



Syllabus, ENVR 500  
Environmental Processes, Exposure, and Risk Assessment  
Fall 2019  
3 Credits, Residential

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## Course Overview

<b>Course Description</b>	This course will equip students with a broad understanding of causes of environmental pollution, pollutant transformation in and movement through the environment, effects on human health, and technical and policy options for preventing pollution.	
<b>Prerequisites</b>	CHEM 261 Calculus Co-requisite: Statistics or Fall Integrated MPH/MSPH Core	
<b>Instructor(s)</b>	Julia Rager, PhD Assistant Professor Environmental Sciences & Engineering Rosenau 347 Phone: 919-966-4410 Email: jrager@unc.edu	Jason D. Surratt, PhD Professor Environmental Sciences & Engineering Rosenau 164 Phone: 919-966-0460 Email: surratt@unc.edu
	Orlando Coronell Associate Professor Environmental Sciences & Engineering Rosenau 163B Phone: 919-966-9010 Email: coronell@unc.edu	
<b>Course Website</b>	<a href="https://sakai.unc.edu/welcome/">https://sakai.unc.edu/welcome/</a> . Use your ONYEN and password.	
<b>Class Days, Times, Location</b>	Tuesdays and Thursdays, 3:30 – 4:45, 1305, McGavran-Greenberg	
<b>Office Hours</b>	There are no set office hours for this course. Students may request an appointment by email. Virtual office hours may be conducted via phone, Skype, or Zoom.	
<b>Course Texts</b>	There is no textbook needed for this course  Journal articles and other readings that are specified throughout the course as required or supplemental reading materials (see below)	
<b>Course Format</b>	The course will include a mix of lectures, in-class discussions, and in-class problem solving.	

## Course Policies and Resources

### Recognizing, Valuing and Encouraging Inclusion and Diversity in the Classroom

We share the School's [commitment to diversity](#). We are committed to ensuring that the School is a diverse, inclusive, civil and welcoming community. Diversity and inclusion are central to our mission — to improve public health, promote individual well-being and eliminate health inequities across North Carolina and around the world. Diversity and inclusion are assets that contribute to our strength, excellence and individual and institutional success. We welcome, value and learn from individual differences and perspectives. These include but are not limited to: cultural and racial/ethnic background; country of origin; gender; age; socioeconomic status; physical and learning abilities; physical appearance; religion; political perspective; sexual identity and veteran status. Diversity, inclusiveness and civility are core values we hold, as well as characteristics of the School that we intend to strengthen.

We are committed to expanding diversity and inclusiveness across the School— among faculty, staff, students, on advisory groups, and in our curricula, leadership, policies and practices. We measure diversity and inclusion not only in numbers, but also by the extent to which students, alumni, faculty and staff members perceive the School's environment as welcoming, valuing all individuals and supporting their development.”

In this class, we practice these commitments in the following ways:

- Develop classroom participation approaches that acknowledge the diversity of ways of contributing in the classroom and foster participation and engagement of *all* students.
- Structure assessment approaches that acknowledge different methods for acquiring knowledge and demonstrating proficiency.
- Encourage and solicit feedback from students to continually improve inclusive practices.

As a student in the class, you are also expected to understand and uphold the following UNC policies:

- **Diversity and Inclusion at the Gillings School of Global Public Health:** <http://sph.unc.edu/resource-pages/diversity/>
- **UNC Non-Discrimination Policies:** <http://policy.sites.unc.edu/files/2013/04/nondiscrim.pdf>
- **Prohibited Discrimination, Harassment, and Related Misconduct at UNC:** <https://deanofstudents.unc.edu/incident-reporting/prohibited-harassmentsexual-misconduct>

### Accessibility

UNC-CH supports all reasonable accommodations, including resources and services, for students with disabilities, chronic medical conditions, a temporary disability, or a pregnancy complication resulting in difficulties with accessing learning opportunities. All accommodations are coordinated through the UNC Office of Accessibility Resources & Services (ARS), <https://ars.unc.edu/>; phone 919-962-8300; email [ars@unc.edu](mailto:ars@unc.edu). Students must document/register their need for accommodations with ARS before accommodations can be implemented.

### Counseling and Psychological Services (CAPS)

CAPS is strongly committed to addressing the mental health needs of a diverse student body through timely access to consultation and connection to clinically appropriate services, whether for short or long-term needs. Go to their website: <https://caps.unc.edu> or visit their facilities on the third floor of the Campus Health Services building for a walk-in evaluation to learn more.

### UNC Honor Code

As a student at UNC-Chapel Hill, you are bound by the university's [Honor Code](#), through which UNC maintains standards of academic excellence and community values. It is your responsibility to learn about and abide by the code. All written assignments or presentations (including team projects) should be completed in a manner that demonstrates academic integrity and excellence. Work should be completed in your own words, but your ideas should be supported with well-cited evidence and theory. To ensure effective functioning of the [Honor System](#) at UNC, students are expected to:

- a. Conduct all academic work within the letter and spirit of the Honor Code, which prohibits the giving or receiving of unauthorized aid in all academic processes.
- b. Learn the recognized techniques of proper attribution of sources used in written work; and to identify allowable resource materials or aids to be used during completion of any graded work.
- c. **Sign a pledge on all graded academic work certifying that no unauthorized assistance has been received or given in the completion of the work.**
- d. Report any instance in which reasonable grounds exist to believe that a fellow student has violated the Honor Code.

