Term Information

Effective Term	Spring 2018

General Information

Course Bulletin Listing/Subject Area	Chemistry
Fiscal Unit/Academic Org	Chemistry - D0628
College/Academic Group	Arts and Sciences
Level/Career	Graduate, Undergraduate
Course Number/Catalog	5230
Course Title	Neurotransmitter Chemistry
Transcript Abbreviation	Neurotrans Chem
Course Description	Come and explore the natural and unnatural organic molecules involved in neurotransmission. Through the study of synthetic strategies, mechanistic principles, and the structural requirements for biological activity, students will investigate the chemical world of endogenous molecules, pharmaceuticals, and drugs of abuse.
Semester Credit Hours/Units	Fixed: 3

Offering Information

Length Of Course	14 Week
Flexibly Scheduled Course	Never
Does any section of this course have a distance education component?	No
Grading Basis	Letter Grade
Repeatable	No
Course Components	Lecture
Grade Roster Component	Lecture
Credit Available by Exam	No
Admission Condition Course	No
Off Campus	Never
Campus of Offering	Columbus

Prerequisites and Exclusions

Prerequisites/Corequisites	Pre-req: Organic Chem Lecture 2 (2520/2620/2920H) and Organic Chem Lab 1 (Chem 2540)
Exclusions	
Electronically Enforced	Yes

Cross-Listings

Cross-Listings

Subject/CIP Code

Subject/CIP Code	40.0501
Subsidy Level	Doctoral Course
Intended Rank	Junior, Senior, Masters, Doctoral, Professional

Requirement/Elective Designation

The course is an elective (for this or other units) or is a service course for other units

Course Details

Course goals or learning objectives/outcomes

- Describe basic neuroanatomy and function of neurotransmitter systems
- Demonstrate fluency in advanced of structural representations of organic molecules (3D line structures and protein folding diagrams)
- Identify neurotransmitter molecules and analogs, therapeutic agents, and drugs of abuse based on molecule structure
- Describe in vitro, in vivo, and behavioral methods for evaluating therapeutic efficacy
- Predict chemical reactivity of molecules of interest
- Propose curve-arrow mechanism for chemical transformations
- Describe imaging techniques and molecular tools used to study neurotransmitter systems
- Identify and describe structure-activity relationships that govern the biological effects of neurotransmitter molecules
- Analyze data to develop new structure-activity paradigms
- Communicate relevant details about new discoveries related to neurotransmitter therapies
- Propose synthetic routes to target molecules

Content Topic List

- Neurons and Neuroanatomy, Neurotransmitter Molecules and their Targets
- Biosynthesis of Endogenous Neurotransmitters, Biomimetic Therapeutics
- Structure-Activity Relationships and Drug Design, In Vitro and In Vivo Assays, Behavioral Methods
- GABA and Glu, Acetylcholine
- Cannabinoids / Opioids
- Histamine / Norepinephrine
- Serotonin
- Dopamine
- A Molecular Perspective of Drug Law
- Biological Basis of Substance Dependence
- The Classics: Cocaine, Heroin, LSD, PCP, and Methamphetamine
- "Designer Drugs": Synthetic Opiods and Ecstasy
- The State of the Art of the Unnatural High
- Addiction Therapeutics: Challenges and Criticisms

Sought Concurrence

Yes

Attachments

- Concurrence Form-- Neuroscience.pdf: Neuroscience Concurrence

  (Concurrence. Owner: Sutherland,Laura Nicolle Romrell)

- CHEM Curricular Map - 071817.pdf: CHEM Curricular Map

  (Other Supporting Documentation. Owner: Sutherland,Laura Nicolle Romrell)

- Concurrence Form-- Pharmacy.pdf: Pharmacy Concurrence

  (Concurrence. Owner: Sutherland,Laura Nicolle Romrell)

- CHEM 5230- Neurotransmitters Syllabus 091917.docx: Updated Syllabus

  (Syllabus. Owner: Sutherland,Laura Nicolle Romrell)

Comments

- Updated syllabus created and re-attached, per instructions in email sent 09-14-17. *(by Sutherland,Laura Nicolle Romrell on 09/19/2017 05:04 PM)*
- See 9-14-17 email to T Gustafson and L Sutherland *(by Oldroyd,Shelby Quinn on 09/14/2017 12:07 PM)*

