Washington University in St. Louis
ARTS & SCIENCES

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Handbook for Chemistry Majors and Minors

Contents

Chemistry Major Website

Department of Chemistry
MSC 1134-196-525
Washington University
St. Louis, Missouri 63130-4899
www.chemistry.wustl.edu

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The Undergraduate Major in Chemistry at Washington University

Chemistry is a central, multi-faceted science, extending in one direction into physics and mathematics, in another direction into biology and medicine, and in yet another into business and commerce. In its major role, chemistry involves the exploration of the structure and constitution of the microscopic world of atoms and molecules, the chemical and physical transformations that occur in it, and the principles that govern these changes. Such investigations yield deep insights into nature, new methods for creating novel compounds and useful materials, and new ways for meeting the needs of a technological society. Modern research in chemistry has provided new insights resulting in the synthesis of a vast array of compounds useful in medicine, industry, and agriculture such as super-conducting materials, solar cells, chemical memory devices, and new drugs for treatment of some of our most devastating diseases.

The Department of Chemistry of Washington University has a tradition of excellence, combining a deep commitment to fundamental research with an equally deep commitment to classroom teaching. Supported by funds from the University, from the Government, and from Industry, it has created a close-knit group of teacher-scientists who provide the opportunity to well-motivated undergraduate students to obtain a superior education and unparalleled undergraduate research opportunities in science. Currently, the Department includes 24 full-time faculty members. In addition to these faculty members involved in teaching and research, there are three full-time research faculty members, four Ph.D. lecturers in General Chemistry, two Ph.D. lecturers in Organic Chemistry, and two Ph.D. undergraduate Laboratory Directors. The student body includes 100 - 110 undergraduate chemistry majors, 80 - 100 graduate students and ~20 postdoctoral associates.

Teaching and Research Areas in Chemistry

- Bioorganic
- Biophysical
- Environmental
- Inorganic
- Materials
- Nuclear
- Organic
- Organometallic
- Physical
- Physical Organic
- Computational
- Theoretical

Additional areas of strong specialization within the Department include:

- Biopolymers
- Catalysis
- Computer Modeling
- Drug Discovery
- Drug-Receptor Interactions
- Dynamic Nuclear Polarization
- Electrochemistry
- EPR Spectroscopy
- Femtosecond Laser Spectroscopy
- Heterocyclic Chemistry
- Infrared Spectroscopy
- Mass Spectrometry
- Materials Chemistry
- Membrane Chemistry
- Natural Products
- NMR Spectroscopy
- Nuclear Reactions
- Nuclear Structures
- Organic Electrochemistry
- Photochemistry
- Polypeptide and Protein Folding
- Radiopharmaceuticals
- Synthetic Organic
- Transition State Structure

Chemistry Department faculty actively collaborate with members of the Departments of Biology, Earth and Planetary Sciences, Physics, and a number of departments in the Schools of Engineering and Medicine. For example, interactions with faculty members in the School of Medicine involve the application of NMR techniques to a variety of biochemical problems and the use of short-lived radioactive isotopes in nuclear medicine.

The Curriculum

A primary goal of the undergraduate Major program in chemistry is to provide a quality educational foundation for productive and creative careers in chemistry and related fields including biochemistry, medicine, and engineering. Many chemistry majors proceed to graduate work in chemistry or biochemistry, to medical school and other healthcare institutions, business school or law school. Other graduates choose to proceed directly to positions in government, industry, or education.

To satisfy the needs of those interested in this most central of sciences, the Department of Chemistry offers a broad range of courses and two slightly different degrees. A student may elect to pursue a regular chemistry major or chemistry major with biochemistry concentration. The course offerings and requirements for these degrees are detailed in the following pages. Advanced undergraduates may elect to take one or more graduate courses (500 level) if the prerequisites are fulfilled.

In order to qualify for graduation with Latin honors (*cum laude*, *magna cum laude*, *summa cum laude*) a student must follow a more rigorous program. The course requirements for honors eligibility are provided on the following pages. It is emphasized that taking and passing one of the course programs outlined below merely qualifies the student to be considered for honors. Granting these honors is at the discretion of the University and depends on the distinction of the student's entire record.

A checklist of the Chemistry Major programs and options is provided for convenience on the last page of this handbook.

