Synthetic Organic Chemistry
Chem 1310/2370 (Class Number 11075)
Fall 2025

Lectures: MW (11:00–11:50 AM) in 227 Benedum Hall
Office Hours: Tuesday 4pm-5pm; Wednesday 5pm-6pm; Thursday 11am-12pm
Instructor: Kay Brummond (kbrummon@pitt.edu)
Kay's office: 1112 Chevron Science Center

Prerequisites
CHEM 0320 or 0740 or 0232 (UP Johnstown) or CHEM 0208 (UP Bradford). If you are uncertain about whether your preparation is sufficient for this course, please don't hesitate to ask. Graduate students need the instructor's permission to enroll in this course.

Course Materials

- Books on reserve in the library from which I will draw course material:

1)The Art of Writing Reasonable Organic Reaction Mechanisms Third Edition 2019 by Robert B. Grossman

2) Strategic Applications of Named Reactions in Organic Synthesis 1st Edition by Laszlo Kurti, Barbara Czako

3) Classics in Total Synthesis IV: New Targets, Strategies, Methods 1st Edition by K. C. Nicolaou, Ruocheng Yu, Stephan Rigol

4) Organic Chemistry Structure and Function, any edition, by K.P.C Vollhardt and Neil Schore

- https://drughunter.com/category/case-studies
- https://organicchemistrydata.org/
- https://rowansci.com/
- PowerPoint presentations used in class will be available on Canvas following each lecture.

Course Description and Overview
This upper-level undergraduate course for advanced chemistry majors builds onto Organic Chemistry I (Chem 310) and Organic Chemistry II (Chem 320) or equivalent courses by applying the learned principles to the synthesis of molecular targets. A strong foundation in relating the chemical structure of a molecule to its reactivity is essential. Additionally, an understanding of the rules and conventions used when communicating organic chemistry is indispensable. The emphasis of the course will be on the chemical synthesis of natural products and FDA-approved drugs whose structures are derived from natural products. In addition to their impact and value to human health, the structural diversity of natural products and drug molecules are a formidable challenge in synthesis requiring creativity and ingenuity, and thus a valuable training ground in total synthesis. To this end, designing a synthesis of and synthesizing complex molecular targets

from simpler starting materials requires a deep understanding of chemical principles to address challenging aspects of total synthesis such as structural complexity, efficiency, and cost. We will also examine how chemical innovations are driving a constant evolution of the tools and concepts to advance the field of organic synthesis and in so doing building molecular targets in the most efficient way. We will discuss in detail the discoveries that made possible the total syntheses of a molecular target.
In this course, you will develop a working knowledge of key concepts and tools required for total synthesis, including:

- reaction arrow pushing and mechanism determination
- conformational analysis
- retrosynthetic analysis
- functional group interconversions and protecting group use
- stereo-, chemo-, and regio-selectivity
- frontier molecular orbital theory
- reaction discovery and optimization.

Learning Objectives
By the end of this course, you will be able to:

- Predict the outcome and mechanism of complex polar, free-radical, pericyclic, and transition-metal catalyzed reactions.
- Apply retrosynthetic analysis to design multi-step syntheses of complex molecular targets.
- Evaluate and select appropriate protecting groups, functional group interconversions, and stereoselective reactions for a given synthesis.
- Make use of frontier molecular orbital theory in the context of Woodward Hoffman rules for predicting outcomes of reactions.
- Analyze the historical and chemical context of a total synthesis to understand the key discoveries that made it possible.

Course Structure
I have adopted the approach of Grossman and organized this course according to mechanistic type (polar, free-radical, pericyclic, and transition-metal catalyzed) and not transformation (addition, elimination, substitution, and rearrangement). To help get you started, the first two lectures will cover basic concepts such as Lewis structures, hydridization, acidity, aromaticity, and resonance structures. The remainder of the lectures will examine polar reactions, free-radical reactions, pericyclic reactions and transition-metal catalyzed reactions. Within each one of these mechanistic reaction categorizations, we will take a deep look into key concepts used to realize the total synthesis of natural products and FDA approved drugs.

Grading
Homework: Ten homework assignments each worth 15 points (total 150 points)
Exams: Three exams (two midterms and one final) each worth 100 points (total 300 points)
Presentation: Case study presentation (100 points) rubric will be provided before first midterm
Attendance: (50 points) After missing four classes, five points will be deducted for each class
520–600 pts = A; 440–519 pts = B; 350–439 pts = C; 250-349 pts = D; below 250 pts = F
Plus and minus letter grades will be at the professor's discretion.

Course Schedule (important dates are highlighted in blue)

August 25	**First day of class**
August 27	The Basics
September 1	**Labor Day (no class)**
September 3	The Basics
September 8	Polar Reactions
September 10	Polar Reactions
September 15	Polar Reactions
September 17	Free Radical Reactions
September 22	Free Radical Reactions
September 24	**Midterm Exam #1**
September 29	Pericyclic Reactions
October 1	Pericyclic Reactions
October 6	Pericyclic Reactions
October 8	Pericyclic Reactions
October 13	Pericyclic Reactions
October 15	Pericyclic Reactions
October 20	Pericyclic Reactions
October 22	**Midterm Exam #2**
October 27	Transition Metal-Catalyzed Reactions
October 29	Transition Metal-Catalyzed Reactions
November 3	Transition Metal-Catalyzed Reactions
November 5	Transition Metal-Catalyzed Reactions
November 10	Transition Metal-Catalyzed Reactions
November 12	Transition Metal-Catalyzed Reactions
November 17	Transition Metal-Catalyzed Reactions
November 19	Student Presentations of Case Studies
November 24	**Thanksgiving (no class)**
November 26	**Thanksgiving (no class)**
December 1	Student Presentations of Case Studies
December 3	Student Presentations of Case Studies

Week of December 8 (Final Exam-date TBD pending posting of Pitt's final schedule)

University Policies

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. If you have (or think you may have) a disability such that you need to record or tape classroom activities, you should contact your instructor and the Office of Disability Resources and Services (see below) to request an appropriate accommodation.