Workflow Information

Status	User(s)	Date/Time	Step
Submitted	Sutherland,Laura Nicolle Romre	07/28/2017 08:54 AM	Submitted for Approval
Approved	Gustafson,Terry Lee	07/28/2017 08:56 AM	Unit Approval
Approved	Haddad,Deborah Moore	07/28/2017 11:02 AM	College Approval
Revision Requested	Oldroyd,Shelby Quinn	09/14/2017 12:07 PM	ASCCAO Approval
Submitted	Sutherland,Laura Nicolle Romre	09/19/2017 05:04 PM	Submitted for Approval
Approved	Gustafson,Terry Lee	09/19/2017 07:09 PM	Unit Approval
Approved	Haddad,Deborah Moore	09/19/2017 08:35 PM	College Approval
Pending Approval	Nolen,Dawn Vankeerbergen,Bernadette Chantal Oldroyd,Shelby Quinn Hanlin,Deborah Kay Jenkins,Mary Ellen Bigler	09/19/2017 08:35 PM	ASCCAO Approval

THE OHIO STATE UNIVERSITY

CHEMISTRY 5230 – SPRING 2018

NEUROTRANSMITTER CHEMISTRY

THE CHEMISTRY OF ENDOGENOUS MOLECULES, PHARMACEUTICALS, AND DRUGS OF ABUSE

Instructor: Dr. Noel M. Paul
Office: CE 380-B Celeste Laboratory
Telephone: (614) 835-6635
Email: paul.108@osu.edu

Lecture: TR 9:35 – 10:55AM in Room TBD (3 Credit Hours)

Recitation: None

Dr. Paul's Office Hours and Availability

My official office hours are posted on Carmen under DR. PAUL'S SCHEDULE AND OFFICE HOURS. To schedule an alternate appointment, contact me via email and be sure to include the course number "Chem 5230" and a selection of times that you might be available. Due to the volume of email received, please allow 48 hours for Dr. Paul to reply to your message.

Course Overview

This course aims to explore the natural and unnatural organic molecules involved in neurotransmission. An overview of neuroanatomy and protein biochemistry will serve as a foundation for exploration of neurotransmitter systems and the therapeutic benefits of their modulation. An introduction to medicinal chemistry principles as well as pertinent pharmacological and behavioral methods will enhance discussion on drug discovery and lead optimization. Particular emphasis will be given to the synthetic strategies and mechanistic principles necessary to develop the most widely used pharmaceuticals. The final portion of the course will focus on molecules that are most commonly abused, the questionable methods of creative criminals, and the development and controversy of addiction therapeutics.

Learning Objectives

Through studies in this course, students will be able to:

- Describe basic neuroanatomy and function of neurotransmitter systems
- Demonstrate fluency in advanced of structural representations of organic molecules (3D line structures and protein folding diagrams)
- Identify neurotransmitter molecules and analogs, therapeutic agents, and drugs of abuse based on molecule structure
- Describe *in vitro, in vivo*, and behavioral methods for evaluating therapeutic efficacy
- Predict chemical reactivity of molecules of interest
- Propose curve-arrow mechanism for chemical transformations
- Describe imaging techniques and molecular tools used to study neurotransmitter systems
- Identify and describe structure-activity relationships that govern the biological effects of neurotransmitter molecules
- Analyze data to develop new structure-activity paradigms
- Communicate relevant details about new discoveries related to neurotransmitter therapies
- Propose synthetic routes to target molecules

