

BIOL 4620/6620
AQUATIC CHEMICAL ECOLOGY

Mark Hay, School of Biology
Environmental Science and Technology Building Office: 2102
mark.hay@biology.gatech.edu

Julia Kubanek, School of Biology
Environmental Science and Technology Building Office: 2242
julia.kubanek@biology.gatech.edu

Course summary: The course focuses on understanding the chemical mechanisms of aquatic signaling and the cascading effects on population regulation, community organization, and ecosystem function.

This class meets on Tuesdays and Thursdays from 3:05 to 4:25 pm in College of Computing room 53. There is no textbook. Required and recommended readings will be made available on T-square (<https://t-square.gatech.edu/portal>), and students are encouraged to use library databases and the scientific literature to pursue topics in more detail. Since there is no textbook and many of the sessions involve class discussion as well as formal lecture, attendance and class participation are required.

Evaluation:

Initial reading assignment and surprise quizzes	5%
Primary literature critique	10%
Midterm test #1	15%
Midterm test #2	20%
Oral presentation and discussion leading	20%
Final paper	20%
Class participation	10%

The **initial reading assignment** will be explained on the first day and is due at the start of the second week. **Surprise quizzes** can come anytime, and usually involve trivial questions about the day's readings that you should always get full points for if you read the paper and show up to class on time.

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 (not a review) that each student chooses by conducting their own literature search. The chosen article should not have been used in a writing assignment for another course. It should be one that the student found particularly interesting and important, and can focus on any area of chemical ecology. In their paper, the student should present a brief overview of the field, report the important findings of the chosen article, argue why this article represents an important contribution, and critically evaluate its strengths and weaknesses. For both this and the final paper, please submit to both instructors by email, and *remember to put your name and email address on the paper itself*.

The **midterm tests** will be based on material covered in lectures, class discussions, and readings up to the date of that test.

Your **oral presentation and discussion leading** works like this: everyone in the class reads the assigned paper(s) and comes prepared to ask questions, discuss the ideas presented, and to play a significant role in class discussion on the assigned paper(s). On the day you lead the discussion, you read all papers

assigned for that day, and bring a short (~15 minute) **powerpoint presentation** to deliver as you lead the discussion, interspersed with questions and comments from the class. Expect the discussion to run for about one hour including the time required to deliver your slides.

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. 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.

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, that's also worth 10 points. If you talk incessantly until you think of something worth saying... well, we don't anticipate that happening.

Please see www.honor.gatech.edu for Georgia Tech's Academic Honor Code, which you are required to uphold.

Class calendar:

Week	Date	Topic	Who	Reading assignment (read BEFORE class)
1	Aug 18	Introduction to the instructors, course, and expectations for student success	JK & MH	-
	Aug 20	No class meeting. Instead, use class time to complete assignment based upon the reading. Assignment explained in class on Aug 18 th .	-	Hay (2009)
2	Aug 25	Chemical ecology: From molecules to ecosystems (part 1) <i>Initial reading assignment due; At the beginning of class today, we will assign oral presentation/discussion leader dates</i>	MH	NO READING
	Aug 27	Chemical ecology: From molecules to ecosystems (part 2)	MH	Steinberg et al (1995)
3	Sept 1	Chemically-mediated competition: Allelopathy <u>Discussion leader:</u> Tracey Myers	JK	Thacker et al (1998) or Prince et al (2008)
	Sept 3	Chemically-mediated competition: Fouling and dominance <u>Discussion leader:</u> Melanie Heckman	JK	Dworjanyn et al (2006) or Bergman & Moore (2005)
4	Sept 8	Consumer-prey interactions: Mobility & behavior <u>Discussion leader:</u>	MH	Kicklighter & Hay (2006)
	Sept 10	Consumer-prey interactions: Induction & costs of defenses <u>Discussion leader:</u>	MH	Baldwin (1998) or Selander et al (2006)
5	Sept 15	Chemical defense theories: Useful or not?? <i>Primary literature critique due</i>	MH	Cronin (2001)
	Sept 17	Consumer-prey interactions: Can small rare prey be chemically defended <u>Discussion leader:</u>	MH	Lindquist & Hay (1995)
6	Sept 22	<i>First midterm test</i>	(JK)	-
	Sept 24	Bacterial chemotaxis for virulence, habitat selection, and food tracking <u>Discussion leader:</u>	JK	Thar & Kuhl (2003) or Butler & Camilli (2004)
7	Sept 29	Chemically-mediated foraging (large-scale tracking) <u>Discussion leader:</u>	MH	Nevitt (2008)
	Oct 1	Chemically-mediated foraging (small-scale tracking and prey responses) <u>Discussion leader:</u>	MH	Smee & Weissburg (2006)
8	Oct 6	Fall break		
	Oct 8	Predator avoidance: The smell of fear and its cascading effects on communities <u>Discussion leader:</u>	MH	Trussell et al (2003) AND Ripple & Beschta (2004)
9	Oct 13	Larval settlement	MH	Dixson et al (2008)