Undergraduate Eligible Courses by Sub-Discipline

General and Analytical Chemistry

105	Principles of General Chemistry I
106	Principles of General Chemistry II
111A	General Chemistry I
112A	General Chemistry II
151	General Chemistry Lab I
152	General Chemistry Lab II
181	First-Year Opportunity: Why is Chemistry Called “the Central Science”?
182	Chemistry for Concerned Citizens: Topics in Energy, the Environment, and More
183	First-Year Opportunity: Chemistry and Energy

Organic Chemistry

261	Organic Chemistry I
262	Organic Chemistry II
358	Advanced Organic Laboratory
430	Simulation in Chemistry & Biochemistry
450	Physical Organic Chemistry
451	Organic Chemistry III
452	Synthetic Polymer Chemistry
453	Bioorganic Chemistry
462	Synthetic Polymer Chemistry Lab
5522	Synthetic Methods
555	Special Topics in Organic Chemistry
557	Advanced Organic Synthesis
558	Spectral Methods in Organic Chemistry
559	Organic Chemistry Seminar

Inorganic Chemistry

426	Inorganic Electrochemistry and Photochemistry
459	Organometallic Chemistry
461	Inorganic Chemistry
464	Inorganic Biochemistry
465	Solid-State and Materials Chemistry
470	Inorganic Chemistry Laboratory
540	Inorganic/Organometallic Seminar
541	Advanced Inorganic Chemistry
542	Special Topics in Inorganic Chemistry

Nuclear and Radiochemistry

435	Nuclear and Radiochemistry Laboratory
436	Introduction to the Atomic Nucleus
437	Radioactivity and Radiation Safety
536	Radiochemistry for the Life Sciences

Biological Chemistry

410	Special Topics in Physical Chemistry: Biophysical Chemistry
475	Chemical Biology
481	General Biochemistry I
482	General Biochemistry II
483	Protein Biochemistry
485	Nucleic Acids
5051	Methods of Biophysical Chemistry
510	Chemical Dynamics of Biological Pathways
515	Biological Chemistry Seminar
Biol 334◊	Cell Biology
Biol 349◊	Fundamentals of Microbiology
Biol 451	General Biochemistry
Biol 4522◊	Protein Biochemistry Lab
Biol 4523◊	Molecular Methods on Enzyme Analysis

Physical Chemistry

400	Physical Science in 12 Problems
401	Physical Chemistry I
402	Physical Chemistry II
403	Chemical Kinetics
4050	Computational Problem Solving in the Chemical Sciences
445	Instrumental Methods in Physical Chemistry
488	Modern Spectroscopy
533	Time-Dependent Quantum Mechanics and Spectroscopy
543	Physical Properties of Quantum Nanostructures
550	Mass Spectrometry
571	Quantum Chemistry and Spectra
576	Magnetic Resonance
580	Special Topics in Physical Chemistry
584	Molecular Spectroscopy
585	Molecular Reaction Dynamics

Additional Chemistry Courses

290	First-Year & Sophomore Research
490	Introduction to Research
495	Advanced Undergraduate Research
500	Independent Work in Chemistry
586	Commercialization in Sciences and Technology

◊These courses do not count as advanced electives for the regular major or minor in Chemistry

Advanced Placement

By AP Scores. Entering students with a score of 5 on the CEEB Advanced Placement (AP) Test in chemistry may receive 6 units of credit, 3 units each for Chem 103 and 104. Entering students with a score of 4 on the AP Test in chemistry receive 3 elective units for Chem 103. Units for Chem 103 or 104 **do not** replace Chem 105/106 or Chem 111A/112A. A student with a 4 or 5 on the AP test should enroll in Chem 111A, rather than Chem 105. Students must complete Chem 105/106 or Chem 111A/112A **before** enrolling in Chem 261.

By IB Scores. Entering students with a score of 6 or 7 on the International Baccalaureate (IB) Exam receive 6 units of elective credit (Chem 103/104). These units **do not** replace Chem 105, 111A, 151, 106, 112A, or 152. A student who receives a 6 or 7 should enroll in Chem 111A, rather than Chem 105. Students must complete Chem 105/106 or Chem 111A/112A **before** enrolling in Chem 261.

By Department Exam. A placement examination for Chem 111A, 112A, 151, and 152 will be given on request by the Department of Chemistry during Orientation Week. Students who pass the placement exams will receive 3 units of credit each for Chem 111A and Chem 112A and 2 units each for Chem 151 and Chem 152. Passing these exams will allow a student to enroll directly in Chem 261 (Organic Chemistry with Lab I). There is no placement exam for Chem 105/106. If a student feels they have mastered the content in Chem 105/106, they are recommended to enroll in Chem 111A.

Students must inform the departmental Academic Coordinator (Brandon Hutchison; b.hutchison@wustl.edu; 314-965-7708) in McMillen 525 of their plans to take the placement test.

Students with Disabilities

Services for students with hearing, visual, orthopedic, learning, or other disabilities are coordinated through Disability Resources. Services provided for students with disabilities may include (but are not limited to) readers, note takers, special parking, tutoring, counseling, appropriate academic accommodations (e.g., alternate testing conditions) and referral to community resources.

