Professor: Daniel Burgard *(on leave 2021–22)*; Johanna Crane, *Chair*; Jeffrey Grinstead *(on leave 2021–22)*; John Hanson; Amanda Mifflin; Steven Neshyba; Eric Scharrer

Associate Professor: Luc Boisvert; Megan Gessel

Assistant Professor: Emily Tollefson

Visiting Assistant Professor: Stacia Rink

Visiting Instructor: Jill McCourt

About the Department

The Chemistry Department offers a broad-based curriculum designed to meet the needs of a variety of students, from those taking only one or two chemistry courses in order to broaden their liberal arts background to those majoring in chemistry in preparation for a career in the chemical sciences. The department is approved by the American Chemical Society and offers degrees that are appropriate for students interested in careers in chemistry, medicine, dentistry, engineering, science teaching, or any other area where a scientific background would be valuable. Students are encouraged to consult with members of the department as they plan their undergraduate programs and to discuss career options in the sciences.

The expertise of the chemistry faculty covers all five major chemical sub-disciplines: analytical chemistry, biochemistry, inorganic chemistry, organic chemistry, and physical chemistry. In addition to core courses in these major areas, faculty members teach upper-level courses on a variety of special topics including atmospheric chemistry, computational chemistry, materials chemistry, organic synthesis, and environmental chemistry. Faculty members are also engaged in a wide range of research projects and all students seeking the BS degree participate in this research and produce a thesis based on their work.

In addition to being introduced to modern chemical knowledge and the role of chemistry in society, students in chemistry courses learn to think analytically and logically. As students move through upper-level courses, they develop the ability to critically assess work in the field and the attitude necessary to cope with the demands of independent inquiry.

Students completing a chemistry degree are able to:

1. rationalize and predict chemical behavior based on chemical principles;
2. apply laboratory methods to investigate chemical phenomena and synthesize compounds in a safe and environmentally responsible manner;
3. operate modern analytical instruments and interpret the data obtained from these instruments;
4. use computers for collection and analysis of chemical data and the modeling and visualization of chemical structures and properties;
5. communicate effectively in both written and oral forms typical of the chemical literature and professional conferences;
6. search and use the chemical literature.

General Requirements for degrees in Chemistry and Biochemistry

The Chemistry and Biochemistry degrees offered at Puget Sound have much in common. Both are rooted in fundamentals of chemistry that include chemical thermodynamics and atomic structure, chemical analysis, organic chemistry, and laboratory techniques. Both degrees provide students the opportunity to study advanced topics in chemistry. The Biochemistry degree emphasizes the chemical basis of biological systems, with students developing skills in interdisciplinary inquiry that include cell biology, genetics, and biochemical laboratory techniques. In contrast, the Chemistry degree places more emphasis on advanced instrumental analysis, quantum mechanics, spectroscopy, and inorganic chemistry.

General Requirements for the Major or Minor

General university degree requirements stipulate that 1) at least four units of the major or three units of the minor be taken in residence at Puget Sound; 2) students earn a GPA of 2.0 in courses taken for the major or the minor; and 3) all courses taken for a major or minor must be taken for graded credit. Any exceptions to these stipulations are indicated in the major and minor degree requirements listed below.

Requirements for Bachelor of Arts Degree in Chemistry

1. PHYS 121, 122;
2. MATH 180, 181, 280;
3. CHEM 115, 230; or CHEM 110, 120, 231;
4. CHEM 250, 251, 340, 341, 420;
5. One-half unit Chemistry elective at the 300 or 400 level;
6. Participation in CHEM 493, Seminar.

Requirements for Bachelor of Science Degree in Chemistry

1. PHYS 121, 122;
2. MATH 180, 181, 280;
3. CHEM 115, 230; or CHEM 110, 120, 231;
4. CHEM 250, 251, 330, 340, 341, 420, 490 (1 unit);
5. One-half unit Chemistry elective at the 300 or 400 level;
6. Participation in CHEM 493, Seminar.

Requirements for Bachelor of Science Degree in Biochemistry

1. PHYS 121, 122
2. MATH 180, 181, 280
3. CHEM 115, 230; or CHEM 110, 120, 231;
4. CHEM 250, 251, 340, 460, 461;
5. BIO 111, 212, 213;
6. One of CHEM 330, 341 or 420;
7. One unit of a 300- or 400-level CHEM or BIOL elective (BIOL 361 may not be used to satisfy this requirement).

