NEED TO BE IN CLASS AND TO TAKE NOTES – NOT ALL INFORMATION WILL BE IN THE READINGS OR ON THE POWERPOINTS. I’ll devote some time in each class period to discussions – some of the test material will come from these discussions – if you are not in class, you won’t know of the issues raised and discussed.

## Collaboration & Group Work

## Science is often a collaborative, interactive effort. During discussions in and out of class it is fine to share ideas, build and learn based on group discussions and interactions, etc. but for your presentation, research proposal, tests, etc. I expect all work to be your independent effort.

## Extensions, Late Assignments, & Re-Scheduled/Missed Exams

If you have an excused absence for missing an exam, I’ll give you a make-up exam, but it may be oral instead of written. Your proposal and presentation can be self-scheduled (but I’ll “help” with this if I don’t see you doing so). I expect all of these to be done on time. If you are late with assignments, come discuss this with me. If you have a very good reason (you were hospitalized due to a wreck, etc.), we will work out a way to give you additional time. If your reason for being late is less persuasive, I’ll deduct 5% of that grade’s value/day for each day it continues to be late.

## Student-Faculty Expectations Agreement

At Georgia Tech we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. See <http://www.catalog.gatech.edu/rules/22/> for an articulation of some basic expectation that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

## Student Use of Mobile Devices in the Classroom

No mobile phone use. You can use your computer for notes, for looking at the specifics of the papers we are discussing, etc, but usage needs to be for academic activities.

**Campus Resources for Students**

Georgia Tech has a range of services to help support your mental, emotional, and physical well-being. Click [here](http://ctl.gatech.edu/sites/default/files/documents/campus_resources_students.pdf) for a list of these relevant campus resources.

**Course Schedule**

This is a DRAFT schedule. It changes every time I teach the class, and Will change before I begin teaching this class in the spring. This is simply my schedule from the last time I taught it.

