CHEMISTRY AND BIOCHEMISTRY

Departmental Guidelines & Mission Statement

Mission Statement

The Department of Chemistry and Biochemistry has two primary goals, which in practice are tightly interrelated. First, we seek to promote a level of scientific literacy and chemical understanding among all students taking courses in the department that will contribute to the University's fundamental mission "to inspire and educate our students to become autonomous thinkers, discerning moral agents and active citizens of a democratic society." Secondly, we will provide a rigorous and comprehensive program in chemistry and biochemistry suitable for those students pursuing careers in science and technology.

Guidelines

In its courses the department seeks to progressively develop skills in building qualitative and quantitative interpretation of chemical phenomena, in experimental analysis and design, and in written and oral communication of scientific ideas. Graduates of this program, grounded in a well-developed molecular worldview, are expected to explain the behavior of chemical and biological systems based on physical models. The department is also deeply committed to sustaining a vigorous and diverse range of collaborative student-faculty research. A community of mutual support among students, faculty, and staff is a vital element in achieving our goals.

The Chemistry and Biochemistry curriculum provides courses that are designed to enable students, as contributing professionals and engaged citizens, to deal effectively with a world increasingly dominated by the ideas and methods of modern science. Majors are qualified for immediate employment in industry. However, many elect to attend graduate school in chemistry, biochemistry, and related areas, or enter schools of medicine, dentistry, or engineering. The department is approved by the Committee on Professional Training of the American Chemical Society (ACS) to grant an ACS-certified bachelor's degree to students who complete specific course and/or research requirements.

Associate Professor Jordan E. Katz, Chair

Professor Joseph J. Reczek; Associate Professors Annabel M. Edwards, Jordan L. Fantini, Jordan E. Katz, Peter Kuhlman, Rachel Mitton-Fry, Kimberly Musa Specht, Lauren Waters; Assistant Professors Timothy L. Atallah, Cassandra Zaremba; Visiting Assistant Professor Erica Moscarello; Visiting Assistant Professor, Lilia Koelemay

Academic Administrative Assistant
Yadi Collins

Chemical Instrumentation Specialist
Quintin Cheek

Stockroom Manager and Chemical Hygiene Officer
Jody Cambraia

View faculty profiles and contact information (https://denison.edu/academics/chemistry-biochemistry/contacts/)

Requirements for Chemistry & Biochemistry Majors

The department offers three options for degrees in Chemistry & Biochemistry: Bachelor of Science (B.S.) programs in Chemistry and in Biochemistry that provide a rigorous course of study in preparation for professional careers, graduate work in chemistry/biochemistry or related fields, or professional schools (medical, dental, pharmacology, veterinary); and a Bachelor of Arts (B.A.) program in Chemistry for students intending to pursue fields such as dentistry, medicine, secondary school teaching or other areas requiring a strong chemistry background. Earning a B.A. degree does not preclude a professional scientific career, although an additional year of undergraduate study may be required for admission to some graduate programs. The department also offers a minor in Chemistry.

Our program requires courses at the introductory (100), intermediate (200 and 300), and advanced (400) levels. We expect that majors will complete the required 300-level courses by the end of their junior year. The Department of Chemistry and Biochemistry recommends strongly that students earn a C or better in each of the core courses, CHEM 131 - Atoms and Molecules: Structure and Dynamics, CHEM 132 - Organic Structure and Reactivity, CHEM 251 - Intermediate Organic Chemistry and CHEM 258 - Intermediate Biochemistry, before proceeding to 300-level courses. 400-level courses, to be counted toward the major, need to be taken after the prerequisites. Any request to waive this requirement must come prior to taking the course. We strongly encourage all majors to have an advisor in the department.

Students pursuing any of the three majors are required to complete the following eight common courses plus the additional courses listed for each program:

Code	Title
Two introductory courses in the principles of chemistry:	
CHEM 131	Atoms and Molecules: Structure and Dynamics
CHEM 132	Organic Structure and Reactivity
Three required intermediate courses:	
CHEM 251	Intermediate Organic Chemistry
CHEM 258	Intermediate Biochemistry
CHEM 343	Intermediate Physical Chemistry
The following three additional science division courses:	
BIOL 210	Molecular Biology and Unicellular Life
MATH 135	Single Variable Calculus [1]
PHYS 121	General Physics I

All Chemistry and Biochemistry majors must also satisfactorily complete two zero-credit courses used for program assessment CHEM 300 - Chemistry & Biochemistry Assessment I and CHEM 400 - Chemistry & Biochemistry Assessment II.