		<u>Discussion leader:</u>		
	Oct 15	Molecular basis for taste: Why capsaicin is hot and menthol is cool <u>Discussion leader:</u>	JK	Jordt & Julius 2002 or McKemy et al (2002)
10	Oct 20	Natural toxins interacting with receptors and toxin-mediated prey capture <u>Discussion leader:</u>	JK	Bricelj et al (2005) or Remigio & Duda (2008)
	Oct 22	Microbes as competitors: Why fish stink <u>Discussion leader:</u>	MH	Burkepile et al. (2006); for fun, google “NPR stinky fish”
11	Oct 27	Microbes as pathogens and host chemical defenses against them <u>Discussion leader:</u>	JK	Stow et al (2007) or Lane et al (2009)
	Oct 29	Microbes as accomplices: Chemically-mediated host-microbe symbioses <u>Discussion leader:</u>	JK	Gil-Turnes et al (1989) or Currie et al (1999)
12	Nov 3	Quorum sensing as a mechanism for regulating social interaction <u>Discussion leader:</u>	JK	Higgins et al (2007) or Rumbaugh et al (2009)
	Nov 5	Chemically-mediated kin recognition <u>Discussion leader:</u>	JK	Queller et al (2003) or Lize et al (2006)
13	Nov 10	Chemically-mediated mate attraction: The importance of sex pheromones <u>Discussion leader:</u>	JK	Bagoien & Kiorbe (2005) or Nojima et al (2005)
	Nov 12	Chemically-mediated gamete and mate recognition <u>Discussion leader:</u>	JK	Riffell et al (2004) or Snell et al (2007)
14	Nov 17	Chemical ecologists take to the field: A meeting with underwater scientists at the Aquarius research station http://uncw.edu/aquarius/	MH	Burkepile and Hay (2008)
	Nov 19	<i>Second midterm test</i>	(MH)	-
15	Nov 24	The case for human sex pheromones: Are there or aren't there? <u>Discussion leader:</u>	JK	Liberles and Buck (2006) or Roberts et al (2008)
	Nov 26	Thanksgiving holiday		
16	Dec 1	The science of sex appeal (part 1)	MH & JK	-
	Dec 3	The science of sex appeal (part 2) and course wrap-up <i>Final paper due</i>	MH & JK	-

Reading list – articles available on T-square

August 18: none

August 20:

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

August 25:

No additional reading today. We'll still be covering the Hay (2009) reading

August 27:

Steinberg PD, Estes JA, Winters FC (1995). Evolutionary consequences of food chain length in kelp forest communities. *Proc. Nat. Acad. Sci.* 92: 8145-8148.

September 1:

Thacker RW, Becerro MA, Lumbang WA, Paul VJ (1998) Allelopathic interactions between sponges on a tropical reef. *Ecology* 79:1740-1750

Prince EK, Myers TL, Naar J, Kubanek J (2008) Competing phytoplankton undermines allelopathy of a bloom-forming dinoflagellate. *Proc Roy Soc B* 275:2733-2741

September 3:

Dworjanyn SA, de Nys R, Steinberg PD (2006) Chemically mediated antifouling in the red alga *Delisea pulchra*. *Mar Ecol Prog Ser* 318:153-163

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

September 8:

Kicklighter CE and Hay ME (2006) Defenses of mobile marine invertebrates are integrated with life-style, mobility, and distribution. *Ecol. Monogr* 76:195-215.

September 10:

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

Selander E, Thor P, Toth G, Pavia H (2006) Copepods induce paralytic shellfish toxin production in marine dinoflagellates. *Proc. Royal Soc B* 273: 1673-1680

September 15:

Cronin G (2001) Resource allocation in seaweeds and marine invertebrates: Chemical defense patterns in relation to defense theories. Pages 325-352 in J McClintock and W. Baker (Eds.) *Marine Chemical Ecology*. CRC Press.