Students with either a temporary or permanent disability should contact the Disability Resource Center at (314) 935-5970 (voice and TTY). The office is located in Gregg Hall on the South Forty.

Campus Wide Student Resources

Habif Health and Wellness: Habif is a full-service medical center with professional medical staff, same-day appointments for many issues, flu and other vaccinations, nutrition services, contraception and reproductive health care, allergy injections, radiology facilities, an on-campus pharmacy and much more. In addition, Habif offers a suite of mental, sexual and emotional health resources.

Gary M. Sumers Fitness Center: Located at the end of campus, this fitness center is the primary area for individual cardio and strength training. The west end of the Sumers Fitness Center is a cardio plaza with 65 cardio machines, including treadmills, ellipticals, stair steppers, lateral trainers, stationary bikes, and rowing machines. The east end of the Fitness Center houses the strength training area, which includes 41 strength stations and a full assortment of free weights. This area is also outfitted with a 12-foot medicine ball wall and a functional fitness rig. **Membership is free to fulltime undergraduate students.**

Part-Time Employment Opportunities

Limited part-time employment opportunities for undergraduates also exist within the Department. These include positions as laboratory technicians, exam graders, glassware room attendants, peer mentors, and teaching assistants in the undergraduate courses and laboratories. Summer positions are also available occasionally. Further information on employment may be obtained from the department's Manager of Financial Operations, Cindy Hodge, in McMillen 519.

Requirements for the Major in Chemistry

In preparing for a major in the Department students are required to take (in residence or externally as stated):

Courses that must be taken in residence at WashU:	
Chem 111A (Chem 105♦)	General Chemistry I (Principles of General Chemistry I)
Chem 112A (Chem 106♦)	General Chemistry II (Principles of General Chemistry II)
Chem 151	General Chemistry Lab I
Chem 152	General Chemistry Lab II
Chem 261	Organic Chemistry I with Lab
Chem 262	Organic Chemistry II with Lab

Courses that can be taken externally with approval from the corresponding WashU Department:	
Math 131*	Calculus I
Math 132*	Calculus II
Math 233*	Calculus III
Phys 191**	Physics I
Phys 191L**	Physics I Lab
Phys 192**	Physics II
Courses only for the Concentration in Biochemistry	
Bio 2960	Principles of Biology I
Bio 2970	Principles of Biology II

♦Students may substitute Chem 105/106 for Chem 111A/112A. Please consult Chemistry's Director of Undergraduate Studies (Prof. Richard Mabbs) for details.

* Math 131E may replace Math 131. Math 203 may replace both Math 131 and 132. Math 204 may replace Math 233.

** Phys 193 may replace Phys 191, Phys 194 may replace Phys 192, Phys 193L may replace Phys 191L, Phys 194L may replace Phys 192L.

For all majors, further physics (e.g. Phys 217) and mathematics (e.g. Math 308) courses are encouraged. Chem 181, a seminar to introduce 1st-years to the research activities of the Chemistry department, is recommended.

A major may follow either of two paths: the regular chemistry major or the chemistry major with a concentration in biochemistry. Each path has an honors program of coursework, which makes the student eligible for Latin honors (*cum laude, etc.*). The honors programs are strongly recommended for students planning to continue their interests in graduate school. The

Department also awards Departmental honors, which place a strong emphasis on the research component of a Chemistry education. A working knowledge of a foreign language is encouraged, but not required. A working knowledge of computer programming (and applications to problems in chemistry) is strongly encouraged. A grade of C- or better must be earned in all courses that are required for the major. Chemistry majors must take all their required chemistry coursework at WU. In some cases, elective chemistry courses may be taken at other institutions.

Regular Chemistry Major. Departmental requirements for the regular major specify a minimum of 18 units in advanced (≥ 300 level) courses in chemistry. These must include Physical Chemistry (Chem 401 and 402), Inorganic Chemistry (Chem 461), an advanced laboratory course (chosen from Chem 358, 435, 445, 462, or 470), plus 6 additional units of chemistry elective courses at the 300 level or above*. Neither Chem 490 nor Chem 495 can be used to satisfy the advanced laboratory or elective credits. Biol 451 (General Biochemistry) may be used as an elective to satisfy the regular chemistry major, but not in combination with Chem 481 or 482 (General Biochemistry I and II).

*please verify with your advisor that courses at the 500 level will count toward the major.