Requirements for the Minor

1. CHEM 115, 230; or CHEM 110, 120, 231;
2. CHEM 250;
3. Two units of Chemistry electives numbered 251 or above.

Notes

1. The student must earn a grade of C or higher in all courses for the major or minor.
2. Students wishing to obtain an American Chemical Society certified degree should complete the BS requirements, and depending on the major should do the following. 1) Chemistry majors should include CHEM 460 as an elective, or 2) Biochemistry majors should consult with a faculty member in the department and have their plan for certification approved in advance by the Chemistry Department Chair.
3. The Chemistry Department reserves the right to determine a time limit, on an individual basis, for the acceptability of courses into a major or minor program.
4. Majors in Biochemistry are encouraged to participate in undergrad-

uate research in the Chemistry or Biology Departments.
5. Biochemistry majors may not earn additional majors in Chemistry or in Molecular and Cellular Biology.
6. BS Chemistry majors may not use CHEM 390 to fulfill the chemistry elective requirement.

Course Offerings

Unless otherwise specified, each course carries 1 unit of credit and is offered at least once each academic year. Please see "Frequency of Course Offerings" on page 18.

Chemistry (CHEM)

105 Chemistry in a Changing Climate In this introductory chemistry course, students learn and apply fundamental chemical modes of analysis to challenges presented by a changing climate. Modes of analysis include acid/base and buffer chemistry, oxidation/reduction reactions and the thermodynamics of combustion, principles underlying electrochemistry, and spectroscopy relevant to the greenhouse effect and photochemical reactions. *CHEM 105 will prepare students to complete either first-year chemistry sequence of CHEM 110 and 120, or 115 and 230. Prerequisite: Students who have already earned credit for CHEM 110 or 115 may not later earn credit for CHEM 105. Satisfies the Natural Scientific Approaches core requirement.*

110 General Chemistry I A two-semester, introductory course designed to give solid introduction to chemical principles while demonstrating the many roles chemistry plays in modern society. The laboratories emphasize reasoning and the methods of science. The first semester emphasizes matter and energy and covers the topics of subatomic structure, atomic structure, molecular structures, and states of matter. The second semester emphasizes molecular dynamics and covers reaction rates, equilibria, stoichiometry, acids-bases, oxidation-reduction, electrochemistry, and aspects of organic chemistry and biochemistry. *Prerequisite: Credit for CHEM 110 will not be granted to students who have received credit for CHEM 115. Satisfies the Natural Scientific core requirement. Offered fall semester.*

115 Integrated Chemical Principles and Analytical Chemistry An accelerated track designed for well-prepared students, particularly those planning to major in the molecular sciences (chemistry, biochemistry, molecular and cellular biology). The first semester topics include nuclear chemistry, atomic structure, stoichiometry, bonding, intermolecular forces and phase changes, reactions, gases, inorganic chemistry, thermochemistry, thermodynamics, and kinetics. The second semester topics emphasize quantitative chemical analysis, advanced equilibria, acids and bases, buffers, electrochemistry, and separation techniques. *Prerequisite: Successful completion of a rigorous high school chemistry program in the junior or senior year. Credit for CHEM 115 will not be granted to students who have received credit for CHEM 110. Satisfies the Natural Scientific core requirement. Offered fall semester.*

120 General Chemistry II A two-semester, introductory course designed to give a solid introduction to chemical principles. The first semester covers topics of atomic structure, stoichiometry, thermochemistry, atomic theory, bonding, intermolecular forces, phase changes, introduction to reactions, gases, and thermodynamics. Second semester topics include equilibria, kinetics, acids and bases, buffers, oxidation-reductions, electrochemistry, and aspects of inorganic chemistry, organic chemistry, and biochemistry. *Prerequisite: CHEM 110. Credit for CHEM 120 will not be granted to students who have received credit for CHEM 230. Satisfies the Natural Scientific Approaches core requirement. Offered spring semester.*