Instructors are required to report suspected violations of the Honor Code, including inappropriate collaborative work or problematic use of secondary materials, to the Honor Court. Honor Court sanctions can include receiving a zero for the assignment, failing the course and/or suspension from the university. If you have any questions about [your rights and responsibilities](#), please consult the Office of Student Conduct at <https://studentconduct.unc.edu/>, or consult these other resources:

- Honor system [module](#).
- UNC library's [plagiarism tutorial](#).
- UNC Writing Center [handout on plagiarism](#).

### Instructor Expectations

#### Email

One of the instructors will typically respond to email within 48 hours or less if sent Monday through Friday. The instructor may respond to weekend emails, but it is not required of them. If you receive an out of office reply when emailing, it may take longer to receive a reply.

#### Grading

Quizzes, homework problem sets, exams, and journal article reviews will be graded within two weeks after the due date.

<b>Syllabus Changes</b>	The instructors reserve to right to modify the syllabus, including project due dates and test dates. These changes will be announced as early as possible.
<b>Telephone Messages</b>	The instructors will respond to telephone messages within 48 hours Monday through Thursday.
<b>Student Expectations</b>	
<b>Appropriate Use of Course Resources:</b>	The materials used in this class, including, but not limited to, syllabus, exams, quizzes, and assignments are copyright protected works. Any unauthorized copying of the class materials is a violation of federal law and may result in disciplinary actions being taken against the student. Additionally, the sharing of class materials without the specific, express approval of the instructor may be a violation of the University's Student Honor Code and an act of academic dishonesty, which could result in further disciplinary action. This includes, among other things, uploading class materials to websites for the purpose of sharing those materials with other current or future students.
<b>Assignments</b>	Submit printed copies of problem sets at the start of class on the day the problem set is due. Submit copies of presentations of journal article review assignments to Sakai under the "Drop Box" folder, and bring a copy of the presentation to class via USB. Emailing assignments is not acceptable unless prior arrangements have been made.
<b>Attendance/ Participation</b>	Your attendance and active participation are an integral part of your learning experience in this course. If you are unavoidably absent, please notify the course instructors in advance. You will receive a grade of zero for missed in-class quizzes, exams, and presentations unless you notify the instructors of extenuating circumstances.
<b>Communication</b>	You are expected to follow common courtesy in all communication to include email, discussion boards, and face-to-face meetings. All electronic communications sent should follow proper English grammar rules to include complete sentences. This is a professional course, and you are expected to communicate as a professional.
<b>Contributions</b>	You are expected to offer individual contributions in class and on individual assignments. You may collaborate with fellow student on problem sets, but these collaborations should be acknowledged on your submitted assignment. In addition, you should submit your own, individual write-up of solved problems, even if you work in a group. You may not collaborate on journal article reviews.
<b>Email</b>	All email correspondence between student/instructor and peer/peer will be conducted in a professional manner following email etiquette. <ul style="list-style-type: none"><li>• View the following link for more information on email etiquette: <a href="http://metropolitanorganizing.com/etiquette-professional-organizing-services/essential-email-etiquette-tips/">http://metropolitanorganizing.com/etiquette-professional-organizing-services/essential-email-etiquette-tips/</a></li></ul>

<b>Late Work</b>	Problem sets should be turned in on time. Late problem sets will lose 10% for each day late. Problem sets may be turned in late only if prior approval of the instructor is given or if there is some very exceptional circumstance that arises (e.g., severe illness, accident).
<b>Readings</b>	Readings for a particular class should be completed before the class session and before completing associated quizzes and problem sets.
<b>Other course material requirements</b>	This course requires a handheld calculator to be used during class activities, quizzes, and exams
<b>Technical support</b>	The UNC Information Technology Services (ITS) department provides technical support 24-hours per day, seven days per week. If you need computer help, please contact the ITS Help Desk by phone at +1-919-962-HELP (919-962-4357), or by email at <a href="mailto:help@unc.edu">help@unc.edu</a> , or by visiting their website at <a href="http://help.unc.edu">http://help.unc.edu</a> , or by UNC Live Chat at <a href="http://its.unc.edu/itrc/chat">http://its.unc.edu/itrc/chat</a> .

## Competencies, Learning Objectives, and Assessment

Competencies addressed in this course, learning objectives mapped to these competencies, and assignments that assess these competencies.

Environmental Health Solutions Competencies	Learning Objectives	Assessment Assignments
Describe and critically evaluate the rationale for and approaches used to measure and model properties of environmental/ human systems	<ul style="list-style-type: none"> <li>• Understand the types of exposures that impact human health</li> <li>• Understand methods in which researchers can evaluate potential relationships between chemical exposures and health outcomes</li> <li>• Understand and be able to convert among units of measurement used to characterize concentrations of environmental pollutants</li> </ul>	<p><b>Mid-term exam 1:</b> Written exam with a combination of worked problems, multiple choice, and short-answer questions</p>
Describe which types of chemical contaminants have long or short lifetimes in the environment and how this eventually affects other environmental processes and human exposure	<ul style="list-style-type: none"> <li>• Understand the sources, reactions, and effects of chemical species emitted into the environment</li> <li>• Understand some of the methods used to monitor pollutant emission and transformation</li> <li>• Understand environmental chemistry success stories and how these successes might be useful for mitigating the presence of emerging contaminants</li> </ul>	
Identify and evaluate the relationships between sources of air pollution and processes that affect the movement, transformations, exposure pathways and health effects of air pollutants in environmental systems	<ul style="list-style-type: none"> <li>• Understand sources of air pollution</li> <li>• Understand how air pollutants move through and are transformed in air and the influence of these processes on human exposure risk</li> <li>• By understanding the chemical sources and processes of air pollution, you should be able to suggest mitigation strategies that could be used to reduce human exposure</li> </ul>	
Identify and evaluate the relationships between sources of water pollution and processes that affect the movement, transformations, exposure pathways and health effects of water pollutants in environmental systems	<ul style="list-style-type: none"> <li>• Understand sources of water pollution</li> <li>• Understand how water pollutants move through and are transformed in water and the influence of these processes on human exposure risk</li> </ul>	<p><b>Mid-term exam 2:</b> Written exam with a combination of worked problems, multiple choice, and short-answer questions</p> <p><b>Journal article review 1:</b> Choose a technical journal article describing sources of an environmental contaminant or class of contaminants (e.g., PAHs, dioxins, heavy metals, PFASs, etc.), contaminant transformation and transport, and the potential for human exposure. Conduct a critical evaluation of the article and present an overview and critique to the class.</p>