Regular Chemistry Major with Honors Eligibility. In order to be eligible for Latin or Departmental honors, a student must take a minimum of 21 units in advanced (≥ 300 level) courses in chemistry. The advanced courses must include Physical Chemistry (Chem 401 and 402), Inorganic Chemistry (Chem 461), one synthetic chemistry laboratory course (Chem 358, 462, or 470), one physical-based chemistry laboratory course (Chem 435 or 445), and 6 additional units in chemistry elective courses at the 300 level or above*. Chem 490 cannot be used to satisfy advanced laboratory or elective requirements. Chem 495 can be counted as an advanced elective but cannot replace an advanced laboratory course. Biol 451 (General Biochemistry) may be used as an elective to satisfy the regular chemistry major but not in combination with Chem 481 or 482 (General Biochemistry I and II).

*please verify with your advisor that courses at the 500 level will count toward the major.

Chemistry Major: Concentration in Biochemistry. In addition to the requirements for the regular chemistry major, the chemistry major with a concentration in biochemistry adds Biol 2960 and 2970 as prerequisites to the major. A minimum of 18 units of advanced (≥ 300 level) courses in chemistry and biology are also required in addition to the prerequisites for the Chemistry major with concentration in biochemistry. The advanced courses must include Physical Chemistry (Chem 401 and Chem 402), Inorganic Chemistry (Chem 461), Biochemistry I and II (Chem 481 and 482), and an advanced laboratory course (chosen from Chem 358, Chem 435, Chem 445, Chem 462, Chem 470, Biol 4522, or Biol 4523). Neither Chem 490 nor 495 satisfy the advanced laboratory requirement.

***Chemistry Major with Honors Eligibility: Concentration in Biochemistry*.** For Latin or Departmental honors eligibility through the Chemistry major with Concentration in Biochemistry, a minimum of 21 units of advanced (≥ 300 level) courses in chemistry and biology are required, in addition to the prerequisites for the Chemistry major with concentration in biochemistry. The advanced courses must include Physical Chemistry (Chem 401 and 402), Inorganic Chemistry (Chem 461), Biochemistry (Chem 481 and 482), and an advanced laboratory course (chosen from Chem 358, Chem 435, Chem 445, Chem 462, Chem 470, Biol 4522, or Biol 4523). In addition, honors eligibility through this major requires an advanced biochemistry course (chosen from Biol 334, Biol 349, Chem 410, Chem 453, Chem 464, Chem 475, Chem 483, Chem 485, or Chem 510), or a second advanced laboratory chosen from the list above. Neither Chem 490 nor 495 satisfy the advanced laboratory requirement.

Departmental Honors. Departmental or “English” honors are awarded by the Chemistry Department for the successful completion of a rigorous Chemistry program of study, which emphasizes research as an important part of a Chemistry education. To graduate with Departmental honors, a student must complete the honors-eligible curriculum (detailed above).

Furthermore, to graduate "with distinction", a student must maintain a Chemistry GPA of 3.5 and complete at least 3 units of Chem 490* research; to graduate "with high distinction", a student must maintain a Chemistry GPA of 3.65 and complete at least 6 units of Chemistry research, 3 of which must come from Chem 495; to graduate "with highest distinction", a student must maintain a Chemistry GPA of 3.8 and complete at least 6 units of Chemistry research, 3 of which must come from Chem 495. Chemistry research is defined as a research project performed under the direction of a Chemistry faculty member, or a research project outside the department which is approved by the Chemistry Department Undergraduate Work Committee. A Chemistry GPA is calculated from the grades received in Chemistry courses prerequisites for the Chemistry major, including lower-level Chemistry courses, Math, Physics, and Biology (if pursuing the Biochemistry concentration major). The level of Departmental Honors a student achieves will appear on the student's final transcript.

*for students with alternate research experiences, petitions will be considered for Chem 490 equivalence. Contact Prof. Richard Mabbs (mabbs@wustl.edu; McMillen Lab room 513).

Additional Opportunities for Majors

Research. Credit can be obtained for performance of undergraduate research through either Chem 490 (variable credits) or Chem 495 (3 credits). To register for Chem 490, a student must select a research advisor. This advisor may be a Department of Chemistry faculty member or a faculty member from an external department if the research involves a significant chemistry component (more information is provided later). The student and research mentor mutually agree upon the research project, how it is designed and implemented. This link provides a list of all research active chemistry faculty. The list outlines specific keywords and research areas for each group, which faculty members are accepting undergraduates, class(es) the faculty would like their researcher to have taken prior to joining the lab*, and a link to the faculty profile with contact information for the faculty member. Chem 490 represents a credit/no credit course

* These are recommendations for completed coursework, not requirements. Faculty could be willing to take in researchers if they are currently enrolled in a course, or if they are passionate and willing to learn while they research. If you are on the fence about joining a lab, reach out and have a conversation with the faculty member.

option that permits the student to conduct research in chemistry. The student who registers for this course will get between one and six credit units (typically 3) per semester based on the amount of work performed in the course and agreed to *in advance* by the supervising faculty member. One unit of credit is equivalent to 3 hours of work per week. A student planning to register for Chem 490 research must obtain the approval of their prospective research mentor. Additionally, a student planning to register for Chem 490 research with **a non-Chemistry research advisor** must first seek permission from the Chemistry Department by submitting the Chem 490 Project Proposal Form, found on the Chemistry Department website (see QR Code). Contact Prof. Richard Mabbs (mabbs@wustl.edu; McMillen Lab room 513) with questions.