230 Integrated Chemical Principles and Analytical Chemistry An accelerated track designed for well-prepared students, particularly those planning to major in the molecular sciences (chemistry, biochemistry, molecular and cellular biology). The first semester topics include nuclear chemistry, atomic structure, stoichiometry, bonding, intermolecular forces and phase changes, reactions, gases, inorganic chemistry, thermochemistry, thermodynamics, and kinetics. The second semester topics emphasize quantitative chemical analysis, advanced equilibria, acids and bases, buffers, electrochemistry, and separation techniques. *Prerequisite: CHEM 115 or permission of instructor. Credit for CHEM 230 will not be granted to students who have received credit for CHEM 120 or 231. Satisfies the Natural Scientific Approaches core requirement. Offered spring semester.*

231 Analytic Methods 0.50 units. This course is designed for students who have previously taken a one-year course in introductory chemistry (CHEM 110/120 or equivalent) but who have not had a detailed introduction to quantitative chemical analysis. Topics include the statistical treatment of data, the use of standards, advanced equilibria, and separation techniques. *This course is exempt from the tuition overload policy. Prerequisite: CHEM 120 or permission of instructor. Credit will not be granted to students who have completed CHEM 230. Offered spring semester.*

250 Organic Chemistry I This course covers the basic chemistry of carbon-containing molecules. Modern principles of chemical bonding are used to develop an understanding of the structure of organic molecules and the reactivity of organic compounds. Thus, the course is organized along the lines of reaction mechanisms rather than by functional groups. The laboratory portion of the course introduces the student to the various techniques involved in the isolation, identification, and synthesis of organic compounds. The laboratory parallels the course lectures so that there is a practical application of theoretical principles. Extensive use is made of chromatographic and spectroscopic techniques. *Prerequisite: CHEM 120 or 230 or equivalent. Satisfies the Natural Scientific core requirement. Offered fall semester.*

251 Organic Chemistry II This course covers the basic chemistry of carbon-containing molecules. Modern principles of chemical bonding are used to develop an understanding of the structure of organic molecules and the reactivity of organic compounds. Thus, the course is organized along the lines of reaction mechanisms rather than by functional groups. The laboratory portion of the course introduces the student to the various techniques involved in the isolation, identification, and synthesis of organic compounds. The laboratory parallels the course lectures so that there is a practical application of theoretical principles. Extensive use is made of chromatographic and spectroscopic techniques. *Prerequisite: CHEM 250. Satisfies the Natural Scientific Approaches core requirement. Offered spring semester.*

320 Chemistry of the Elements This course focuses on the elements and their organization into the periodic table. Students examine the origin of the elements, the periodic and group relationships, and the role of the elements and their compounds in medicine, materials, and society. Much of the course material is directly drawn from the scientific literature. *Prerequisite: CHEM 251. Offered occasionally.*

330 Instrumental Analysis Introduction to basic theory and applications of modern instrumental methods of analysis. Includes an introduction to electronics, x-ray, ultraviolet, visible, infrared, Raman, mass, and nuclear magnetic resonance spectrometry; atomic absorption and plasma emission; chromatography, thermal, and electrochemical methods. *Prerequisite: CHEM 230 or 231, and PHYS 122. CHEM 251 is strongly recommended. Offered fall semester.*

333 Environmental Analytical Chemistry The course emphasizes the analytical process in making environmental chemistry measurements. An overview of methods used for the chemical analysis of air, soil, and water will be covered. Special attention is given to sampling, quality assurance, spectroscopic measurements and chromatographic separations with mass spectral determination. This course builds on the analysis techniques presented in the prerequisite courses and applies them to the specific challenges when dealing with complex environmental systems. This course has a laboratory component to give hands on experience to illustrate some of these analytical challenges. The lab meets during the regularly scheduled course periods. This class has field trips to local and state laboratories and environmental facilities. *Prerequisite: CHEM 230 or 231, and 250. Offered occasionally.*

338 Biochemical Analysis This course introduces analytical techniques and instrumental methods that are commonly used to character biological systems. Techniques surveyed may include chromatography, mass spectrometry, X-ray diffraction, NMR, circular dichroism, fluorescence spectroscopy, and molecular dynamics simulations. The course focuses on applications of these methods to a specific system or research area, which may vary from year to year, e.g. lipid membrane, toxicology, proteomics, etc. *This course does not require but is complimentary to CHEM 330 and CHEM 460. Prerequisite: CHEM 250 and CHEM 230 or 231 or permission of instructor. Offered occasionally.*