Note[1] Students who based on high school coursework and placement scores receive a zero-credit waiver for MATH 135 are required to take MATH 145 (or equivalent) to satisfy this requirement.

BA in Chemistry

A student may graduate with a B.A. degree in Chemistry on fulfillment of G.E. requirements and the successful completion of the following 11 courses:

- The eight common courses listed above
- One additional four-credit 300-level CHEM course
- One additional four-credit 400-level CHEM course[1]
- One additional four-credit 300 or 400 level CHEM course[1]

Note[1] CHEM 451 or 452 will not satisfy this requirement

BS in Chemistry

A student may graduate with a B.S. degree in Chemistry on fulfillment of G.E. requirements and the successful completion of the following 16 courses:

Code	Title
The eight common courses listed above	
CHEM 317	Intermediate Inorganic Chemistry
CHEM 331	Intermediate Analytical Chemistry
One additional four-credit 300 or 400-level CHEM course	
Three additional four-credit 400-level CHEM courses	
PHYS 122	General Physics II
One additional calculus-based MATH course (Math 145, 213 or higher) or CS 111.	
Example two-course sequence in MATH / CS. One of the following: MATH 135 / MATH 145 MATH 135 / CS 111 (If zero-credit waiver for MATH 135 received) MATH 145 / MATH 213 MATH 145 / CS 111	

Note: In order to successfully complete the required courses for a B.S. in Chemistry, students are strongly encouraged to start CHEM 131 in the first semester of their first year.

BS in Biochemistry

A student may graduate with a B.S. degree in Biochemistry on fulfillment of G.E. requirements and the successful completion of the following 16 courses:

Code	Title
The eight common courses listed above	
CHEM 331	Intermediate Analytical Chemistry
One Advanced Biochemistry Course (CHEM 44X)	
One four-credit 300-level or 400-level CHEM course	
One four-credit 300 level BIOL course	
One additional 300-level BIOL or 400-level CHEM course	
BIOL 220	Multicellular Life
PHYS 122	General Physics II
One additional MATH course (Math 120, Math 145 or higher) or CS 111	
Example two-course sequence in MATH / CS. One of the following: MATH 135 / MATH 120 MATH 135 / MATH 145 MATH 135 / CS 111 (If zero-credit waiver for MATH 135 received) MATH 145 / Math 120 MATH 145 / Math 213 MATH 145 / CS 111	

[1] (All advanced courses in Biology have prerequisite courses that a student majoring in Biochemistry may not have completed. Students must either obtain the appropriate prerequisite courses or obtain the permission of the instructor before registering for these advanced Biology courses.)

Note: In order to successfully complete the required courses for a B.S. in Biochemistry, students are strongly encouraged to start CHEM 131 in the first semester of their first year.

The Minor in Chemistry

A student may graduate with a minor in chemistry on successful completion of the following six courses, taken at Denison:

Code	Title
Two introductory courses in the principles of chemistry:	
CHEM 131	Atoms and Molecules: Structure and Dynamics
CHEM 132	Organic Structure and Reactivity
Two required intermediate courses	
CHEM 251	Intermediate Organic Chemistry
CHEM 258	Intermediate Biochemistry
Two additional 300 or 400-level CHEM courses	

Research and ACS Certification

For students pursuing the B.S. degree in either Chemistry or Biochemistry, two semesters of Senior Research (or a summer research experience at Denison followed by one semester of Senior Research in the same laboratory) may be counted as one of the 400-level electives.

The B.S. Chemistry major who takes CHEM 325 - Polymer Chemistry as part of the degree requirements will earn a degree certified to the American Chemical Society. The B.S. Biochemistry major who takes CHEM 317 - Intermediate Inorganic Chemistry and CHEM 325 - Polymer Chemistry as part of the degree requirements will earn a degree certified to the American Chemical Society.

Majors are encouraged to participate in the various on-going research projects in the department. Additional research opportunities are available in the department during the summer and as part of the Oak Ridge Science Semester (https://www.acm.edu/programs/15/oakridge/?utm_source=%2foakridge&utm_medium=web&utm_campaign=redirect).

Additional Points of Interest

Students interested in teaching should consult with faculty in the Department of Education. Faculty and staff in the Department of Education assist students in creating individually designed plans for obtaining licensure through a range of programs after graduation. Students interested in pursuing a B.A. degree in Chemistry before pursuing a teaching career are strongly encouraged to take all three 300-level Chemistry course options (as described below).