Undergrad Research In Chemistry Link

Another research option is Chem 495. This is a 3-credit research course that requires the student's commitment to submit to an oral exam at the end of the research experience. This is a graded course. The prerequisites and completion requirements for Chem 495 must be approved by the faculty research advisor prior to enrollment. A prerequisite for Chem 495 is the prior completion of at least 3 units of Chem 490 (or equivalent), preferably in the same laboratory. Research mentors may have other prerequisites. **All** students who wish to enroll in Chem 495 must submit the Chem 495 Project Proposal Form, found on the Chemistry Department website (see QR Code). Contact Prof. Richard Mabbs (mabbs@wustl.edu; McMillen Lab room 513) with questions. Similar to Chem 490, Chem 495 may be taken outside the chemistry department. Chem 495 qualifies as a capstone experience and may be counted as an advanced elective toward the regular chemistry major with honors.

Capstone Experiences. At the present time, two capstone experiences are available to students through the Department of Chemistry. One is Chem 495, Advanced Undergraduate Research in Chemistry, and the other is Chem 500, Independent Work. Proposals for alternate capstone experiences will be considered but must be submitted to Prof. Richard

Mabbs (513 McMillen Lab) in writing a full semester in advance of registration. The proposal must address the objective of the experience, the breadth of the experience, and describe a method of faculty evaluation.

Writing Intensive. Students may complete the College's requirement of a writing intensive course in any one of four advanced laboratory courses in Chemistry (Chem 358, 445, 462W, or 470W), in Chemistry 453W (Bioorganic Chemistry) or in a writing-intensive course in another department.

Study Abroad. Study Abroad programs are available both for chemistry and pre-medical studies. Details of these programs can be found at the Overseas Programs web site: http://www.artsci.wustl.edu/~overseas/. For chemistry programs, you may be able to receive elective/Chem 490 credit for courses taken/research done abroad. Eligibility of external courses for such credit must be determined in advance by the chemistry Undergraduate Work Committee. It is strongly advised that you contact the Department of Chemistry Study Abroad Advisor, Prof. Richard Mabbs (mabbs@wustl.edu) as soon as possible after you declare your major to discuss study abroad plans.

Program Assessment. In an effort to develop an annual program evaluation in cooperation with the Higher Learning Commission (HLC), the Department of Chemistry has decided to offer an exit exam to all graduating seniors as part of that assessment. At the present time, the exam that has been selected is the American Chemical Society (ACS) Diagnostic of Undergraduate Chemistry Knowledge, two hours in length, which includes questions with multiple choice answers in four key areas of chemistry: physical, organic, analytical, and inorganic chemistry. This exam is mandatory, but the performance on this exam does not affect the student's transcript or GPA. The exam is tentatively scheduled during Commencement Week.

Typical Program for Regular Chemistry Major

		Units	
First Year:		Fall	Spring
General Chemistry	111A*, 112A*	3	3
General Chemistry Lab	151, 152	2	2
Mathematics (Calculus)	131, 132	3	3
Physics (or Elective)	191/191L, 192/192L	4	4
Writing I	100	3	
First-Year Chemistry Seminar	181		1
Elective			3
		15	**16**
Second Year:			
Organic Chemistry	261, 262	4	4
Mathematics	233	4	
Elective (or Physics)		4	4
Electives		3	6
		15	**14**

* Students may substitute Chem 105/106 for Chem 111A/112A. Please consult the Chemistry Director of Undergraduate Studies (Prof. Richard Mabbs) for details.
NOTE: Math and Physics requirements should be completed prior to the third year, since they are prerequisites for Physical Chemistry.
NOTE: Chemistry majors must take required Chemistry courses at WUStl.