340 Physical Chemistry I Chemical thermodynamics and its applications to macroscopic systems. Analysis of microscopic properties of atoms and molecules using kinetic molecular theory with emphasis on Maxwell-Boltzmann distribution functions. *Prerequisite: CHEM 230 or 231, MATH 181, PHYS 121. MATH 280 is strongly recommended. Offered fall semester.*

341 Physical Chemistry II Introduction to quantum mechanics with applications to molecular spectroscopy. Statistical thermodynamics linking microscopic and macroscopic chemical behavior. Laboratory experiments emphasize fundamental instrumentation and theory associated with physical chemistry. *Prerequisite: CHEM 230 or 231, MATH 280. Offered spring semester.*

345 Chemistry and Physics of Atmospheres The main work of the course is to understand the Earth's atmosphere from the perspective of physical chemistry. Tools include the use of thermodynamics to understand global atmospheric circulation, and quantum mechanics to interpret the spectra of atmospheric gases and aerosols. Applications include the interpretation of remote sensing data, with a focus on selected topics in the Earth climate system, including anthropogenic influences. The course concludes with a brief survey of other planetary atmospheres and atmospheric evolution. *Prerequisite: CHEM 230 or 231, MATH 181. CHEM 340 is strongly recommended. Offered occasionally.*

347 The Devil's Playground: the Chemistry of Surfaces Surfaces play an important role in our lives. Enzymatic reactions at biological interfaces, heterogeneous catalysis, transport of contaminants in soils, and atmospheric aerosol chemistry are all controlled by interactions at surfaces. This course explores the physical and chemical phenomena that occur between the three states of matter-solid, liquid, and gas. Particular emphasis is placed on interactions with solid surfaces. Topics include, but are not limited to, reactions on surfaces, kinetics of surface reactions, binding of molecules to surfaces, and techniques of surface analysis. The importance of surface phenomena to environmental and catalytic chemistry is discussed. *Prerequisite: CHEM 251; recommended co-requisite of CHEM 340. Offered occasionally.*

356 Organic Synthesis This course explores methods and strategies that are used in the analysis and synthesis of moderately complex organic molecules. The first part of the course focuses on the use of advanced spectroscopic techniques (with a particular emphasis on 2D NMR techniques) in structure determination. The second part of the course focuses on the use of modern synthetic methods in organic synthesis, with emphasis on the formation of carbon-carbon bonds and the control of stereochemistry. These methods are applied to the synthesis of natural products through application of retrosynthetic analysis. *Prerequisite: CHEM 251. Offered occasionally.*

357 Organometallic Chemistry This course focuses on the fundamental reactivity of organotransition metal complexes. Topics include oxidative addition, reductive elimination, and the unique behavior of compounds possessing metal-carbon bonds. Applications of organometallic chemistry to industrial catalysis and organic synthesis are also discussed. *Prerequisite: CHEM 251. Offered occasionally.*

363 Materials Chemistry This course emphasizes the synthesis, characterization, and properties of organic materials. In particular, the focus is on the impact of structural changes upon macroscopic properties (mechanical strength, optical behavior, etc.). The first part of the course focuses on polymer science and draws heavily on students' knowledge of synthetic and mechanistic organic chemistry. The second part of the course emphasizes liquid crystals and other related materials. Specific applications of materials to areas such as microlithography (patterning of computer chips), liquid crystal displays, and drug delivery are discussed, with many examples coming from the primary literature. *Prerequisite: CHEM 251. Offered occasionally.*

371 The Chemistry of Food This course explores the science of food and cooking. Topics include flavor, physical properties, nutrition, cooking methods, and reactions. In-class demonstrations and hands-on experiments allow for a tactile and sensory experience. Modern issues in food are discussed, including organic farms, GMO food, and the science behind recent dietary fads. Optional field trips occur throughout the semester. *Prerequisite: CHEM 230/231 and CHEM 251, and instructor permission. Offered occasionally.*

377 Biomolecular Interactions The course emphasizes intermolecular interactions of biological macromolecules such as proteins with other molecules. The first part of the course addresses fundamental chemical concepts underlying these types of noncovalent interactions, description of various protein complexes, and a hands-on application of molecular docking protocols to calculate structures of complexes using data from the biochemical literature. The second part of the course focuses on student independent projects utilizing protein structures and data from the literature. Molecular docking is used as a tool to test predictions about the wider biological implications of altering biomolecular interactions. *Prerequisite: CHEM 251, 460 is preferred, or permission of the instructor. Offered occasionally.*