The Chemistry courses listed above must be taken at Denison with the following exception: the Department of Chemistry and Biochemistry recognizes the valuable contribution that off-campus study can provide to a broad liberal arts education, so one course in the major at the 300-level or higher may be taken at another institution, providing that prior approval is received from the department. Students considering study off-campus are encouraged to discuss these plans with their academic advisor early in their Denison careers. The department understands that transfer students, students who adopt a chemistry or biochemistry major after the first year, and students who study off-campus may have unique

needs; we encourage them to contact us so that we can work together to help them achieve their academic objectives.

Approved eye protection is required in all laboratory courses.

Courses

CHEM 101 - Topics in Modern Chemistry (4 Credit Hours)
Together we will explore applications of chemistry in our world today. Course topics will focus on an instructor chosen area of chemistry. Students will learn to connect fundamental concepts used to describe atoms and molecules to everyday applications and solutions to global problems.

CHEM 131 - Atoms and Molecules: Structure and Dynamics (4 Credit Hours)
This course is an introduction to the study of chemical phenomena using an "atoms-first" approach -- starting with atoms and building up to more complex molecules. Students will explore principles of atomic structure, molecular bonding and structure, electronic properties, intermolecular forces in all phases of matter, chemical equilibrium, and thermodynamics. Core concepts will be taught through active learning, and laboratory investigation will develop skills in foundational quantitative analysis (measurement, stoichiometry, error analysis) and spectroscopy. Cognitive skills in graphical and written presentation of chemistry developed in this course will be built on in subsequent courses. This course satisfies the Quantitative Reasoning requirement. Three class periods and one laboratory weekly.

CHEM 132 - Organic Structure and Reactivity (4 Credit Hours)
This course builds on the foundation of molecular structural and electronic properties developed in CHEM 131. Students will be introduced to chemical reactions of inorganic and organic compounds, including acid/base reactions, precipitation reactions and substitution and elimination reactions. In-depth analysis of reaction chemistry will encompass aspects of equilibrium, thermodynamics, and kinetics. The principles of conformation and stereochemistry of organic and inorganic molecules, and organic reaction mechanisms will be emphasized. Skills in presentation of scientific data, and experimental design and analysis will be developed and built on in subsequent courses. This course satisfies the Quantitative Reasoning requirement. Three class periods and one laboratory weekly.
Prerequisite(s): CHEM 131.

CHEM 199 - Introductory Topics in Chemistry (1-4 Credit Hours)
A general category used only in the evaluation of transfer credit.

CHEM 251 - Intermediate Organic Chemistry (4 Credit Hours)
This course expands upon concepts in molecular structure and behavior presented in CHEM 131 and CHEM 132 and applies them to the systematic investigation of the reactivity of organic molecules. Students will explore the transformation and reaction chemistry of organic functional groups, including alcohols, aromatics, aldehydes, ketones, carboxylic acids, and their derivatives. Reactions are explored with an emphasis on the mechanism of reactivity, and in the context of organic synthesis with a focus on the art of retrosynthetic analysis for complex targets. Laboratory experiments are selected to introduce techniques for the synthesis, purification, and analysis of organic compounds discussed in class. Three class periods and one laboratory weekly. Safety glasses required.
Prerequisite(s): CHEM 132.

CHEM 258 - Intermediate Biochemistry (4 Credit Hours)
A study of the major chemical processes and molecular species that characterize living organisms. Principles of molecular structure and chemical reactivity from CHEM 131, 132, and 251 will be developed in greater quantitative detail and applied to investigation of the molecular interactions that underlie cellular life. Primary emphasis will be placed on understanding the relationship between the structures of biological macromolecules (particularly proteins) and their functions. Laboratory work will consist of a series of multi-week experiments focused on the isolation and subsequent characterization of active biological macromolecules from living organisms. Offered in the spring only. Three class periods and one laboratory weekly.
Prerequisite(s): CHEM 251 and BIOL 210, or consent.

CHEM 299 - Intermediate Topics in Chemistry (1-4 Credit Hours)
A general category used only in the evaluation of transfer credit.

CHEM 300 - Chemistry & Biochemistry Assessment I (0 Credit Hours)
A pass/fail course used to track all chemistry and biochemistry majors' completion of the required third-year departmental assessment exam. Earning the required S (pass) in this course entails completion of the assessment exam with a passing score as designated by the department. Required of all majors in the fall semester after completion of CHEM 258.
Prerequisite(s): CHEM 258.