Regular Chemistry Major

Third and Fourth Years:

Physical Chemistry	Two courses	Chem 401 and 402
Inorganic Chemistry	One course	Chem 461
Advanced Laboratory	One course from	Chem 358, 435, 445, 462, or 470
Electives	Two courses from	Chemistry courses 300 and above (including courses listed above or Biol 451*) not used to fulfill previous requirements or upper level requirements for other majors. Neither Chem 490 nor Chem 495 may be used as an elective

Regular Chemistry Major with Honors Eligibility

Third and Fourth Years:

Physical Chemistry	Two courses	Chem 401 and 402
Inorganic Chemistry	One course	Chem 461
Adv. Synthetic Laboratory	One course from	Chem 358, 462, or 470
Adv. Physical Laboratory	One course from	Chem 435 or 445
Electives	Two courses from	Chemistry courses 300 and above (including courses listed above or Biol 451*) not used to fulfill previous requirements or upper level requirements for other majors. Chem 495 but not Chem 490 may be used as an elective.

* Students counting either/or Chem 481/482 cannot use Biol 451 to fulfill an elective requirement.

Typical Program for Chemistry Major with Concentration in Biochemistry

		Units	
First Year:		Fall	Spring
General Chemistry	111A*, 112A*	3	3
General Chemistry Lab	151, 152	2	2
Mathematics (Calculus)	131, 132	3	3
Biology	2960		4
Writing I	100	3	
Freshman Chemistry Seminar	181		1
Elective		3	3
		14	**16**
Second Year:			
Organic Chemistry	261, 262	4	4
Biology	2970	4	†
Mathematics	233	4	
Physics	191/191L, 192/192L	4	4
Electives			6
		16	**14**

*Students may substitute Chem 105/106 for Chem 111A/112A. Please consult the Chemistry Director of Undergraduate Studies (Prof. Richard Mabbs) for details.

NOTE: Math and Physics requirements should be completed prior to the third year since they are prerequisites for Physical Chemistry.

† Students may consider taking Cell Biology (Bio 334) as an elective this semester after consultation with their advisor.

Chemistry Major with Concentration in Biochemistry

Third and Fourth Years:

Biochemistry	Two courses	Chem 481 and 482
Physical Chemistry	Two courses	Chem 401 and 402
Inorganic Chemistry	One course	Chem 461
Advanced Laboratory	One course from	Chem 358, 435, 445, 462, 470, Biol 4522, 4523

Chemistry Major with Concentration in Biochemistry and Honors Eligibility

Third and Fourth Years:

Biochemistry	Two courses	Chem 481 and 482
Physical Chemistry	Two courses	Chem 401 and 402
Inorganic Chemistry	One course	Chem 461
Advanced Laboratory	One course from	Chem 358, 435, 445, 462, 470, Biol 4522, 4523
Advanced Biochemistry or a Second Advanced Lab	One course from	Chem 410, 453, 464, 475, 483, 485, 510, Biol 334, 349, or second advanced lab from list above

Minor in Chemistry*.* With the exception of Math 233, a student planning to complete a minor in chemistry must enroll in the prerequisite courses for the regular Chemistry major: Chem 111A, 112A, 151, 152, 261, 262, Phys* 191/191L, 192/192L, Math** 131 and 132. Nine units of chemistry with at least 3 units in each of two different sub-disciplines (sub-disciplines are noted on page 4) are required at the advanced level (Chem 358 or any chemistry course $\geq$ 400 level). Biol 451 may be used to satisfy one course of the three required, but not in combination with Chem 481 or Chem 482. Chem 490 and 495 are specifically excluded from the minor. Deviations from these requirements will be handled on an individual basis. Contact Prof. Richard Mabbs (513 McMillen Lab) to discuss petitions for deviation. Please note: Students wishing to substitute Chem 105/106 for Chem 111A/112A should consult Chemistry's Director of Undergraduate Studies (Prof. Richard Mabbs) for details.

Note Regarding "Double Counting". For students pursuing two majors or a major and a minor, no advanced course may be used to simultaneously satisfy both program's minimal requirements (this is called "double-counting"). Should a student's two majors or major and minor require the same course, a departmentally-sanctioned elective must be chosen to replace the course in one of the programs. For any questions regarding double-counting or to gain approval for a departmentally- sanctioned elective, contact Prof. Richard Mabbs (513 McMillen Labs).

Double Major with Teaching Certification. A curriculum has been developed in cooperation with the Department of Education. Students complete the degree requirements for a B.A. in both Chemistry and Education. These students will receive State of Missouri Teaching Certification in Chemistry. The science requirements for this major include completion of the chemistry core sequence of Chem 111A, 112A, 261, and 262 and the two basic labs, Chem 151 and 152; Physics* 191/191L, 192/192L; Math** 131, 132, and 233; Bio 2960. The students are also

* Phys 193 may replace Phys 191, Phys 194 may replace Phys 192, Phys 193L may replace Phys 191L, Phys 194L may replace Phys 192L.
** Math 131E may replace Math 131. Math 203 may replace both Math 131 and 132.

required to take two semesters of Physical Chemistry (Chem 401 and 402), Inorganic Chemistry (Chem 461), Biochemistry (Chem 481), one advanced chemistry laboratory (Chem 358, 435, 445, 462, 470), and one additional elective course in order to complete the minimum of 18 units in advanced courses. The elective may be any 400- or 500-level Chemistry course that counts towards the Major. Chem 490 and 495 are specifically excluded from the double major with teaching certification.