September 17:

Lindquist N, Hay ME (1995) Can small rare prey be chemically defended? the case for marine larvae. *Ecology* 76: 1347-1358

September 22: none

September 24:

- Thar R, Kuhl M (2003) Bacteria are not too small for spatial sensing of chemical gradients: an experimental evidence. *Proc Natl Acad Sci* 100:5748-4753
- Butler SM, Camilli A (2004) Both chemotaxis and net motility greatly influence the infectivity of *Vibrio cholerae*. *Proc Natl Acad Sci* 101:5018-5023

September 29:

- Nevitt GA (2008) Sensory ecology on the high seas: the odor world of the procellariiform seabirds. *J. Exp. Biol.* 211: 1706-1713

October 1:

- Smee DL, Weissburg MJ (2006) Clamming up: Environmental forces diminish the perceptive ability of bivalve prey. *Ecology* 87: 1587-1598

October 8:

- Trussell GC, Ewanchuk PJ, Bertness MD (2003) Trait-mediated effects in rocky intertidal food chains: Predator risk cues alter prey feeding rates. *Ecology* 84: 629-640
- Ripple WJ, Beschta RL (2004) Wolves and the ecology of fear: can predation risk structure ecosystems? *BioScience* 54: 755-766

October 13:

- Dixon DL, Jones GP, Munday PL, et al.(2008) Coral reef fish smell leaves to find island homes. *Proc. Royal Soc B.* 275: 2831-2839

October 15:

- Jordt SE, Julius D (2002) Molecular basis for species-specific sensitivity to “hot” chili peppers. *Cell* 108:421-430
- McKemy DD, Neuhauser WM, Julius D (2002) Identification of a cold receptor reveals a general role for TRP channels in thermosensation. *Nature* 416:52-58

October 20:

- Bricelj VM, Connell L, Konoki K, MacQuarrie SP, Scheuer T, Catterall WA, Trainer VL (2005) Sodium channel mutation leading to saxitoxin resistance in clams increases risk of PSP. *Nature* 434:763-767
- Remigio EA, Duda TF (2008) Evolution of ecological specialization and venom of a predatory marine gastropod. *Molecular Ecol* 17:1156-1162

October 22:

- 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

October 27:

- Stow A, Briscoe D, Gillings M, Holley M, Smith S, Leys R, Silberbauer T, Turnbull C, Beattie A (2007) Antimicrobial defences increase with sociality in bees. *Biol Lett* 3:422-424
- Lane AL, Nyadong L, Galhena AS, Shearer TL, Stout EP, Parry RM, Krasnik M, Wang MD, Hay ME, Fernandez FM, Kubanek J (2009) Desorption electrospray ionization mass spectrometry reveals surface-mediated antifungal chemical defense of a tropical seaweed. *Proc Natl Acad Sci* 106:7314-7319

October 29:

- Gil-Turnes MS, Hay ME, Fenical W (1989) Symbiotic marine bacteria chemically defend crustacean embryos from a pathogenic fungus. *Science* 246:116-118
- Currie CR, Scott JA, Summerbell RC, Malloch D (1999) Fungus-growing ants use antibiotic-producing bacteria to control garden parasites. *Nature* 398:701-704

November 3:

- Higgins DA, Pomianek ME, Kraml CM, Taylor RK, Semmelhack MF, Bassler BL (2007) The major *Vibrio cholerae* autoinducer and its role in virulence factor production. *Nature* 450:883-886
- Rumbaugh KP, Diggle SP, Watters CM, Ross-Gillespie A, Griffin AS, West SA (2009) Quorum sensing and the social evolution of bacterial virulence. *Current Biol* 19:341-345

November 5:

- Queller DC, Ponte E, Bozzaro S, Strassmann JE (2003) Single-gene greenbeard effects in the social amoeba *Dictyostelium discoideum*. *Science* 299:105-106
- Lize A, Carval D, Cortesero AM, Fournet S, Poinot D (2009) Kin discrimination and altruism in the larvae of a solitary insect. *Proc Roy Soc B* 273:2381-2386

November 10:

- 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
- Nojima S, Schal C, Webster FX, Santangelo RG, Roelofs WL (2005) Identification of the sex pheromone of the German cockroach, *Blattella germanica*. *Science* 307:1104-1106

November 12:

- Riffell JA, Krug PJ, Zimmer RK (2004) The ecological and evolutionary consequences of sperm chemoattraction. *Proc Natl Acad Sci* 101:4501-4506
- Snell TW, Kim J, Zelaya E, Resop R (2007) Mate choice and sexual conflict in *Brachionus plicatilis* (Rotifera). *Hydrobiologia* 593:151-157

November 17:

- Burkepile DE, Hay ME (2008) Herbivore species richness and feeding complementarity affect community structure and function: the case for Caribbean reefs. *Proc Nat Acad Sci* 105: 16201-16206

November 19: none

November 24:

- Liberles SD, Buck LB (2006) A second class of chemosensory receptors in the olfactory epithelium. *Nature* 442:645-650
- Roberts SC, Gosling LM, Carter V, Petrie M (2008) MHC-correlated odour preferences in humans and the use of oral contraceptives. *Proc Roy Soc B* 275:2715-2722