Dr. Paul – CHEM 5230 Course Schedule – SP18

WEEK	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
1	1/8 FIRST DAY OF CLASSES	1/9 Lecture #1	1/10	1/11 Lecture #2	1/12
2	1/15 MLK JR. DAY	1/16 Lecture #3 WORKSHEET 1 DUE	1/17	1/18 Lecture #4	1/19
3	1/22	1/23 Lecture #5 WORKSHEET 2 DUE	1/24	1/25 Lecture #6	1/26 Lecture #8 ALT MT TIME DEADLINE
4	1/29	1/30 Lecture #7 WORKSHEET 3 DUE	1/31	2/1 Lecture #8	2/2 DROP W/O "W"
5	2/5 MIDTERM EXAM 1 6:00–8:00 pm • room TBA	2/6 Lecture #9	2/7	2/8 Lecture #10	2/9 MT1 EXAM RETURNED
6	2/12	2/13 Lecture #11 WORKSHEET 4 DUE	2/14	2/15 Lecture #12	2/16
7	2/19	2/20 Lecture #13 WORKSHEET 5 DUE	2/21	2/22 Lecture #14	2/23
8	2/26	2/27 Lecture #15 WORKSHEET 6 DUE	2/28	3/1 Lecture #16	3/2
9	3/5 MIDTERM EXAM 2 6:00–8:00 pm • room TBA	3/6 Lecture #17 TRIP TO STATE HIGHWAY PATROL CRIME LAB	3/7	3/8 Lecture #18 TRIP TO STATE HIGHWAY PATROL CRIME LAB	3/9 MT2 EXAM RETURNED
10	3/12 * * * * S P R I N G B R E A K * * *	3/13	3/14	3/15	3/16
11	3/19	3/20 Lecture #19	3/21	3/22 Lecture #20	3/23 DROP W/O PETITION
12	3/26	3/27 Lecture #21 WORKSHEET 7 DUE	3/28	3/29 Lecture #22 LIT. REPORT 1 DUE	3/30
13	4/2	4/3 Lecture #23 WORKSHEET 8 DUE	4/4	4/5 Lecture #24 LIT. REPORT 2 DUE	4/6
14	4/9	4/10 Lecture #25 WORKSHEET 9 DUE	4/11	4/12 Lecture #26 LIT. REPORT 3 DUE	4/13
15	4/16	4/17 Lecture #27 WORKSHEET 10 DUE	4/18	4/19 Lecture #28 SYNTH. PROJECT DUE	4/20
16/F	4/23 LAST DAY OF CLASSES	4/24	4/25	4/26	4/27

Course Topics

The exact order of topics, suggested readings, and problems will be posted on **Weekly Outlines**.

Week 1 – Neurons and Neuroanatomy, Neurotransmitter Molecules and their Targets
The Organic Chemistry of Drug Design and Drug Action: Chapters 1-3 (selected readings)
Week 2 – Biosynthesis of Endogenous Neurotransmitters, Biomimetic Therapeutics
Primary literature readings TBA (4 articles)
Week 3 – Structure-Activity Relationships and Drug Design, *In Vitro* and *In Vivo* Assays, Behavioral Methods
The Organic Chemistry of Drug Design and Drug Action: Chapters 4-6 (selected readings)
Primary literature readings TBA (1 article)
Week 4 – GABA and Glu, Acetylcholine
The Receptors Series: Selected readings (4 chapters, 50 pp)
Primary literature readings TBA (1 article)
Week 5 – Cannabinoids / Opioids
The Receptors Series: Selected readings (4 chapters, 50 pp)
Primary literature readings TBA (1 article)
Week 6 – Histamine / Norepinephrine
The Receptors Series: Selected readings (2 chapters, 30 pp)
Primary literature readings TBA (2 articles)
Week 7 – Serotonin
The Receptors Series: Selected readings (2 chapters, 30 pp)
Primary literature readings TBA (2 articles)
Week 8 – Dopamine
The Receptors Series: Selected readings (2 chapters, 30 pp)
Primary literature readings TBA (2 articles)
Week 9 – A Molecular Perspective of Drug Law
Primary literature readings TBA (3 articles)
Week 11 – Biological Basis of Substance Dependence
Primary literature readings TBA (4 articles)
Week 12 – The Classics: Cocaine, Heroin, LSD, PCP, and Methamphetamine
Primary literature readings TBA (4 articles)
Week 13 – "Designer Drugs": Synthetic Opiods and Ecstasy
Primary literature readings TBA (3 articles)
Week 14 – The State of the Art of the Unnatural High
Primary literature readings TBA (3 articles)
Week 15 – Addiction Therapeutics: Challenges and Criticisms
Primary literature readings TBA (3 articles)

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IMPORTANT INFORMATION

Required Prerequisites

Organic Chemistry Lecture II (Chem 2520, 2620, or 2920H)
Organic Chemistry Laboratory I (Chem 2540)
Students with Graduate standing may enroll
Students may also enroll with permission of the instructor

Recommended Prerequisites

Organic Chemistry Laboratory II (Chem 2550)
Introductory Biochemistry (Biochem 4511 or 5613)

Required Materials

The Organic Chemistry of Drug Design and Drug Action (3rd Edition) by Richard B. Silverman and Mark W. Holladay, Academic Press, ISBN-13: 978-0123820303. *OSU E-Book Link:* http://www.sciencedirect.com.proxy.lib.ohio-state.edu/science/book/9780123820303