CHEM 317 - Intermediate Inorganic Chemistry (4 Credit Hours)
This course in inorganic chemistry investigates the structural and bonding models of molecules using concepts of symmetry and molecular orbitals. Investigation of reactions and intermolecular forces is done in the context of inorganic substances. The classroom portion includes introduction to and an oral presentation on the primary literature of the discipline while the laboratory portion includes synthesis of molecules and measurement of their properties. Three class periods and one laboratory weekly.
Prerequisite(s): CHEM 258 or consent.

CHEM 325 - Polymer Chemistry (4 Credit Hours)
This course will explore the synthesis, structure, composition and function of the polymers (“plastics”) that surround us. We will learn how fundamental chemical and physical properties of polymeric materials are characterized, measured, controlled and utilized in the clothes, cars, smartphones medical devices ever present in our modern life. The topics covered integrate many fundamental concepts in chemistry in a course with practical relevance for majors and minors interested in basic or applied science, sustainability, health, engineering, and emerging technologies. Three class periods and one three-hour laboratory weekly.
Prerequisite(s): CHEM 258, or consent.

CHEM 331 - Intermediate Analytical Chemistry (4 Credit Hours)
A course of quantitative analytical chemistry, based on principles of chemical equilibrium and thermodynamics. The laboratory includes exposure to a range of gravimetric and volumetric methods along with spectroscopic, chromatograhic, and electrochemical techniques for analysis. Three class periods and one laboratory period weekly. Offered fall semester only.
Prerequisite(s): CHEM 258, or consent.

CHEM 343 - Intermediate Physical Chemistry (4 Credit Hours)
An examination of the physical properties of chemical systems from both macroscopic and microscopic points of view. Topics include thermodynamics, structure and bonding from a quantum mechanical point of view, an introduction to spectroscopy, and chemical kinetics. Three class periods and one laboratory weekly.
Prerequisite(s): CHEM 258, MATH 145 and PHYS 121, or consent.

CHEM 361 - Directed Study (1-4 Credit Hours)
Laboratory (or library) research, in consultation with a member of the chemistry faculty. Hours arranged. Safety glasses required.
Prerequisite(s): Consent of faculty mentor.

CHEM 362 - Directed Study (1-4 Credit Hours)
Laboratory (or library) research, in consultation with a member of the chemistry faculty. Hours arranged. Safety glasses required.
Prerequisite(s): Consent of faculty mentor.

CHEM 363 - Independent Study (1-4 Credit Hours)

CHEM 364 - Independent Study (1-4 Credit Hours)

CHEM 399 - Advanced Topics in Chemistry (1-4 Credit Hours)
A general category used only in the evaluation of transfer credit.

CHEM 400 - Chemistry & Biochemistry Assessment II (0 Credit Hours)
A pass/fail course used to track all chemistry and biochemistry majors' completion of the required senior interview. Earning the required S (pass) in this course entails completing the senior interview in good faith. Students who are not adequately prepared will be required to retake the interview. Required of all senior majors in the spring of senior year.

CHEM 416 - Chemistry in 2D: Surface Chemistry and its applications (4 Credit Hours)
This course will explore the chemistry and physics behind monolayers and the interfacial phenomena that control the behavior of these single molecule thick films. We will connect what we know about 3D or bulk systems (such as the thermodynamics, intermolecular interactions, and phase behavior) to a 2D surface environment. This course thus reviews and builds on the topics presented in physical chemistry. Our discussion of monolayers and surfaces will also include common measurement techniques. The second part of this course will discuss modern applications of and the use of monolayers (and bilayers) as models to study topics in biophysics and materials science. The specific applications covered will vary with student interest. Three class periods and one three-hour laboratory weekly.
Prerequisite(s): CHEM 317 or CHEM 325 or CHEM 331 or CHEM 343 or consent.

CHEM 418 - The Chemistry and Materials of Sustainable Energy (4 Credit Hours)
This course will explore chemical processes and materials science underlying energy conversion processes, with a focus on sustainable approaches. After an overview of the science of climate change and an analysis of current energy practices, the course will focus on renewable sources of electricity, energy storage, and sustainable production of chemical fuels. Throughout, the emphasis will be on the thermodynamics, materials science, catalysis, and (photo) electrochemical processes central to energy use and production. The course will include a semester-long research project that will require students to engage with the primary literature from a variety of sub-disciplines. Three class periods and one three-hour laboratory weekly.
Prerequisite(s): CHEM 317 or CHEM 325 or CHEM 331 or CHEM 343 or consent.