<p>Weigh the scientific bases of hazard identification, exposure and health risk assessment to support environmental management and policy</p>	<ul style="list-style-type: none"><li>• Be able to describe what climate change is and the technical options for mitigating climate change</li><li>• Using knowledge gained over the course of the semester, understand methods for estimating the concentration of pollutants to which humans may be exposed in the environment and how those exposures can be decreased or prevented.</li><li>• Know where to find and how to use dose-response functions that translate estimates of pollutant exposure to human health risks.</li><li>• Understand the importance of characterizing uncertainty in risk assessments used to support environmental management and policy decisions.</li><li>• Be able to identify and understand purpose and regulatory approach of major U.S. environmental laws.</li></ul>	<p><b>Mid-term exam 2:</b> Written exam with a combination of worked problems, multiple choice, and short-answer questions</p> <p><b>Final exam:</b> Written exam with a combination of worked problems, multiple choice, and short-answer questions; emphasis on methods for quantifying human exposure to contaminants, combining exposure estimates with dose-response functions, and characterizing human health risks. Short-answer questions on U.S. environmental laws.</p> <p><b>Journal article review 2:</b> Choose an article that estimates human exposure to an environmental pollutant or pollutants and that uses the exposure information to quantify the benefits of environmental management or policy strategies for decreasing those exposures. Conduct and present a critical evaluation of the article.</p>
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## Course Assignments and Assessments

Evaluation Component	Points/Percentages
1. In-class quizzes	15
2. Mid-term exams (15% each)	30
3. Final exam	15
4. Homework problem sets	20
5. Presentation of journal articles	20
TOTAL	100

### Grading

**Grading:** For the journal article reviews, refer to the attached rubric for grading details. The relative weight of each course component is shown in the table above.

#### Grading Scale:

##### *Graduate Students*

Final course grades will be determined using the following [UNC Graduate School grading scale](#).

Percentage Score	Grade
93-100	H
80-92	P
70-79	L
< 70	F

##### *Undergraduate Students*

Final course grades will be determined using the following [UNC Undergraduate School grading system](#).

Percentage Score	Grade
93-100	A
90-92	A-
87-89	B+
83-86	B
80-82	B-
77-79	C+
73-76	C
70-72	C-
67-69	D+
60-66	D
<60	F

## Assignment Descriptions

### 1. Journal Article Critiques (10% each, 20% of total grade)

Fundamental to a career in environmental science or public health is reading, comprehending, and critiquing published or under-review research articles, as well as presenting to your colleagues complicated research findings in a clear and concise manner. Due to the importance of these skills, you will practice in this course selecting two peer-reviewed journal articles.

Briefly, you will pick any research article (not a review article; unless it reviews available data and conducts a risk assessment) from any peer-reviewed journal of your choice. The first article must describe sources of an environmental contaminant or contaminants, contaminant transformation and transport, and the potential for human exposure. The second must estimate human exposure to an environmental pollutant or pollutants and use the exposure information to quantify the benefits of environmental management or policy strategies for decreasing those exposures.

**The instructors must approve your articles at least two weeks before the scheduled presentations.** We prefer that you select articles you have not already read and that might be helpful to your own research project (or thesis or dissertation work).

This assignment will require a formal presentation of the student's review. Students will be given 10 minutes for their presentation, with an additional three minutes for questions/discussion. Details of the expectations for the presentation will include the following three components: (1) an overview section that summarizes the purpose, design, and major findings of the study, (2) a comments section addressing the three principal criteria of scientific significance, scientific quality, and presentation quality, and (3) a relevance description section of how this article directly relates to material covered in this course.

**Oral presentations (in either PDF or Power Point format) are due by 5:00 PM the day before the presentations, uploaded to Sakai in the "Drop Box" folder. Students should also bring their presentations in a jumpdrive/USB memory.**

Rubric.

Criteria	Met (3)	Partially Met (2)	Not Met (1-0)
<b>Overview section, introduction (20 points)</b>	The introduction clearly summarizes the aims of and methods used by the authors.	The introduction summarizes the aims of and methods used by the authors but lacks clarity.	1-The introduction summarizes the aims of and methods used by the authors but lacks clarity, and the connections to the paper are not obvious.  0-There is not an introduction summarizing the aims of and methods used by the authors.
<b>Overview section, research design and findings (20 points)</b>	Very clear understanding of the research design. The writer also has a clear understanding of the study's findings and how they arose from the research.	Partial understanding of the research design. The writer does not have a clear understanding of the findings and how they were derived from the research.	1-Significant gaps in understanding of research design. The writer does not have a clear understanding of how findings arose from the research.  0-Little to no understanding of the research design or how findings connect to that design. Major errors interpretation of findings.
<b>Comments section (20 points)</b>	Clear understanding and articulation of the study's limitations, not only in research design but	Mostly clear understanding of the study's limitations and the implications of those limitations for supporting the overall findings.	1-Evaluation of limitations is incomplete and/or inaccurate.  0-No or completely inaccurate evaluation of study's limitations.

	also in the strength of the findings		
<b>Relevance to the course (20 points)</b>	Clear understanding and description of how the article relates directly to material learned in the course.	Partially clear but not fully complete description of the article's relevance to the course.	1-Relevance to course not described accurately and completely.  0-Relevance to the course not described at all or completely inaccurate.
<b>Clarity of Presented Materials (20 points)</b>	Clear communication and articulation of the key aspects of the study, and the three components requested. No spelling or grammatical errors. Visually pleasing and organized layout.	Partially clear but not fully complete/organized. Very few spelling or grammatical errors.	1-Slides include information that is unorganized and unclear. Multiple spelling or grammatical errors.  0-Excessive spelling or grammatical errors. Lack of clear communication. Unclear slides.

