Honors Organic Chemistry Laboratory Course_Antibiotics Discovery
CHEM 0745

Fall 2017
MoWe 1-4:50pm / TuTh 8-11:50am / TuTh 1-4:50pm
306 Chevron Science Center

Lingfeng Liu, Ph.D.
616 Chevron Science Center, Wednesday 11:00am-1:00pm
lfliu@pitt.edu
412-624-3111
Mailbox: 212

I. Course Description

The two-credit Honors Organic Chemistry Laboratory Course serves as an alternative to the Organic Chemistry Laboratory Course (CHEM 0345). This research-based laboratory course has been developed as part of an integrated 2-semester sequence in collaboration with the Department of Biological Sciences. One major goal of this course is to offer undergraduate students an opportunity to perform authentic scientific research in the laboratory course. This collaborative course sequence engages the students in learning approaches towards antibiotic discovery in order to address the world's current antibiotic crisis. Students start out in the biology course by isolating bacterial strains that display antibiotic activity. This biology course is followed up with the organic chemistry lab course that affords the students the opportunity to develop strategies for antibiotic isolation and purification using chemical separation techniques, and to characterize these unknown antibiotics through spectroscopic techniques commonly used in organic chemistry.

Students are encouraged to take the biology Small World course (BIOSC 0067) prior to this Honors Organic Chemistry Lab course. However, the Small World course is not required for the students to enroll in this course.

II. Learning Objectives

This course will:

a. Require students to practice, and develop second_nature, safe laboratory practices.

b. Enable students to continue developing scientific skills of observing, reflecting on, questioning, and explaining the natural world.

c. Require students to re_consider their ideas and to justify or refute them with laboratory derived evidence.

d. Require students to devise experiments, write hypotheses, make predictions, change variables, use controls, and create a model that can be tested further.

e. Provide an opportunity for students to collect, organize, analyze and present data.

f. Require students to create, present, and defend, a scientifically accurate and robust poster.

III. Learning Strategy

a. Contact hours:
This course includes two 3-hour-50-minute sessions per week. Each session is composed of a 50-minute discussion section and a 3-hour wet-lab section.
b. Global planning:
At the beginning of the semester, students are required to read two provided references and develop an overall plan for the research project.
c. Pre-lab preparations:
Pre-lab materials covering chemistry concepts and techniques are provided for each lab sessions. Students are required to go through the pre-lab materials prior to the lab session.
d. Student-led experimental design:
Upon studying the pre-lab materials, students are required to design the wet-lab experiments and write down an experimental plan in their Electronic Lab Notebooks (ELN)
e. Discussion section:
During the discussion section of each lab session: (1) a lecture will introduce the chemistry concepts by raising questions that students discuss, (2) the class will discuss the prepared experimental plans and decide on an optimal plan for the students to perform in the wet-lab, (3) the class will discuss about results analysis and trouble-shooting for last lab session.
f. Post-lab summary:
Students are required to summarize each lab session in PowerPoint slides to present the experiment and their result analysis.
g. Capstone poster presentation:
Students will present their research story at the undergraduate poster symposium at the end of each semester.

IV. Course Expectations & Requirements

A. Assignments and Projects:

a. Pre_lab reading:

Students are required to complete the pre_lab review (material reading and/or videos) and put the experimental plan into their electronic notebook prior to each lab session. The experimental plan should include but not limited to: Purposes, Materials and Equipment, Procedure and Questions. The plan should be sensible and can serve as a clear guideline for the experiments.

b. Post_lab assignments:

Students are required to record the experimental data and analysis in PowerPoint slides after each lab session and prior to the next lab session.

c. Quizzes:

Three quizzes will be given through out the semester. The quizzes have to be completed independently.

d. Capstone poster:

Students are required to make a poster (size: 3feet!4feet) and present at the Chemistry department poster symposium.

B. Attendance: Students must attend all laboratory sessions at the time scheduled for their section. Pre and post-lab assignments can only be turned in by those students who attend the appropriate lab session. We encourage you never to miss a single lab session though we do recognize acceptable reasons such as serious illness or personal trauma, or participation if a few University sponsored events. In general, sorority, fraternity, and club activities are NOT recognized as valid reasons to miss a lab.

C. Course Web: Students are responsible for being aware of all materials posted and requirements due, as described on course web. Materials will be posted at least three days in advance, and often, long before that. Check the CourseWeb site often.

V. Course Evaluation

Grades will be based on the following four parts, and each accounts for 25% of the final grade.

a. Electronic Lab Notebook (ELN): Pre_ and post_lab assignments.

Pre-lab records the students experimental planning and the post-lab students record the experimental results in PowerPoint format using an ELN. The instructor, TAs and UTAs review and grade the notebooks periodically.

b. Quiz grades.

Three quizzes will be given in the semester.

c. Participation: Discussion session participation, lab technique/citizenship and research contribution.

Students are expected to participate in the in-class discussion. Based on the pre-lab readings and planning, students raise questions and answer each other's questions.