CHEM 422 - Organometallic Chemistry (4 Credit Hours)
This course explores the structure and reactivity of organometallic compounds. Organometallic compounds contain one or more covalent bonds between carbon and a metal. The course focuses on compounds of the transition (d-block) metals, a broad family of species which are featured prominently in modern organic synthesis, including pharmaceutical and polymer synthesis. Organotransition metal compounds exhibit modes of reactivity and structure types beyond those encountered in introductory organic chemistry. The use of modern instrumentation to characterize these compounds and their reactivity will be investigated in the classroom and laboratory.
Prerequisite(s): CHEM 317 or CHEM 325 or CHEM 331 or CHEM 343 or consent of instructor.

CHEM 423 - Medicinal Chemistry (4 Credit Hours)
This course will explore the interface between organic chemistry and the discovery, development, and biological analysis of pharmaceutical targets. Topics will include isolation and optimization of drug candidates; the total synthesis of candidates from discovery to production; analysis of pharmacokinetics and pharmacodynamics; ethical aspects of drug development and intellectual property; and other topics from current literature. Additional topics may vary depending upon student interest. We will use these topics to further our critical thinking skills towards advanced organic synthesis and method development in application to the pharmaceutical industry. The class will consist of three 50-minute lectures and one three-hour lab weekly.
Prerequisite(s): CHEM 251, CHEM 258, and at least one CHEM 300 level course, or instructor consent.

CHEM 427 - Synthetic Organic Chemistry: Designing Molecules and Materials (4 Credit Hours)
This course will explore the art of modern organic synthesis. This includes learning the chemistry behind current organic techniques and reactions, as well as gaining an understanding of design strategies to achieve complex molecules and functional materials. Students will engage with the synthesis strategies of several key pharmaceutical targets and the motivations for their exploration (drugs design). This class will also explore the fundamental principles governing the properties of modern organic materials, from compostable plastics to flat screen TVs. In addition, throughout this course students will engage in the process of proposal writing, from idea development to finished proposal. Three class periods and one three-hour laboratory weekly.
Prerequisite(s): CHEM 317 or CHEM 325 or CHEM 331 or CHEM 343 or consent of instructor.

CHEM 430 - Special Topics in Chemistry (1-4 Credit Hours)
This advanced course in Chemistry and Biochemistry will explore current topics in the field.
Prerequisite(s): CHEM 258 and at least one 300-level CHEM course.

CHEM 441 - Advanced Topics in Biochemistry: Modern Techniques (4 Credit Hours)
An in-depth exploration of modern techniques in biochemistry research. The focus will be on how the structure and function of biological macromolecules are investigated with a historical perspective of seminal studies leading to a detailed discussion of the most modern laboratory techniques ind instrumentation. Topics will vary, but may include DNA and protein crystallography, NMR, genomics, proteomics, radiotracers, microarrays, and other topics from the current scientific literature. Three class periods and one three-hour research/writing laboratory weekly.
Prerequisite(s): CHEM 258 and at least one CHEM or BIOL class at the 300-level, or consent.

CHEM 443 - Advanced Topics in Biochemistry: Diet, Metabolism, and Disease (4 Credit Hours)
This advanced biochemistry course will explore the metabolic fates of food molecules and how these molecules affect an individual's health and predisposition towards a range of diseases. We will consider concepts of health, diet, and fitness as presented in popular culture as well as investigating their biochemical bases. The class will include a semester-long research project focusing on the interplay of diet, metabolism, and disease and will require students to become conversant with current primary research literature in the field. Three class periods and one laboratory weekly.
Prerequisite(s): CHEM 258 and at least one CHEM or BIOL class at the 300-level, or instructor's consent.

CHEM 449 - Advanced Topics in Biochemistry: Nucleic acids (4 Credit Hours)
An in-depth exploration of modern topics in the field of nucleic acids. A focus will be on macromolecular structure and intermolecular interactions between proteins and nucleic acids, and the effects of these on biological systems and scientific research. Topics will vary, but may include restriction enzymes, RNA silencing, RNA-directed prokaryotic immunity, riboswitches, and other topics from the current scientific literature. Two class periods and one three-hour laboratory weekly.
Prerequisite(s): CHEM 317 or CHEM 325 or CHEM 331 or CHEM 343 or consent.

CHEM 451 - Senior Research (4 Credit Hours)
Laboratory research for qualified seniors working under faculty supervision. Hours arranged. Safety glasses required.
Prerequisite(s): Staff approval.

CHEM 452 - Senior Research (4 Credit Hours)
Laboratory research for qualified seniors working under faculty supervision. Hours arranged. Safety glasses required.
Prerequisite(s): Staff approval.