**Schedule of Topics and Readings**

***Class calendar:***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Week | **Date** | **Topic** | **Guests** | **Reading assignment**  **(read BEFORE class)** |
|  |  | **OVERVIEW** |  |  |
| 1 | Jan 9 | Introduction to the Class |  | No reading |
| Jan 11 | Chemical ecology: Setting the stage -from molecules to ecosystems (part 1) |  | Hay (2009) |
| 2 | Jan 16 | Chemical ecology: Setting the stage -from molecules to ecosystems (part 2) |  | Pohnert et al. 2007 |
|  | **CHEMICALLY- MEDIATED FORAGING AND CONSUMER-PREY INTERACTIONS** |  |  |
|  | Jan 18 | Chemically-mediated foraging (large-scale tracking) + (small-scale tracking and prey responses) |  | Savoca & Nivette (2014) |
| 3 | Jan 23 | Micro-scale responses |  | Seymour et al. Science (2010) |
| Jan 25 | Defense: Getting lunch w/o becoming lunch – chemical warfare in the sea |  | Rasher et al. 2015 |
| 4 | Jan 30 | HOPEFULLY, we can proceed as below – but I’m still checking to be sure you can attendInstead of attending class today, go to the **SUDDATH SYMPOSIUM, which is being held on campus at GT – see** <http://petitinstitute.gatech.edu/suddath-symposium>  Session I - Better Living through Chemistry  1:05 p.m.     "Bacterial Quorum Sensing and its Control" - Bonnie Bassler, Ph.D. - Princeton University 1:45 p.m.     "Chemical Chatter between the Cystic Fibrosis-associated Microbiome" - Neha Garg, Ph.D. - Georgia Tech 2:25 p.m.     "Phenotypic Screening of Disease-associated Human Gut Microbes" - Jon Clardy, Ph.D. - Harvard Medical School 3:05 p.m.     Break  Session II - Evolution of Microbial Interactions  3:30 p.m.    "How Do Microbes Form Relationships with Animals?" - Seth Bordenstein, Ph.D. - Vanderbilt University 4:10 p.m.    "How can Microbiomes Serve as a Model for the Emergence and Early Evolution of Life?" - Mary Voytek, Ph.D. - National Aeronautics and Space Administration (NASA) | Several options | READ:  Cantley and Clardy (2015)  Other reading if interested:  Pappenfort & Bassler 2016. Quarum sensing signal-response systems in Gram-negative bacteria. Nature Reviews Microbiology 14: 576-588 |
| Feb 1 | Chemical mimicry to avoid detection Mary Mcwirth presentation |  | Brooker et al. 2015 |
| 5 | Feb 6 | **TEST #1 (covers Jan 9 – Feb 1)** |  |  |
| Feb 8 | GUEST LECTURE Associational defenses driving chemical usage | Prof. Jay Stachowicz | Stachowicz and Hay (1999) |
| 6 | Feb 13 | The geography of chemical defenses Melissa Ruszczyk presentation |  | Pennings et al. (2009) **OR**  Morrison & Hay (2012) |
| Feb 15 | A counter argument: is greater herbivory in the tropics a “zombie hypothesis?”  Kyle Hamilton presentation |  | Moles et al. 2011 |
| 7 | Feb 20 | The smell of fear and its cascading effects on populations, communities, and ecosystems –  Merisa Cepeda presentation |  | Trussell et al. (2006) |
| Feb 22 | Induction, activation, & costs of defenses  Daniel Muratore presentation |  | Baldwin (1998)  AND EITHER  Selander et al. (2015) OR  Lindstrom et al. (2017) |
| 8 | Feb 27 | **COMPETITION**  Killing your neighbor - Allelopathy (costs and benefits) Caroline Zabinski presentation |  | Rasher and Hay (2014) |
| Mar 1 | GUEST LECTURE  The chemical ecology of host microbiomes | Prof. Frank Stewart |  |
| 9 | Mar 6 | Chemistry and dominance  Alissa Schlosberg presentation |  | Bergman and Moore (2005) |
| Mar 8 | GUEST LECTURE -Agrocemical effects in the environments | Prof. Jason Rohr | Rohr et al. (2008) |
|  |  | **MICROBES MAY RULE THE PLACE** |  |  |
| 10 | Mar 13 | **TEST #2 (covers Feb 6 to March 8)** |  |  |
| Mar 15 | Defense and offense via mutualists  **TURN IN YOUR PRIMARY LITERATURE CRITIQUE ON OR BEFORE TODAY** |  | Lopanik (2014) |
| 11 | Mar 20 | Spring Break |  | None |
| Mar 22 | Spring Break |  | None |
| 12 | Mar 27 | Microbes as competitors: Why fish stink  Savannah Berry presentation |  | Burkepile et al. 2006 |
| Mar 29 | **SOCIAL INTERACTIONS/ RECRUITMENT**  Sex (Pheromones) |  | Bagoien & Kiorbe (2005) AND Gelstein et al. (2011) |
| 13 | Apr 3 | Kin and competitor recognition |  | Karban et al. (2013)  Grossberg (1981) |
| Apr 5 | GUEST LECTURE –  Pee in the sea: cues to danger from predators | Prof. Marc Weissburg | Poulin et al. 2018 |
| 14 | Apr 10 | Cuing of larval recruitment (chemistry vs other cues) |  | Leis et al. 2011 |
| Apr 12 | Global change effects on chemical cuing and signaling  FINAL PAPER IS DUE TODAY, BUT CAN BE TURNED IN AS LATE AS THE 24TH W/O DEDUCTED POINTS |  | Munday et al. 2014 |
| 15 | Apr 17 | Chemical ecology as drug discovery for the planet |  | Dixson et al. 2014 |
| Apr 19 | **TEST #3 (covers March 15 – April 17)**  **PAPERS TURNED IN BY TODAY GET EDITED AND RETURNED W/O A GRADE** |  |  |
| 16 | Apr 24 | \*The science of sex appeal |  | No reading |
|  |  |  |  |
| Apr 30 | Final |  | THERE IS NONE |

\* In most semesters, some well-known chemical ecologists stop by for a visit and I’m be able to get them to give you a seminar – I many cancel the April 24 presentation and use it as a “just-in-case” opportunity – which may cause a shifting of above the timing of some of the above topics.

**Reading list – articles available on T-square**

**January 9:** none

**January 11:**

Hay ME (2009) Marine chemical ecology: chemical signals and cues structure marine populations, communities, and ecosystems. Annu Rev Mar Sci 1:193-212

**January 16:**

Pohnert G, Steinke M, Tollrian R (2007) Chemical cues, defence metabolites and the shaping of pelagic interspecific interactions. Trends in Ecology and Evolution 22:198-204

**January 18:**

Savoca MS, Nevitt GA (2014) Evidence that dimethyl sulfide facilitates a tritrophic mutualism between marine primary producers and top predators. Proc. Nat. Acad. Sci. 111: 4157-4161.

**January 23:**

Seymour JR, Simo R, Ahmed T, Stocker R (2010) Chemoattraction to dimethylsulfoniopropionate throughout the marine microbial food web. Science 329: 342-345.

**January 25:**

Rasher DB, Stout EP, Engel S, Shearer TL, Kubanek J, Hay ME. (2015) Marine and terrestrial herbivores display convergent chemical ecology despite 400 million years of independent evolution. Proceedings of the National Academy of Sciences 112: 12110-12115

**Jasnuary 30:**

Cantley AM, J Clardy. 2015. Animals in a bacterial world: opportunities for chemical ecology. Nat. Prod. Rept. 32:888-892.