## 2. In-Class Exams (15% each, 45% of total grade)

**Mid-Term Exam 1.** Worked problems and true/false, multiple choice, and short-answer questions will cover material from sessions 1-11.

**Mid-Term Exam 2.** Worked problems and true/false, multiple choice, and short-answer questions will cover material from sessions 12-21.

**Final Exam.** Worked problems and true/false, multiple choice, and short-answer questions will cover the full semester but will strongly emphasize sessions 23-30.

## Course-at-a-Glance

The instructors reserve the right to make changes to the syllabus, including due dates and test dates.

Class	Date	Topic	Instructor Lecturing on Topic	In-Class Quiz (Instructor)	Homework Assignment (Instructor) (Due Date)
		<b>INTRODUCTION TO EXPOSURE SCIENCE AND PUBLIC HEALTH</b>			
1	8/20	Course introduction	All instructors		
2	8/22	Introduction to exposure science and public health	Rager		
3	8/27	Environmental chemical exposures: units of measurement	Rager	Q1 (Rager)	
4	8/29	Environmental chemical exposures: mass balance	Rager		HW1 (Rager) (9/5)
5	9/3	Environmental chemistry overview	Surratt	Q2 (Rager)	
		<b>ATMOSPHERIC AND AIR POLLUTION CHEMISTRY</b>			
6	9/5	Atmospheric and air pollution chemistry: atmospheric structure, composition, general air circulation and trace constituents (part I)	Surratt		
7	9/10	Atmospheric and air pollution chemistry: trace constituents, radiation, and typical reactions (part II)	Surratt		
8	9/12	Atmospheric and air pollution chemistry: chemical families and "natural" stratospheric chemistry (part III)	Surratt	Q3 (Surratt)	
9	9/17	Atmospheric and air pollution chemistry: catalytic processes of stratospheric ozone depletion (part IV)	Surratt		HW2 (Surratt) (9/26)
10	9/19	Atmospheric and air pollution chemistry: polar stratospheric clouds (PSCs) and "ozone holes" as well as introduction to tropospheric chemistry (part V)	Surratt		
11	9/24	Atmospheric and air pollution chemistry (part VI): volatile organic compound oxidations yielding urban (or "bad") ozone and fine particulate matter	Surratt	Q4 (Surratt)	
		<b>WATER POLLUTION AND CONTROL</b>			
12	9/26	Water cycle and origin of constituents of natural water	Coronell		
13	10/1	<b>Exam 1</b>	Rager & Surratt		
14	10/3	Physico-chemical processes affecting the transformation and speciation of water constituents and contaminant (Part I)	Coronell		Articles to review are due
15	10/8	Physico-chemical processes affecting the transformation and speciation of water constituents and contaminants (Part II)	Coronell		
16	10/10	Sources of water pollution and human exposure to water pollutants	Coronell	Q5 (Coronell)	HW3 (Coronell) (10/29)

17	10/15	<i>Student peer-reviewed article presentations, round 1</i>	All instructors		
	10/17	<i>Fall Break – no class</i>			
18	10/22	<i>Student peer-reviewed article presentations, round 1 (continued)</i>	All instructors		
19	10/24	Physico-chemical processes used for the transformation or removal of contaminants during water purification	Coronell		
		<b>CLIMATE CHANGE</b>			
20	10/29	Climate change: part I	West	Q6 (Coronell)	
21	10/31	Climate change: part II	West		
22	11/5	<b>Exam 2</b>	Coronell		
		<b>HUMAN HEALTH RISK ASSESSMENT</b>			
23	11/7	Risk assessment step 1: hazard identification	Lee (EPA) & Rager		
24	11/12	Risk assessment step 2: exposure assessment	Price (EPA) & Rager		Articles to review are due
25	11/14	Risk assessment steps 3 & 4: dose-response and risk characterization	Rager	Q7 (Rager)	
26	11/19	Modernizing risk assessment in the 21 <sup>st</sup> century	Wambaugh (EPA) & Rager		
27	11/21	<b>Second round of student presentations</b>	All instructors		
	11/26	No class (Thanksgiving)			
	11/28	No class (Thanksgiving)			
28	12/3	<b>Second round of student presentations, continued</b>	All instructors		
29	12/3	<b>Final Exam (4:00 p.m.)</b>	All instructors		

## Course Schedule

The instructors reserve the right to make changes to the syllabus, including project due dates and test dates. These changes will be announced as early as possible.