Lab technique/citizenship & Research contribution: As is true for all Organic labs, the technique grade reflects an individual's attention to cleanliness, safety, and quality of in_lab work. Cleanliness includes a clean and tidy hood and drawer during and after experiments, and proper care for communal areas of the lab space. Lab citizenship reflects awareness and attention to mandatory protocols, lab safety rules, and accommodation of needs of all individuals in the lab space and using shared equipment. Asking questions or making an honest mistake are expected.

d. Poster: the final poster presentation.

As the final project students present a poster (size: 3feet × 4feet) at the Chemistry department poster symposium. The poster score includes two parts: content and design of the poster, and oral presentation of the poster.

VI. Important Dates

The final poster presentation will be 4-6:30pm on Friday December 8, 2017 at the student study area in Chevron Science Center. You are required to arrive at 3:45pm to set up your poster. At 6pm, the poster awards will be announced.

VII. Learning Outcomes

Outcome 1: Students gain a highly interdisciplinary research experience that integrates required biology and chemistry labs to investigate a scientific challenge of broad interest: discovery of new antibiotics.

Outcome 2: Students will learn these chemistry concepts and methods that include: Liquid-liquid extraction; Rotavaping; Freeze-drying; Thin-layer Chromatography (TLC); Normal/Reverse phase Chromatography; High-Performance Liquid Chromatography (HPLC); Mass Spectroscropy; IR; 1H NMR; 13C NMR; Chemical synthesis (oxidation and metal chelating reactions). Students will apply these techniques in their research on antibiotics isolation and spectroscopic characterization.

Outcome 3: Students take the lead and gain a full experience of authentic research. Students learn how to raise a question/project, how to design experimental strategies for a project, how to analyze experimental results and perform trouble-shooting, and how to summarize and present their research projects.

Outcome 4: Students become familiar with reading the primary scientific literature through background research, designing experimental strategies, seeking for troubleshooting ideas and discussing research discovery.

VIII. Student Opinion of Teaching Surveys

Students in this class will be asked to complete a *Student Opinion of Teaching Survey*. Surveys will be sent via Pitt email and appear on your CourseWeb landing page during the last three weeks of class meeting days. Your responses are anonymous. Please take time to thoughtfully respond, your feedback is important to me. Read more about *Student Opinion of Teaching Surveys*

IX. University Policies

Academic Integrity

Students in this course will be expected to comply with the University of Pittsburgh's Policy on Academic Integrity. Any student suspected of violating this obligation for any reason during the semester will be required to participate in the procedural process, initiated at the instructor level, as outlined in the University Guidelines on Academic Integrity. This may include, but is not limited to, the confiscation of the examination of any individual suspected of violating University Policy. Furthermore, no student may bring any unauthorized materials to an exam, including dictionaries and programmable calculators.

Disability Services

If you have a disability for which you are or may be requesting an accommodation, you are encouraged to contact both your instructor and Disability Resources and Services (DRS), 140 William Pitt Union, (412) 648-7890, drsrecep@pitt.edu, (412) 228-5347 for P3 ASL users, as early as possible in the term. DRS will verify your disability and determine reasonable accommodations for this course.

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X. Statement on Classroom Recording

To ensure the free and open discussion of ideas, students may not record classroom lectures, discussion and/or activities without the advance written permission of the instructor, and any such recording properly approved in advance can be used solely for the student's own private use.

XI. Syllabus

The discovery of antibiotics since 1928 has drastically empowered mankind in battling against bacteria infections. However, The pace of antibiotic discovery is not keeping up with the rapid evolution of resistance in microbes. The 'post-antibiotic' era is near, according to a report released today by the World Health Organization (WHO) in 2014. In the U.S., the Centers for Disease Control reported in 2013 that over 2 million people acquired serious resistant infections and at least 23,000 individuals died as a direct result of these infections, with many more dying from conditions complicated by the antibiotic-resistant infection. The discovery of new antibiotics has become an urgent task for the scientific community.

At the Department of Chemistry, we have decided to engage passionate and creative undergraduates in the research of discovering new antibiotics. In this Honors Organic Chemistry Lab course, the students will participate in the isolation, purification, and characterization of antibiotics produced by two bacterial organisms. The students will start by working with a Lysobactor Antibioticus bacteria strain using protocols developed and verified by the instructor. Based on the experience with the first strain, the students will develop their own protocols to discover the antibiotics from an unknown bacteria strain. The students will receive training in both experimental skills and scientific thinking while taking on this challenging and exciting task to discover new antibiotics.

The schedule below is the tentative schedule for the semester. The content may be subjected to changes depending on the research progress of each team.