The Receptors (Book Series). Editor-in-chief: Giuseppe Di Giovanni, Humana Press. OSU E-Book Link: https://link.springer.com/search?facet-series=%227668%22&facet-content-type=%22Book%22

Monocle Top Hat Account – https://tophat.com
Chem 5XXX Join Code: 000000 and password: somechemistrypun

SciFinder Scholar – See detailed instructions posted to Carmen. Access is available at no additional cost to OSU students through an OSU Library subscription. http://scifinder.cas.org/

Perkin-Elmer ChemDraw Software – See detailed instructions posted to Carmen. ChemDraw will be required for some assignments in the course. The software is available at no additional cost to OSU students through a University Site License: http://sitelicense.cambridgesoft.com/sitelicense.cfm?sid=31

Recommended Materials

WebMO – Molecular Modeling Web Interface hosted on the Ohio Supercomputer Center. Mobile App for Android and iPhone ($5) is also available.

Any recent, sophomore-level Organic Chemistry textbook (2010 or newer) for reference/review purposes

Webpage: https://carmen.osu.edu

The Chemistry 5XXX page on Carmen will serve as a repository for all course-related materials, including weekly lecture outlines, homework problems assignments, homework keys, handouts, study guides, and additional resources. A majority of the online content will be posted as Adobe PDF files, and you are encouraged to install the most current version of Adobe Reader, available free of charge at http://get.adobe.com/reader/.

All grades for this course will be posted to Carmen on a regular basis. You are responsible for all updates posted to Carmen, and if you find any mistakes in content or grading, or you need help accessing these materials, please contact your TA or instructor as soon as possible.

Weekly Outlines

A **Weekly Outline** will be posted to Carmen each Friday afternoon and will feature a proposed summary of topics to be covered in lecture the following week as well as **Reading Assignments**, **Suggested**

Textbook Problems, and other course reminders. **Weekly Outlines** will be updated at the end of each week to reflect the actual topics covered.

Lecture Attendance

Attendance to all lectures is expected, though points are not earned. Students that need to miss class for an excused reason need to speak with their instructor as soon as possible.

Lecture Notes and Course Handouts

Due to the nature of the course material, lectures will be presented using a compliment of chalk board, overhead, and PowerPoint notes. PowerPoint slides will be available on Carmen no later than one (1) day prior to lecture. Overhead and chalk board notes will be available during the eighty minutes of lecture and will not be available outside of the lecture when they are presented. Your preparation before, attendance to, and attention in class are all critical to your success in this course. Take good notes and be an active participate in lecture to maximize the value of the time we spend together.

Textbook Problems, Problem Sets, and Archived Worksheets & Exams

A list of suggested textbook problems will be provided in each **Weekly Outline**. In addition to the book resources, original **Problem Sets** pertinent to the week's lecture topics will be provided. All of these problems should be worked in preparation for quizzes and exams; however, they will not be graded or collected. The answer keys to the practice problem sets will be posted on Carmen at the end of each week. Examples of **Worksheets** and **Exams** from previous courses will be posted for your benefit, and will help students in their studies, though specific quiz and exam content will vary

Extra Office Hours Prior to Exam Week

The instructor will offer additional office hours prior to each exam. These times will be announced in class and posted to Carmen to allow students to make appropriate arrangements to attend.

Dropping and Withdrawal

The last day for withdrawal from this course without a W is Friday, February 2nd, 2018 and the last day for withdrawal without petition is Friday, March 23rd, 2018.

Diversity Statement

The Department of Chemistry and Biochemistry promotes a welcoming and inclusive environment for all students and staff, regardless of race, gender, ethnicity, national origin, disability or sexual orientation. There is no tolerance for hateful speech or actions. All violations of this policy should be reported to the OSU Bias Assessment and Response Team (studentaffairs.osu.edu/bias).

The Department encourages diversity at all levels, particularly among the next generation of scientists. Students are encouraged to participate in organizations that provide support specifically for science and engineering students who are African-American, Asian, disabled, Hispanic, LGBTQ or women. These organizations are listed on the Colleges of Arts and Sciences (artsandsciences.osu.edu/stem-organizations) and Engineering (engineering.osu.edu/studentorgs) web sites.

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Disabilities

The University strives to make all learning experiences as accessible as possible. If you anticipate or experience academic barriers based on your disability (including mental health, chronic or temporary medical conditions), please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. SLDS contact information: slds@osu.edu; 614-292-3307; slds.osu.edu; 098 Baker Hall, 113 W. 12th Avenue.