<b>Session 1 (Tues, 8/20)</b>	<b>All instructors</b>
<b>Topic</b>	<b>Course introduction</b>
Competency	Describe and critically evaluate the rationale for and approaches used to measure and model properties of environmental/ human systems
Learning Objectives	Understand course format, learning objectives, and expectations; Motivations for studying environmental sciences and public health
Required Readings	Articles uploaded to Sakai describing steps used in the peer-review process
Class Activity	<i>Lecture on course overview, teacher introductions, and student introductions</i>
Assignments/Deadlines	None

<b>Session 2 (Thurs, 8/22)</b>	<b>Rager</b>
<b>Topic</b>	<b>Introduction to exposure science and public health</b>
Competency	Describe and critically evaluate the rationale for and approaches used to measure and model properties of environmental/ human systems
Learning Objectives	<ul style="list-style-type: none"> <li>• Overview on the big picture: source-to-exposures; relationships between sources of environmental contaminants and processes that affect the movement, transformation, exposure pathways and health effects of contaminants in environmental systems</li> <li>• Characterize types of exposures</li> <li>• Understand methods to evaluate chemical exposures</li> <li>• Understand ways to evaluate associations between exposures and health outcomes</li> </ul>
Required Readings	None
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	<i>Lecture; Chemical exposure monitoring activity</i>
Assignments/Deadlines	<i>Review for first in-class quiz at start of next session</i>

<b>Session 3 (Tues, 8/27)</b>	<b>Rager</b>
<b>Topic</b>	<b>Environmental chemical exposures: units of measurement</b>
Competency	Describe and critically evaluate the rationale for and approaches used to measure and model properties of environmental/ human systems
Learning Objectives	<ul style="list-style-type: none"> <li>Understand and be able to convert among units of measurement used to characterize concentrations of environmental pollutants; understand the principles of mass balance modeling for tracking the fate and transport of environmental pollutants</li> </ul>
Required Readings	
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	<i>10-min quiz #1 (Rager)</i>  <i>Problem solving: unit conversions</i>
Assignments/Deadlines	None

<b>Session 4 (Thurs, 8/29)</b>	<b>Rager</b>
<b>Topic</b>	<b>Environmental chemical exposures: mass balance</b>
Competency	Describe and critically evaluate the rationale for and approaches used to measure and model properties of environmental/ human systems
Learning Objectives	<ul style="list-style-type: none"> <li>Understand and be able to convert among units of measurement used to characterize concentrations of environmental pollutants; understand the principles of mass balance modeling for tracking the fate and transport of environmental pollutants</li> </ul>
Required Readings	
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	<i>Problem solving: mass-balance modeling</i>
Assignments/Deadlines	<i>Review for in-class quiz at start of next session</i>  <i>Homework #1: due on 9/5 (Rager)</i>

<b>Session 5 (Tues, 9/3)</b>	<b>Surratt</b>
<b>Topic</b>	<b>Environmental chemistry overview</b>
Competency	Describe which types of chemical contaminants have long or short lifetimes in the environment and how this eventually affects other environmental processes and human exposure
Learning Objectives	<ul style="list-style-type: none"> <li>• Understand the sources, reactions, and effects of chemical species emitted into the environment</li> <li>• Understand some of the methods used to monitor pollutant emission and transformation</li> <li>• Understand environmental chemistry success stories and how these successes might be useful for mitigating the presence of emerging contaminants</li> </ul>
Required Readings	Notes and handouts provided by instructor
Other Required Resources	<ul style="list-style-type: none"> <li>• Lecture 5_Overview of Environmental Chemistry.pdf</li> <li>• Lecture 5_Background on Organic Chemistry.pdf</li> <li>• Lecture 5_Rules for Determining Oxidation States.pdf</li> </ul>
Optional/Additional Resources	None
Class Activity	<i>10-min quiz #2 (Rager)</i>
Assignments/Deadlines	None

<b>Session 6 (Thurs, 9/5)</b>	<b>Surratt</b>
<b>Topic</b>	<b>Atmospheric and air pollution chemistry: atmospheric structure, composition, general air circulation and trace constituents (part I)</b>
Competency	Identify and evaluate the relationships between sources of air pollution and processes that affect the movement, transformations, exposure pathways and health effects of air pollutants in environmental systems
Learning Objectives	<ul style="list-style-type: none"> <li>• Introduction to the atmosphere (composition and circulation)</li> <li>• Atmospheric lifetimes of trace air pollutants</li> <li>• Emissions of atmospheric trace constituents (pollutants)</li> <li>• Quick review of basic organic chemical classes</li> </ul>
Required Readings	<ul style="list-style-type: none"> <li>• Lecture 6_The Atmosphere and its Composition.pdf</li> <li>• Lecture 6_Atmospheric Chemical Kinetics.pdf</li> </ul>
Other Required Resources	None

Optional/Additional Resources	None
Class Activity	None
Assignments/Deadlines	<i>Review for in-class quiz at start of next session</i>

<b>Session 7 (Tues, 9/10)</b>	<b>Surratt</b>
<b>Topic</b>	<b>Atmospheric and air pollution chemistry: trace constituents, radiation, and typical reactions (part II)</b>
Competency	Identify and evaluate the relationships between sources of air pollution and processes that affect the movement, transformations, exposure pathways and health effects of air pollutants in environmental systems
Learning Objectives	<ul style="list-style-type: none"> <li>• Continue discussion of emissions of inorganic and organic compounds into atmosphere</li> <li>• Discuss atmospheric radiation at various levels of the atmosphere and its implications for driving atmospheric reactions</li> <li>• Understand typical atmospheric reactions</li> </ul>
Required Readings	<ul style="list-style-type: none"> <li>• Lecture 7_Atmospheric Radiation and Photochemistry.pdf</li> </ul>
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	<i>10-min quiz #3 (Surratt)</i>
Assignments/Deadlines	None