Chemistry Faculty and Their Research

Jonathan Barnes, Associate Professor; Ph.D. Northwestern University, 2014. **Synthetic Organic Chemistry, Polymer Chemistry, Materials Chemistry:** multi-disciplinary approach towards research challenges in the areas of stimuli-responsive materials, combination therapeutics, and porous crystalline materials that serve as a platform for catalysis, chemical separation, and energy storage applications.

Cory Berkland, Professor (joint appointment with McKelvey School of Engineering); Ph.D. University of Illinois, 2003. **Conjugation Chemistry, Synthesis, Biochemistry:** synthesis of pharmaceuticals and biomaterials with a particular emphasis on molecular design, drug formulation, and transport in the human body.

Vladimir B. Birman, Associate Professor; Ph.D. University of Chicago, 2000. **Synthetic Organic Chemistry:** total synthesis of bioactive natural products, rational design of catalysts for asymmetric transformations.

John R. Bleeke, Professor; Ph.D. Cornell University, 1981. **Organometallic Chemistry:** synthesis of transition-metal complexes, particularly those containing pentadienyl and hetero-pentadienyl ligands; development of selective homogeneous catalysts; mechanistic studies of transition-metal-catalyzed reactions; metallabenzenes and other aromatic metallacycles.

Joseph Fournier, Assistant Professor; Ph.D. Yale University, 2015. **Physical Chemistry:** ultrafast spectroscopy, infrared laser spectroscopy, mass spectrometry, cryogenic ion-trapping and processing; reaction dynamics and mechanisms of proton-coupled electron transfer processes and small molecule catalysis.

Michael L. Gross, Professor; Ph.D. Minnesota, 1966. **Analytical Chemistry, Biochemistry:** protein mass spectrometry, proteomics, properties of gas-phase ions, instrument and method development.

Richard W. Gross, Professor (joint appointment with Medical School); M.D. New York University, 1976; Ph.D. Washington University in St. Louis, 1982. **Biophysical Chemistry:** phospholipid dynamics and membrane structure-function relationships, enzyme kinetics of biphase membrane systems.

Sophia E. Hayes, Professor and Vice Dean of Graduate Education in Arts & Sciences; Ph.D. University of California Santa Barbara, 1999. **Inorganic/Materials Chemistry:** application of solid-state NMR to problems in materials science, in particular semiconductors and the photochemistry of organic single crystals and polymers.

Jennifer Heemstra, Charles Allen Thomas Professor and Chair of Chemistry; Ph.D. University of Illinois, 2005. **Chemical Biology, Supramolecular Chemistry:** harnessing the molecular recognition and self-assembly properties of nucleic acids for applications in biosensing and bioimaging.

Dewey Holten, Professor; Ph.D. Washington (Seattle), 1976. **Physical/Biophysical Chemistry:** ultrafast laser spectroscopy, primary electron-transfer processes in photosynthesis, photophysics of tetrapyrrole chromophores and arrays.

Meredith Jackrel, Assistant Professor; Ph.D. Yale University, 2010. **Biological Chemistry:** protein folding, misfolding, and neurodegenerative disease; protein chaperones; protein engineering; amyloid, yeast models of disease; and motor proteins.

Chenfeng Ke, Assistant Professor; Ph.D. Nankai University, 2009. **Organic Chemistry:** Developing smart materials for 3D printing applications, elastic crystalline porous organic materials for energy and environmental related applications, and carbohydrate receptors for biological applications. The research scheme overlaps organic synthesis, crystal engineering, polymer synthesis, materials characterization, and 3D printing, with an emphasis on the design of supramolecular materials that are noncovalently assembled.

Richard A. Loomis, Professor; Ph.D. University of Pennsylvania, 1995. **Physical Chemistry:** probing and controlling of reaction dynamics within small radical- molecule clusters; femtosecond to nanosecond time scale linear and non-linear laser spectroscopy; quantum wave packet dynamics; intramolecular and intermolecular energy redistribution.