YOU ARE RESPONSIBLE FOR ALL CHANGES TO THIS SYLLABUS MADE IN CLASS WHETHER OR NOT YOU ARE IN ATTENDANCE

GRADING

Points for the course can be earned according to the following breakdown:

8	Worksheets (8 x 25 pts)	200	40%
2	Midterm Exams (2 x 100 pts)	200	40%
3	Literature Reports (3 x 15 pts)	45	9%
1	Synthesis Project	55	11%
	Total Points	500	100%

Worksheets

There will be ten (10) WORKSHEETS distributed during the semester. Each WORKSHEET will be 4-6 pages in length and will contain short answer and explain questions. A portion of lecture time on most Thursdays will be devoted to beginning problem solving in small groups using the WORKSHEETS. Each WORKSHEET will be collected for a grade at the beginning of class the following Tuesday as indicated on the course schedule. Each Worksheet is worth 25 points and only the eight (8) highest WORKSHEETS are will count towards your final grade. A zero (0) will be assigned for any WORKSHEET submitted after the due date and time but an extension may be granted in the event of a University-approved absence or documented illnesses. A Make-Up WORKSHEET may be offered at the end of the semester to students with excused absences but only in situations where less than eight (8) worksheets were submitted for a grade. Estimated time to complete one (1) WORKSHEET: 2-4 hours outside of lecture.

Midterm Exams

Two (2) midterm exams will be given outside of scheduled lecture time on the days indicated on the COURSE SCHEDULE. The coverage of exam topics is as follows:

Midterm Exam 1: Lecture #1–#8
Midterm Exam 2: Lecture #9–#16

Use of calculators (but not calculator applications on mobile phones or other communication devices) and molecular model kits will be permitted during all exams, but these approved items may not be shared between students. Use of notes, notebooks, or textbooks will not be permitted and mobile communication devices (iPhones, mobile phones, PDAs, computers, netbooks, etc.) should remain turned off and stored in your bag for the duration of the exam period. Violations of this policy will be submitted to the Committee on Academic Misconduct for review.

Each student is required to write their initials and exam number on the Exam Sign-In Sheet after completing their Exam during the testing time, and without this mark of attendance, a student will be considered absent from the exam.

Literature Report

Three (3) literature reports will be due during the last third of the course as indicated on the course schedule. The LITERATURE REPORT should be a 1-2 page summary of a drug molecule from a current literature report. The assignment should be typed and should use chemical structure drawings within the text as much as possible. Briefly summarize the important points of the paper, including: (a) why the work is significant, (b) in what way is it novel, and (c) what are the limitations of the chemistry if it deals with new synthetic methodology. The journals you should examine are: *J. Am. Chem. Soc*., *J. Org. Chem.*, *Org. Lett.*, *J. Med. Chem.* or others approved by the course instructor. Estimated time to complete one (1) LITERATURE REPORT: 1-2 hours outside of lecture.

Synthesis Project

Students may work alone or in groups to propose the synthesis of new molecules with a predicted biological activity. This report must include primary literature references to support synthetic approaches and drug efficacy, and summarize procedures that accomplish the transformations. The length of this report will vary with complexity of target structure but is estimated to be between 5-10 pages per student, including pictures. Detailed guidelines will be distributed in lecture during Week 11 of the course.

Alternate Midterm Time Policy

Students with University-approved absences or course-related conflicts will be given the opportunity to take course Midterm Exams at the University Testing Center (Student Academic Services Building, Room 585, 281 W. Lane Ave., Ph. 614-292-2241). Anticipation of these conflicts is critical to our planning as well as to your success. Students are responsible for contacting Dr. Paul no later than the 3rd Friday of the Semester to receive further instructions. Conflicts identified after this point will be subject to extreme scrutiny and only written documentation of verified University conflicts will be considered for review.

Missed Midterm/Final Policy

Students absent from a Midterm Exam due to documented illness should contact Dr. Paul immediately to begin the process of scheduling a Make-Up Exam. Since Midterm Exams will be returned at the end of class on the days marked on the COURSE SCHEDULE, any student who does not complete the Exam by this time will not be permitted to take the same exam as their classmates. Out of fairness to the students in the course, a Make-Up Exam will not be offered for any undocumented reason, though special arrangements can be made for students with documented absences who cannot take the Exam prior to the return of graded exams.