**February 1:**

Brooker RM, PL Munday, DP Chivers, GP Jones. 2015. You are what you eat: diet-induced chemical crypsis in a coral-feeding reef fish. Proceedings of the Royal Society B 282:1-7

**February 6:**

TEST DAY – NO READING ASSIGNMENT

**February 8:**

Stachowicz, J.J. and M.E. Hay. 1999. Reducing predation through chemically-mediated camouflage: indirect effects of plant defenses on herbivores. **Ecology** 80:495-509.

**February 13:**

Pennings SC, Ho IC, Salgado CS, Wieski K, Nilam D, Kunza AE, Wason E (2009) Latitudinal variation in herbivore pressure in Atlantic Coast salt marshes. Ecology 90:183-195

**OR**

Morrison WE and ME Hay. 2012. Are lower latitude plants better defended? Palatability of freshwater macrophytes. Ecology 93: 65–74

**February 15:**

Moles AT, Bonser SP, Poore AGB, Wallis IR, Foley WJ (2011) Assessing the evidence for latitudinal gradients in plant defence and herbivory. Functional Ecology 25, 380–388

**February 20:**

Turssell GC, Ewanchuk PJ, Matassa CM (2006) Habitat effects on the relative importance of traitand density-mediated indirect interactions. Ecology Letters 9: 1245–1252

**February 22:**

Baldwin, IT. 1998. Jasmonate-induced responses are costly but benefit plants under attack in native populations. Proc. Nat. Acad. Sci. USA 95 (14): 8113-8118

**AND**

Selasnder E, Kubanek J, Hambergd M, Anderssona MX, Cervinc G, Pavia H. (2015) Predator lipids induce paralytic shellfish toxins in bloom-forming algae. Proc. Nat Acad Sci. 112: 6395-6400

**OR**

Lindstrom J, Grebner W , Rigby K Selander E (2017) Effects of predator lipids on dinoflagellate defence mechanisms – increased bioluminescence capacity. Scientific Reports | 7: 13104 | DOI:10.1038/s41598-017-13293-4

**February 27:**

Rasher DB, ME Hay. 2014. Competition induces allelopathy but suppresses growth and anti-herbivore defence in a chemically rich seaweed. Proceedings of the Royal Society B 281: 1-9

**March 1:**

Will be assigned later

**March 6:**

Bergman DA, Moore PA (2005) Prolonged exposure to social odours alters subsequent social interactions in crayfish (*Orconectes rusticus*). Animal Behaviour 70:311-318

**March 8:**

Rohr JR, et al. (2008) Agrochemicals increase trematode infection in a declining amphibian species. Nature 455: 1235-1239

**March 13:**

TEST DAY – NO READING ASSIGNMENT

**March 15:**

Lopanik NB (2014) Chemical defensive symbioses in the marine environment. Functional Ecology 28: SI 328-340.

**March 20:**

Spring Break – enjoy

**March 22**

Spring Break – enjoy

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**March 27:**

Burkepile, DE, JD Parker, CB Woodson, HJ Mills, J Kubanek, PA Sobecky, and ME Hay. 2006. Chemically-mediated competition between microbes and animals: microbes as consumers in food webs. Ecology 87:2821-2831

**March 29:**

Bagoien E, Kiorboe T (2005) Blind dating – mate finding in planktonic copepods. I. Tracking the pheromone trail of *Centropages typicus*. Mar Ecol Prog Ser 300:105-115

AND

Gelstein S, Y Yeshurun, L Rozenkrantz, S Shushan, I Frumin, Y Roth, N Sobel. 2011. Human tears contain chemosignal. Science 331: 226-230

**April 3:**

Karban R, Shiojiri K, Ishizaki S, Wetzel WC, Evans RY. 2013 Kin recognition affects plant communication and defence. Proc R Soc B 280: 20123062. http://dx.doi.org/10.1098/rspb.2012.3062

AND

Grosberg RK (1981) Competitive ability influences habitat choice in marine invertebrates. Nature 290: 700-702

**April 5:**

Poulin RX, Lavoie S, Siegeld K, Gaula DA, Weissburg MJ, Kubanek J (2018) Chemical encoding of risk perception and predator detection among estuarine invertebrates. Proceedings of the National Academy of Sciences doi/10.10713/pnas.1713901115

**April 10:**

Leis JM, Siebeck U, Dixson DL (2011) How Nemo finds home: the neuroecology of dispersal and of population connectivity in larvae of marine fishes. Integrative and Comparative Biology 51: 826-843 doi: 10.1093.icb/icr004

**April 12:**

Munday PL, AJ Cheal, DL Dixson, JL Rummer, KE Fabricius. 2014. Behavioral impairment in reef fishes caused by ocean acidification at CO2 seeps. Nature Climate Change 4: 487-492.

**April 17:**

Dixson DL, D Abrego, ME Hay. 2014. Chemically-mediated behavior of recruiting corals and fishes: a tipping point that may limit reef recovery. Science 345:892-897

**April 19:**

TEST DAY – NO READING ASSIGNMENT