<b>Session 8 (Thurs, 9/12)</b>	<b>Surratt</b>
<b>Topic</b>	<b>Atmospheric and air pollution chemistry: chemical families and “natural” stratospheric chemistry (part III)</b>
Competency	Identify and evaluate the relationships between sources of air pollution and processes that affect the movement, transformations, exposure pathways and health effects of air pollutants in environmental systems
Learning Objectives	<ul style="list-style-type: none"> <li>• Describe chemical families and their utility for summarizing complex atmospheric reactions that produce or destroy ozone</li> <li>• Describe the “natural” stratospheric chemistry that yields “good” ozone (Chapman Mechanism)</li> </ul>

Required Readings	Notes and handouts provided by instructor
Other Required Resources	Lecture 8_Stratospheric Chemistry.pdf
Optional/Additional Resources	None
Class Activity	None
Assignments/Deadlines	None

<b>Session 9 (Tues, 9/17)</b>	<b>Surratt</b>
<b>Topic</b>	<b>Atmospheric and air pollution chemistry: catalytic processes of stratospheric ozone depletion (part IV)</b>
Competency	Identify and evaluate the relationships between sources of air pollution and processes that affect the movement, transformations, exposure pathways and health effects of air pollutants in environmental systems
Learning Objectives	<ul style="list-style-type: none"> <li>• Discuss the role of HO<sub>x</sub>, NO<sub>x</sub>, and ClO<sub>x</sub> families in destroying stratospheric ozone</li> <li>• Understand how the interactions of HO<sub>x</sub>, NO<sub>x</sub> and ClO<sub>x</sub> families yield critical species that later produce “ozone holes”</li> </ul>
Required Readings	<ul style="list-style-type: none"> <li>• Lecture 9_Stratospheric Chemistry 2.pdf</li> </ul>
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	None
Assignments/Deadlines	<i>Homework #2: due on 9/26 (Surratt)</i>

<b>Session 10 (Thurs, 9/19)</b>	<b>Surratt</b>
<b>Topic</b>	<b>Atmospheric and air pollution chemistry: polar stratospheric clouds (PSCs) and “ozone holes” as well as introduction to tropospheric chemistry (part V)</b>
Competency	Identify and evaluate the relationships between sources of air pollution and processes that affect the movement, transformations, exposure pathways and health effects of air pollutants in environmental systems

Learning Objectives	<ul style="list-style-type: none"> <li>Describe the interactions of HO<sub>x</sub>, ClO<sub>x</sub>, and NO<sub>x</sub> families and their products (reservoirs) with PSCs to yield “ozone holes” each winter-to-spring transition at the poles (i.e., Arctic and Antarctic regions).</li> <li>Understand the differences between the stratosphere and troposphere</li> <li>Understand the general atmospheric reaction mechanisms in the troposphere that lead to “bad” ozone (or urban smog).</li> </ul>
Required Readings	<ul style="list-style-type: none"> <li>Lecture 10_Tropospheric Chemistry.pdf</li> </ul>
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	
Assignments/Deadlines	<i>Review for in-class quiz at start of next session</i>

<b>Session 11 (Tues, 9/24)</b>	<b>Surratt</b>
<b>Topic</b>	<b>Atmospheric and air pollution chemistry (part VI): volatile organic compound oxidations yielding urban (or “bad”) ozone and fine particulate matter</b>
Competency	Identify and evaluate the relationships between sources of air pollution and processes that affect the movement, transformations, exposure pathways and health effects of air pollutants in environmental systems
Learning Objectives	<ul style="list-style-type: none"> <li>Describe the general reactions of VOCs and NO<sub>x</sub> that yield bad ozone in urban areas; examples with carbon monoxide and methane will be used</li> <li>Understand how atmospheric reactions of VOCs, NO<sub>x</sub>, and SO<sub>2</sub> yield fine particulate matter and acid rain in urban areas</li> <li>Be able to recommend ways to mitigate air pollution in populated areas</li> </ul>
Required Readings	<ul style="list-style-type: none"> <li>Lecture 11_Tropospheric Chemistry 2.pdf</li> </ul>
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	<i>10-min quiz #4 (Surratt)</i>

Assignments/Deadlines	
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<b>Session 12 (Thurs, 9/26)</b>	<b>Coronell</b>
<b>Topic</b>	<b>Water cycle and origin of constituents of natural waters</b>
Competency	Identify and evaluate the relationships between sources of water pollution and processes that affect the movement, transformations, exposure pathways and health effects of water pollutants in environmental systems
Learning Objectives	<ul style="list-style-type: none"> <li>• Understand the basics of the water cycle</li> <li>• Understand the relationship between the various stages of the water cycle and the identity and concentration of the water constituents associated with each step of the cycle</li> <li>• Identify common natural water constituents that act as pollutants and pose (potential) risks to human health</li> <li>• Become familiar with the metrics used for quantifying the concentration of substances in water</li> </ul>
Required Readings	Notes and handouts provided by instructor
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	Lecture; class discussion on the water cycle and sources of natural water constituents
Assignments/Deadlines	<i>Homework # 2 Due today; Review for exam 1</i>

<b>Session 13 (Tues, 10/1)</b>	<b>Rager &amp; Surratt</b>
<b>Topic</b>	<b>Exam 1</b>
Competency	Describe and critically evaluate the rationale for and approaches used to measure and model properties of environmental/ human systems Identify and evaluate the relationships between sources of air pollution and processes that affect the movement, transformations, exposure pathways and health effects of air pollutants in environmental systems
Learning Objectives	Examine materials from lecture sessions 1-11, to include: <ul style="list-style-type: none"> <li>• Understand general concepts of exposure science, chemical fate and transport, and human health assessments</li> </ul>