Grading Rubrics and Regrades

Partial credit for Worksheets and Exams may be assigned using a “bin” system and details of these bins will be provided with the Worksheet and Exam Keys. At any point, a student may request their work be reassessed using the alternate grading rubric of minus one point (-1 pt) per mistake. There are no half-points (½ pts) in this course.

Final Grade Distribution

The average letter grade assigned in this class is anticipated to be a B and the minimum final percentage distribution for the grading scale is shown below. If this grading scale produces an average lower than anticipated, the grading scale will be adjusted in favor of the students.

100 – 85%	=	A
84 – 70%	=	B
69 – 55%	=	C
54 – 40%	=	D
39 – 0%	=	E

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ACADEMIC INTEGRITY

Although lively and productive discussions among classmates, teaching assistants, and instructors are encouraged, each student in this course is responsible for composing and submitting his or her own original work for all graded assignments. Direct collaboration on assignments, including but not limited to the sharing or misappropriation of print work or digital files between students, is not permitted and instances of these will be reported to the University Committee on Academic Misconduct. It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term "academic misconduct" includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487). For additional information, see the Code of Student Conduct http://studentlife.osu.edu/csc/.

In a more general sense, the instructor of this course recommends avoiding "cutting and pasting" from internet sources or between documents at all costs to avoid citation issues and inadvertent instances of plagiarism. The course instructor also recommends that students avoid sharing print or digital copies of their work in this course or others with any other student at any time to avoid having your work misappropriated even well after the course is completed. A few more tips are listed below (with a citation):

1. *Know Your Rights.* Do not let other students in your class diminish the value of your achievement by taking unfair advantage. Report any academic dishonesty you see.

2. *Acknowledge Your Sources.* Whenever you use words or ideas that are not your own when writing a paper, use quotation marks where appropriate and cite your source in a footnote, and back it up at the end with a list of sources consulted. Avoid the appearance of plagiarism.

3. *Protect Your Work.* In examinations, do not allow your neighbors to see what you have written; you are the only one who should receive credit for what you know.

4. *Avoid Suspicion.* Do not put yourself in a position where you can be suspected of having copied another person's work, or of having used unauthorized notes in an examination. Even the appearance of dishonesty may undermine your instructor's confidence in your work.

5. *Do your own work.* The purpose of assignments is to develop your skills and measure your progress. Letting someone else do your work defeats the purpose of your education, and may lead to serious charges against you.

6. *Never falsify a record* or permit another person to do so. Academic records are regularly audited and students whose grades have been altered put their entire transcript at risk.

7. *Never fabricate* data, citations, or experimental results. Many professional careers have ended in disgrace, even years after the fabrication first took place.

8. *Always tell the truth* when discussing your work with your instructor. Any attempt to deceive may destroy the relation of teacher and student.

Source: http://www.northwestern.edu/provost/policies/academic-integrity/cardinal-rules.html