Should significant increases in COVID spread or other circumstances require a switch to online instruction, lectures and full-class discussions conducted via Zoom will be recorded by the instructor and shared via Canvas. Access to these recordings will be restricted (via Pitt login) to students currently enrolled in the class, and you may not share your access to these materials with

any other students. If you are not comfortable having your voice or image included in the full-class recordings, however, you are welcome to turn off your webcam and mute your microphone.

Student Disability Resources
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.

Academic Integrity
Students in this course will be expected to comply with the University of Pittsburgh's Policy on Academic Integrity (https://www.as.pitt.edu/faculty/policies-and-procedures/academic-integrity-code). 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.

For examinations, you may not leave the classroom in the middle of the exam and then return to continue with the examination. If there are any questions or concerns regarding the grade for an examination, these questions should be brought to the attention of Dr. Brummond no later than ONE week after the graded exam is returned. Please note that graded exams are routinely photocopied before they are returned. Any examination turned in for regrading will be compared against the photocopy, therefore please do not write on the examination paper after it is graded if you intend to request regrading.

Note: Use of AI Is Prohibited for Case Study Presentations and Reports
Use of ChatGPT (or other similar tools or software that generate suggested text) is not allowed in this class for any part of the case study presentations, including generation of ideas, writing of text, or rewriting your own work. Violations will result in failure of the assignment and possible failure of the course. I assume that all work submitted by students will be generated by the students themselves, working individually or in groups. Students should not have another person/entity do the writing of any portion of an assignment for them, which includes hiring a person or a company to write assignments and using artificial intelligence (AI) tools such as ChatGPT. Since writing, analytical, and critical thinking skills are part of the learning outcomes of this course, all writing assignments should be prepared by the student. Developing strong competencies in this area will prepare you for a competitive workplace. Therefore, AI-generated submissions are not permitted and will be treated as plagiarism.

Absences or make up policies
If you are too ill to come to class, please email me. Otherwise, please rest and recover and get notes from your classmates on the material you miss. If you must miss a required class activity or exam for any other reason, please contact me as soon as possible so that we can make alternate arrangements. While some exceptions may apply, make-up work will generally only be offered in the case of conflicts with religious observances, documented illnesses, and personal or family emergencies.

In scheduling midterms and other exams, I have tried to avoid conflicts with major religious holidays. If there is a conflict with your religious observances, please let me know as soon as possible so that we can work together to make arrangements.

Classroom environment and accommodations
It is my intent that students from all backgrounds and perspectives be well-served by this course, that students' learning needs be addressed both in and out of class, and that the range of experiences that students bring to this class be viewed as a resource, strength and benefit. It is my intent to present materials and activities that are respectful of gender, sexual orientation, disability, age, socioeconomic status, ethnicity, race, culture, perspective, and other background characteristics. Your suggestions about how to improve the value of this course are encouraged and appreciated. Please let me know ways to improve the effectiveness of the course for you personally or for other students or student groups. (source with some modifications: University of Iowa)

For case studies and classics in total synthesis, see:
Nicolaou, K. C.; Rigol, S. Perspectives from nearly five decades of total synthesis of natural products and their analogues for biology and medicine. Nat. Prod. Rep. 2020, 37, 1404−1435.

Nicolaou, K. C.; Vourloumis, D.; Winssinger, N.; Baran, P. S. The Art and Science of Total Synthesis at the Dawn of the Twenty-First Century. Angew. Chem., Int. Ed. 2000, 39, 44−122.

Baran, P. S. Natural Product Total Synthesis: As Exciting as Ever and Here To Stay. J. Am. Chem. Soc. 2018, 140, 4751−4755.

For perspectives on natural product synthesis, see:
Natural Product Synthesis in the 21st Century: Beyond the Mountain Top, Ryan A. Shenvi, ACS Central Science 2024 10 (3), 519-528. DOI: 10.1021/acscentsci.3c01518

Hetzler, B.E., Trauner, D. & Lawrence, A.L. Natural product anticipation through synthesis. *Nat Rev Chem* **6**, 170–181 (2022). https://doi.org/10.1038/s41570-021-00345-7

For articles/perspectives on classification strategies
Carpenter, B. K. An argument for abandoning the “allowed” and “forbidden” classification of electrocyclic reactions.Chem. Sci., 2025,16, 4264-4278.

Li, J.; Eastgate, M. Current complexity: a tool for assessing the complexity of organic molecules. Bioorg. Med. Chem. Lett. 2015, 13, 7164−7176.

For an example case study
Steven J. McKerrall, Lars Jørgensen, Christian A. Kuttruff, Felix Ungeheuer, Phil S. Baran Development of a Concise Synthesis of (+)-Ingenol. J. Am. Chem. Soc. 2014, 136, 15, 5799–5810

I will continue to add citations to these brief listings as the semester progresses.