	<ul style="list-style-type: none"> <li>• Understand and be able to convert among units of measurement used to characterize concentrations of environmental pollutants</li> <li>• Air pollutant chemistry 101</li> <li>• Methods to remediate/reduce air pollution in the environment</li> </ul>
Required Readings	Notes and handouts provided by instructor
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	<b>Mid-term exam 1:</b> Written exam with a combination of worked problems and true/false, multiple choice, and short-answer questions
Assignments/Deadlines	

<b>Session 14 (Thurs, 10/3)</b>	<b>Coronell</b>
<b>Topic</b>	<b>Physico-chemical processes affecting the transformation and speciation of water constituents and contaminants (Part I)</b>
Competency	Identify and evaluate the relationships between sources of water pollution and processes that affect the movement, transformations, exposure pathways and health effects of water pollutants in environmental systems
Learning Objectives	<ul style="list-style-type: none"> <li>• Understand the basics of the physical and chemical processes that affect the transformation and speciation of water constituents and contaminants in the environment: phase transfer, acid/base dissociation, precipitation/solubility, oxidation-reduction, and complexation</li> </ul>
Required Readings	Notes and handouts provided by instructor
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	Lecture; group exercises on phase transfer and acid/base dissociation
Assignments/Deadlines	<i>Articles to review are due today</i>

<b>Session 15 (Tues, 10/8)</b>	<b>Coronell</b>
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<b>Topic</b>	<b>Physico-chemical processes affecting the transformation and speciation of water constituents and contaminants (Part II)</b>
Competency	Identify and evaluate the relationships between sources of water pollution and processes that affect the movement, transformations, exposure pathways and health effects of water pollutants in environmental systems
Learning Objectives	<ul style="list-style-type: none"> <li>• Understand the basics of the physical and chemical processes that affect the transformation and speciation of water constituents and contaminants in the environment: phase transfer, acid/base dissociation, precipitation/solubility, oxidation-reduction, and complexation</li> </ul>
Required Readings	Notes and handouts provided by instructor
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	Lecture; group exercises on precipitation/dissolution and oxidation-reduction
Assignments/Deadlines	<i>Review for in-class quiz</i>

<b>Session 16 (Thurs, 10/10)</b>	<b>Coronell</b>
<b>Topic</b>	<b>Sources of water pollution and human exposure to water pollutants</b>
Competency	Identify and evaluate the relationships between sources of water pollution and processes that affect the movement, transformations, exposure pathways and health effects of water pollutants in environmental systems
Learning Objectives	<ul style="list-style-type: none"> <li>• Understand the identity and sources of common water contaminants</li> <li>• Understand the environmental impacts and potential health impacts of common contaminants present in drinking water sources</li> <li>• Understand with the main routes of human exposure to water pollutants</li> </ul>
Required Readings	Notes and handouts provided by instructor
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	Lecture
Assignments/Deadlines	<i>Homework #3: due on 10/29 (Coronell)</i>  <i>10-min quiz #5 (Coronell)</i>

	<i>Presentations of peer review of scientific articles are due next class</i>
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<b>Session 17-18 (Tues, 10/15 and Thurs, 10/22)</b>	<b>All Instructors</b>
<b>Topic</b>	<b>Student presentations of peer-reviewed journal articles</b>
Competency	Describe and critically evaluate the rationale for and approaches used to measure and model properties of environmental/ human systems. Identify and evaluate the relationships between sources of air pollution and processes that affect the movement, transformations, exposure pathways and health effects of air pollutants in environmental systems. Identify and evaluate the relationships between sources of water pollution and processes that affect the movement, transformations, exposure pathways and health effects of water pollutants in environmental systems.
Learning Objectives	<ul style="list-style-type: none"> <li>• Demonstrate competency in understanding pollutant sources, transformation and transport, potential for human exposure, evaluating relationships between exposure and health outcomes, and mitigation options.</li> </ul>
Required Readings	Notes and handouts provided by instructor
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	Presentations
Assignments/Deadlines	

<b>Session 19 (Thurs, 10/24)</b>	<b>Coronell</b>
<b>Topic</b>	<b>Physico-chemical processes used for the transformation or removal of contaminants during water purification</b>
Competency	Identify and evaluate the relationships between sources of water pollution and processes that affect the movement, transformations, exposure pathways and health effects of water pollutants in environmental systems
Learning Objectives	<ul style="list-style-type: none"> <li>• Become familiar with the physical and chemical processes used for the treatment of water for production of drinking water</li> </ul>

	<ul style="list-style-type: none"> <li>• Become familiar with the physical, chemical and biological processes used for the treatment of wastewaters</li> <li>• Become familiar with technologies used for remediation of groundwaters</li> </ul>
Required Readings	Notes and handouts summarizing current major chemical legislation
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	Lecture; class discussion on how the same processes that nature uses to transform water constituents and contaminants are used in water treatment facilities to purify water
Assignments/Deadlines	

<b>Session 20 (Tues, 10/29)</b>	<b>West</b>
<b>Topic</b>	<b>Climate Change: Part I</b>
Competency	Weigh the scientific bases of hazard identification, exposure and health risk assessment to support environmental management and policy
Learning Objectives	<ul style="list-style-type: none"> <li>• Understand the greenhouse effect and global temperature carbon, nitrogen, and oxygen cycles</li> </ul>
Required Readings	Notes and handouts provided by instructor
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	
Assignments/Deadlines	<i>10-min quiz #6 (Coronell)</i>  <i>Homework # 3 Due today;</i>

<b>Session 21 (Thurs, 10/31)</b>	<b>West</b>
<b>Topic</b>	<b>Climate Change: Part II</b>
Competency	Weigh the scientific bases of hazard identification, exposure and health risk assessment to support environmental management and policy