Session#	Topic
1	**Discussion & Design of Antibiotics Discovery** Discussion: Global planning: How to discover antibiotics from bacteria Wet-lab: Start antibiotics production from *Lysobactor Antibioticus*
2	**Chemical Extraction of Antibiotics** Discussion: extraction and purification of antibiotic compounds from bacteria Wet-lab: Centrifugation / Liquid-liquid extraction of antibiotics from *Lysobactor antibioticus* culture / Rotavaping
3	**Antibiotics Activity Assay of the Crude Extract** Discussion: Tester strains and the antibiotic activity assay Wet-lab: Test the crude extract's antibiotic activity against tester strains
4	**Isolation of Antibiotics: Normal-phase Chromatography** Discussion: Molecular polarity/Dielectric Constant/Normal phase chromatography Wet-lab: Separation of the crude extract using silica column
5	**Antibiotics Activity Assay of the Fractions from Silica Column** Discussion: How to optimize conditions for silica column separation Wet-lab: Test the antibiotic activity of all fractions separated from silica column
6	**Purification of Antibiotics: HPLC** Discussion: Chemical polarity / Reverse phase chromatography/HPLC Wet-lab: Purify the antibiotic compounds using HPLC
7	**Structural Characterization: Mass Spectrometry** Discussion: The principle of Mass Spectrometry Wet-lab: Run the purified compounds on LC-MS
8	**Structural Characterization: ^{1}H NMR** Discussion: The principle of ^{1}H NMR / How to analyze ^{1}H NMR spectrum Wet-lab: Obtain ^{1}H NMR of the purified compounds
9	**Structural Characterization: ^{13}C NMR** Discussion: The principle of ^{13}C-NMR / How to analyze ^{13}C NMR spectrum Wet-lab: Obtain ^{13}C NMR of the purified compounds
10	**Structural Characterization: IR** Discussion: Principle of IR / How to analyze IR spectrum Wet-lab: Obtain IR of the purified compounds
11	**Structural Analysis of the Purified Compounds & Plan for the Unknown Strain** Discussion: Derive the chemical structure of the compounds based on the spectroscopy data / Summary of the research on the *Lysobactor Antibioticus* strain / Literature research to plan for the unknown strain Wet-lab: Antibiotic activity assay of the purified compounds / Start producing antibiotics from the unknown bacteria strain
12	**Synthesis I: mCPBA Oxidation** Discussion: The mechanism of mCPBA oxidation Wet-lab: Synthesize a Phenazine derivative containing N-oxide from an antibiotic compound the students purified from *Lysobactor antibioticus using* mCPBA oxidation
13	**Synthesis II: Organometallic Chemistry** Discussion: The mechanism of phenol chelating around iron Wet-lab: Make a Iron coordination compound from a phenol-like antibiotic compound the students purified from *Lysobactor antibioticus*
14	**Chemical Extraction of the Antibiotics from the Unknown Bacteria Strain** Discussion: extraction and purification of antibiotic compounds from the unknown strain / potential problems and alternative strategies

	Wet-lab: Centrifugation / Liquid-liquid extraction of antibiotics from culture of the unknown strain / Rotavaping
15	**Antibiotics Activity Assay of the Crude Extract from the Unknown Strain** Discussion: Tester strains and the antibiotic activity assay Wet-lab: Test the crude extract's antibiotic activity against tester strains
16	**Isolation of Antibiotics from the Unknown Strain: Normal-phase Chromatography** Discussion: Molecular polarity/Dielectric Constant/Normal phase chromatography Wet-lab: Separation of the crude extract using silica column
17	**Antibiotics Activity Assay of the Fractions from Silica Column** Discussion: How to optimize conditions for silica column separation Wet-lab: Test the antibiotic activity of all fractions separated from silica column
18	**Purification of Antibiotics from the Unknown Strain: HPLC II** Discussion: Chemical polarity/Reverse phase chromatography/HPLC Wet-lab: Purify the compounds using HPLC
19	**Purification of Antibiotics from the Unknown Strain: HPLC with Optimizations** Discussion: How to optimize HPLC conditions for purification with higher resolution Wet-lab: Purify the compounds using HPLC
20	**Structural Characterization: Mass Spectrometry II & Literature examples** Discussion: Analyzing Mass Spectrum / Literature study on MS of antibiotic compounds Wet-lab: Run the purified compounds from the unknown strain on LC-MS
21	**Structural Characterization: ^{1}H NMR II & Literature examples** Discussion: How to obtain high quality ^{1}H NMR data / How to analyze ^{1}H NMR spectrum / literature study on ^{1}H NMR of antibiotic compounds Wet-lab: Obtain ^{1}H NMR of the purified compounds from the unknown strain
22	**Structural Characterization: ^{13}C-NMR II & 2D NMR** Discussion: How to obtain high quality ^{13}C NMR data / How to analyze ^{13}C NMR spectrum / 2D NMR Wet-lab: Obtain ^{13}C NMR of the purified compounds from the unknown strain
23	**Structural Characterization: IR** Discussion: Principle of IR / How to analyze IR spectrum Wet-lab: Obtain IR of the purified compounds from the unknown strain
24	**Quantifying the Antibiotic's Activity Against Multiple Pathogens** Discussion: Antibiotic activity profiling Wet-lab: Quantitatively test the activity of the purified compounds against multiple pathogenic tester strains
25	**Structural Analysis of the Antibiotics from the Unknown Strain** Discussion: Derive chemical structure of the antibiotics Practice: using ChemDraw to draw the structure of the antibiotics
26	**Research Summary & Poster practice** Discussion: Literature research on the antibiotic compounds isolated from the unknown strain / How to use SciFinder
27	**Poster Presentation practice & Lab Cleanup** Discussion: Peer-review style of poster presentation practice Wet-lab: Materials storage & Lab cleanup