Richard Mabbs, Associate Professor and Director of Undergraduate Studies in Chemistry; Ph.D. University of Nottingham, 1995. **Physical Chemistry:** time resolved (fs) photodissociation dynamics and electronic structure evolution in anionic species and clusters; time resolved electron transfer/collision induced dynamics in mass selected, molecular assemblies; solvation effects on electronic structure through photoelectron imaging; photochemistry and photophysics of heteroaromatic compounds.

Kevin D. Moeller, Professor; Ph.D. University of California Santa Barbara, 1985. **Organic Chemistry:** synthetic applications of organic electrochemistry, synthesis of natural products and conformational probes; site-selective synthesis and the use of micro-electrode arrays.

Yusuke Okuno, Assistant Professor; Ph.D. University of Wisconsin at Madison, 2017. **Biophysical Chemistry:** solution-state NMR; protein-ligand/protein-protein interactions; protein hydration; weak non-covalent interactions; neurodegenerative diseases.

Gary J. Patti, Michael and Tana Powell Professor; Ph.D. Washington University in St. Louis, 2008. **Biological Chemistry:** Genetics/Medicine: mass spectrometry, metabolomics and metabolite imaging, profiling of cellular metabolites, isotopic labeling to define metabolism pathways.

Jay Ponder, Professor (joint appointment with Medical School); Ph.D. Harvard University, 1984. **Computational Chemistry, Molecular Mechanics, Organic Chemistry:** application of computational tools to solve problems in structural biology and protein engineering, function, and folding.

Kelly Powderly, Assistant Professor; Ph.D. Princeton, 2022. **Inorganic/Materials Chemistry:** developing kinetically controlled routes to extended solids with quantum properties; assembling magnetic cluster-organic frameworks; synthesizing metastable intermetallics with exotic electronic properties; probing magnetism, superconductivity, and non-trivial topology, topics of interest in quantum information science.

Courtney Reichhardt, Assistant Professor; Ph.D. Stanford, 2016. **Biophysical Chemistry:** solid-state NMR, confocal laser scanning microscopy, electron microscopy, biofilms.

Bryce Sadtler, Associate Professor; Ph.D. University of California Berkeley, 2009. **Inorganic/Materials Chemistry:** understanding how hierarchical structure of materials from the atomic level to nano- and meso-scale can be used to control their physical properties and chemical reactivity; chemical synthesis of inorganic materials; development of functional materials for solar energy conversion, photonics, and catalysis.

Lee G. Sobotka, Professor; Ph.D. University of California Berkeley, 1982. **Nuclear Chemistry:** correlations in many-body fermion systems; light- and heavy-ion reaction dynamics; fission and fission-like phenomena; collective nuclear motion; nuclear level densities; structure and decay of nuclei far removed from beta stability; development of novel detectors and electronics for ionizing radiation.

John-Stephen A. Taylor, Professor; Ph.D. Columbia University, 1981. **Bioorganic Chemistry:** design and synthesis of conformation and structure- specific DNA probes and drugs; synthesis and structure-activity relationships of premutagenic DNA lesions; protein engineering.

Timothy Wencewicz, Associate Professor and Director of Graduate Studies in Chemistry; Ph.D. University of Notre Dame, 2011. **Bioorganic Chemistry:** development of new antibiotic therapeutics, elucidation of mechanisms of biosynthetic enzymes involved in natural product antibiotics, targeted drug delivery across bacterial membranes.

Robert Wexler, Assistant Professor; Ph.D. University of Pennsylvania, 2019. **Theoretical/Physical Chemistry:** sustainable energy and environmental remediation, computational and theoretical materials chemistry, data science and machine learning, water splitting, CO2 utilization, solar energy conversion, environmental energy harvesting.

Chemistry Major Checklist

For students who entered as a 1st Year Fall 2016 or later.

Requirement	Regular	Regular with Latin Honors Eligibility	Biochemistry	Biochemistry with Latin Honors Eligibility
C461	3	3	3	3
C401 and C402	6	6	6	6
C481	****	****	3	3
C482	****	****	3	3
C ≥ 300 or B451*	6	6	****	****
Advanced Lab C358/C462/C470/ C435/C445	3 or 4	****	****	****
Synthesis-based Lab C358/C462/C470	****	3 or 4	****	****
Physical-based Lab C435 or C445	****	3	****	****
Advanced Lab C358/C462/C470/C435/ C445 OR B4522/B4523	****	****	3 or 4	3 or 4
Adv. Biochem. Course C410/C453/C464/C475/ C483/C485/C510 OR B334/B349 OR Adv. Lab (listed above)	****	****	****	3 or 4
minimum units	18	21	18	21

*Students counting either/or Chem 481/482 cannot use Biol 451 to fulfill an elective requirement

**** not applicable; C = Chemistry; B = Biology