Learning Objectives	<ul style="list-style-type: none"> <li>• Describe technical and policy options for mitigating climate change</li> <li>• Understand IPCC emissions scenarios and international agreements</li> </ul>
Required Readings	Notes and handouts provided by instructor
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	
Assignments/Deadlines	<i>Review for exam #2</i>

<b>Session 22 (Tues, 11/5)</b>	<b>Coronell</b>
<b>Topic</b>	<b>Exam 2</b>
Competency	Identify and evaluate the relationships between sources of water pollution and processes that affect the movement, transformations, exposure pathways and health effects of water pollutants in environmental systems
Learning Objectives	Examine materials from lecture sessions 12-21, to include: <ul style="list-style-type: none"> <li>• Understand water pollution chemistry and remediation</li> <li>• Be able to describe what climate change is and the technical options for mitigating climate change</li> </ul>
Required Readings	Notes and handouts provided by instructor
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	<b>Mid-term exam 2:</b> Written exam with a combination of worked problems and true/false, multiple choice, and short-answer questions
Assignments/Deadlines	

<b>Session 23 (Thurs, 11/7)</b>	<b>Lee &amp; Rager</b>
<b>Topic</b>	<b>Risk Assessment Step 1: Hazard Identification</b>
Competency	Weigh the scientific bases of hazard identification, exposure and health risk assessment to support environmental management and policy

Learning Objectives	<ul style="list-style-type: none"> <li>• Gain familiarity of the overall risk assessment process</li> <li>• Learn epidemiology and toxicology measures of health hazard</li> <li>• Understand example risk assessment calculations</li> </ul>
Required Readings	Notes and handouts provided by instructor
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	Lecture; student participation
Assignments/Deadlines	

<b>Session 24 (Tues, 11/12)</b>	<b>Price &amp; Rager</b>
<b>Topic</b>	<b>Risk Assessment Step 2: Exposure Assessment</b>
Competency	Weigh the scientific bases of hazard identification, exposure and health risk assessment to support environmental management and policy
Learning Objectives	<ul style="list-style-type: none"> <li>• Understand exposure assessment in the regulatory setting</li> <li>• Understand single chemicals vs. aggregate and cumulative exposures</li> </ul>
Required Readings	Notes and handouts provided by instructor
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	Lecture; student participation
Assignments/Deadlines	<i>Review for in-class quiz at start of next session</i>  <i>Articles for peer review are due today</i>

<b>Session 25 (Thurs, 11/14)</b>	<b>Rager</b>
<b>Topic</b>	<b>Risk Assessment Steps 3 &amp; 4: Dose Response and Risk Characterization</b>
Competency	Weigh the scientific bases of hazard identification, exposure and health risk assessment to support environmental management and policy
Learning Objectives	<ul style="list-style-type: none"> <li>• Understand how relationships between exposure doses and responses and evaluated and quantified in the regulatory setting</li> </ul>

	<ul style="list-style-type: none"> <li>Understand how this is placed into the context of overall risk characterization</li> </ul>
Required Readings	Notes and handouts provided by instructor
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	Lecture; student participation
Assignments/Deadlines	<i>10-min quiz #7 (Rager)</i>

<b>Session 26 (Tues, 11/19)</b>	<b>Wambaugh &amp; Rager</b>
<b>Topic</b>	<b>Modernizing Risk Assessment in the 21<sup>st</sup> Century</b>
Competency	Weigh the scientific bases of hazard identification, exposure and health risk assessment to support environmental management and policy
Learning Objectives	<ul style="list-style-type: none"> <li>Understand the fields of 21st Century Exposure Science &amp; Toxicology and how these methods are being used to meet current environmental regulatory demands</li> </ul>
Required Readings	Notes and handouts provided by instructor
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	Lecture; student participation
Assignments/Deadlines	<i>Presentations of peer review of scientific articles are due next class</i>

<b>Session 27, 30 (Thurs, 11/21 and Tues, 12/3)</b>  <i>Note: sessions 28 &amp; 29 are holidays (Thanksgiving break)</i>	<b>All Instructors</b>
<b>Topic</b>	<b>Student presentations of peer-reviewed journal articles</b>
Competency	Weigh the scientific bases of hazard identification, exposure and health risk assessment to support environmental management and policy

Learning Objectives	<ul style="list-style-type: none"> <li>• Demonstrate competency in hazard identification, exposure and health risk assessment to support environmental management and policy</li> </ul>
Required Readings	None
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	Presentations
Assignments/Deadlines	<i>Review for final exam</i>

<b>Session 31 (12/12)</b>	<b>All Instructors</b>
<b>Topic</b>	<b>Final Exam</b>
Competency	<p>Describe and critically evaluate the rationale for and approaches used to measure and model properties of environmental/ human systems.</p> <p>Identify and evaluate the relationships between sources of air pollution and processes that affect the movement, transformations, exposure pathways and health effects of air pollutants in environmental systems.</p> <p>Identify and evaluate the relationships between sources of water pollution and processes that affect the movement, transformations, exposure pathways and health effects of water pollutants in environmental systems.</p> <p>Weigh the scientific bases of hazard identification, exposure and health risk assessment to support environmental management and policy.</p>
Learning Objectives	<p>Examine materials from all lecture sessions, with increased focus on sessions 23-30, to include:</p> <ul style="list-style-type: none"> <li>• Exposure science and public health concepts</li> <li>• Air and water pollution</li> <li>• Global climate change</li> <li>• Human health risk assessment</li> </ul>
Required Readings	None
Other Required Resources	None
Optional/Additional Resources	None
Class Activity	<b>Final exam:</b> Written exam with a combination of worked problems and true/false, multiple choice, and short-answer questions
Assignments/Deadlines	