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	KEY					Students develop knowledge within a historical perspective of the chemical principles and theories, both factual and conceptual	Working both individually and in groups, students solve both classical and contemporary chemistry problems which exemplify the current integrated nature of science disciplinary and interdisciplinary principles	Perform experimental laboratory procedures in a safe and ethical manner, collect and properly evaluate scientific data	Students develop effective skills in oral and written communication of scientific knowledge, formulate logical explanations and conclusions, and construct effective arguments.	Students retrieve information from the literature, and become proficient in online database searching including the evaluation of the quality and validity of both the source and content of such searches.	Students recognize social, historical, and philosophical implications of scientific discoveries, and understand the potential of science and technology to address problems of the contemporary world.
0 =	*Not in course*										
1 =	*Beginning Level*										
2 =	*Intermediate Level*										
3 =	*Advanced Level*										
	Name	**Elective**	**BA**	**BS**	**Lec/Lab**	**PG1- Foundational Knowledge**	**PG2- Problem Solving**	**PG3- Laboratory Finesse**	**PG4- Scientific Communication**	**PG5- Information Acquisition**	**PG6- Real World Implications**
CHEM 1210	Gen Chem 1		x	x	both	1	0	1	0	0	0
CHEM 1220	Gen Chem 2		x	x	both	1	0	1	0	0	0
CHEM 1610	Majrs Gen Chem 1		x	x	both	1	0	1	0	0	0
CHEM 1620	Majrs Gen Chem 2		x	x	both	1	1	1	1	0	1
CHEM 1910H	Hnrs Gen Chem 1		x	x	both	1	0	1	0	0	0
CHEM 1920H	Hnrs Gen Chem 2		x	x	both	1	1	1	1	0	1
CHEM 1612	PLTL Chem 1		x	x	Workshop	1	1	0	0	0	0
CHEM 1622*	**PLTL Chem 2**		x	x	Workshop	1	1	0	0	0	0
CHEM 2510	Org Lec 1		x	x	Lec	2	1	0	1	0	1
CHEM 2520	Org Lec 2		x	x	Lec	2	2	0	2	0	1
CHEM 2610	Mjrs Org Lec 1		x	x	Lec	2	1	0	1	0	1
CHEM 2620	Mjrs Org Lec 2		x	x	Lec	2	2	0	2	0	1
CHEM 2910H	Hnrs Org Lec 1		x	x	Lec	2	1	0	1	0	1
CHEM 2920H	Hnrs Org Lec 2		x	x	Lec	2	2	0	2	0	1
CHEM 2540	Org Lab 1		x	x	Lab	1	1	2	1	1	1
CHEM 2550	Org Lab 2		x	x	Lab	2	2	2	2	1	1
CHEM 5420	Org Spectroscopy	x			Lec	2	3	0	2	0	1
CHEM 5430	Carbohydrates	x			Lec	3	3	0	2	2	1
CHEM 52XX*	**Neurotransmitters**	x			Lec	3	3	0	2	2	3
CHEM 2210	Anal Chem 1		x	x	both	3	2	2	2	1	2
CHEM 2210H	Hnrs Anal Chem 1		x	x	both	3	2	2	2	2	2
CHEM 4870	Anal Chem 2			x	both	3	3	3	3	1	3
CHEM 4880	Instr. Analysis			x	Lab	3	3	3	3	2	3
CHEM 2990*	**Prof Dev**	x			Lec	0	0	0	3	3	0
CHEM 4300	P Chem 1			x	Lec	3	3	0	0	0	2
CHEM 4310	P Chem 2			x	Lec	3	3	0	0	0	2
CHEM 4410	P Chem Lab		x	x	Lab	0	3	3	3	3	2
BIOCHEM 5721	P Biochem 1		x		Lec	3	3	0	0	0	2
BIOCHEM 5722	P Biochem 2		x		Lec	3	3	0	0	0	2
BIOCHEM 4511	Intro Biochem	x			Lec	3	2	0	2	1	0
BIOCHEM 5621	Biochem Lab	x			Lab	3	3	3	3	2	1
CHEM 3510	Inorg Chem			x	Lec	3	2	0	0	0	3
CHEM 4550	Inorg Lab	x			Lab	3	3	3	3	0	3
CHEM 4998/98H	Research	x			Lab	3	3	3	2	3	3
CHEM 4999/99H	Thesis Research	x			Lab	3	3	3	3	3	3

	KEY					Students develop knowledge within a historical perspective of the chemical principles and theories, both factual and conceptual	Working both individually and in groups, students solve both classical and contemporary chemistry problems which exemplify the current integrated nature of science disciplinary and interdisciplinary principles	Perform experimental laboratory procedures in a safe and ethical manner, collect and properly evaluate scientific data	Students develop effective skills in oral and written communication of scientific knowledge, formulate logical explanations and conclusions, and construct effective arguments.	Students retrieve information from the literature, and become proficient in online database searching including the evaluation of the quality and validity of both the source and content of such searches.	Students recognize social, historical, and philosophical implications of scientific discoveries, and understand the potential of science and technology to address problems of the contemporary world.
0 =	*Not in course*										
1 =	*Beginning Level*										
2 =	*Intermediate Level*										
3 =	*Advanced Level*										
	Name	**Elective**	**BA**	**BS**	**Lec/Lab**	**PG1- Foundational Knowledge**	**PG2- Problem Solving**	**PG3- Laboratory Finesse**	**PG4- Scientific Communication**	**PG5- Information Acquisition**	**PG6- Real World Implications**
CHEM 5440	Computational	x			Lec	3	3	3	3	3	3
CHEM 5520	Nanochemistry	x			Lec	3	3	0	3	3	3
CHEM 5240*	**Protein Modeling**	x			Lec	3	3	3	3	3	3
**Courses in red are the new courses we were hoping to get approved by Spring 2018*											