390 Directed Research Variable credit up to 1.00 unit. Theoretical or experimental research done in an area of chemistry, with guidance from a mentor in the Chemistry department. *Prerequisite: A research contract must be completed prior to registration. May be repeated for credit up to 2.00 units. Cannot be audited. Cannot be taken Credit/No Credit.*

405 Frontiers in Atmospheric Chemistry Seminar Series 0.25 units. In conjunction with a planned cross-institutional virtual speaker series, which will feature weekly seminars spanning the cutting-edge topics in atmospheric chemistry research, students in this course will meet weekly to discuss a paper from the primary literature related to the sem-

inar. The course will deepen students' understanding of the frontiers of atmospheric chemistry, while we learn to evaluate scholarship, pose questions, and participate in scientific discourse. Students will also have opportunities to meet and network with undergraduates and graduate students around the United States with interests in atmospheric chemistry. *Prerequisite: CHEM 110/120/231 or 115/230, and 250, or permission of instructor. Pass/Fail Required. Offered spring semester.*

420 Advanced Inorganic Chemistry This course presents both theoretical and descriptive concepts related to inorganic chemical compounds including periodic relationships, structure and bonding, molecular symmetry, acid base chemistry, electrochemistry, and inorganic reaction mechanisms. Laboratory experiments illustrate common synthetic and characterization processes for inorganic compounds. These concepts and techniques are brought together through the topics of coordination chemistry, organometallic chemistry, bioinorganic chemistry, and solid state chemistry. *Prerequisite: MATH 181 or MATH 280, CHEM 230 or 231, CHEM 340, PHYS 122. Offered occasionally.*

455 Computational Organic Chemistry This course uses computer-based molecular modeling as a tool for understanding and predicting the structure, stability, and reactivity of organic compounds. Practical topics, such as selecting appropriate calculational methods, visualizing and analyzing results of calculations, and interpreting results in terms of the chemical behavior of the system under study are emphasized. The theoretical principles underlying various computational methods are discussed. *Prerequisite: CHEM 251. Offered occasionally.*

460 Physical Biochemistry This course applies concepts of physical chemistry to the study of biological processes. The topics covered include protein and nucleic structure and stability, thermodynamics of protein folding, enzyme kinetics and instrumental techniques such x-ray crystallography, NMR and mass spectrometry. *Prerequisite: CHEM 230 or 231, CHEM 251, and permission of the instructor. Offered fall semester.*

461 Metabolic Biochemistry This course explores the chemistry of various metabolic processes including glycolysis, citric acid cycle, oxidative phosphorylation, electron transport, fatty acid and amino acid synthesis and degradation, DNA synthesis, RNA synthesis and processing, and protein synthesis and processing. Particular attention is paid to the experimental approaches that have provided information about these processes. *Prerequisite: CHEM 460 and BIOL 361 redundant. Offered spring semester.*

465 Chemical Biology This course explores how modern chemical and biochemical strategies are used to interrogate and manipulate biological systems. The course will focus on selected, recent developments in the field as described in review articles and the primary literature. Themes include modifying and expanding the genetic code, screening and selection of chemical and biological libraries, directed evolution and rational design in the production of new protein activities, molecular imaging and probes for spatial and temporal localization of biological activity, modification of biological systems to produce new products or new activities, and design and use of novel molecular effectors of biological systems. In addition to examining the science of chemical biology, the course will also explore the commercialization of chemical biology and the background and influence of key individuals involved in developing this hybrid discipline. The course will emphasize process, with students directly engaging with primary sources, collaboratively analyzing and discussing information obtained from those sources, selecting and investigating topics in chemical biology that interest them, presenting the results of their investigations to their peers, and reflecting upon the scientific, commercial, and social impacts of modern chemical biology. *Cross-listed as BIOL/CHEM 465 Cross-listed as BIOL/CHEM 465. Prerequisite: CHEM 251 and either BIOL 212 OR 213. Instructor permission required. Cannot be audited. Offered occasionally.*

490 Senior Research Thesis Variable credit up to 1.00 unit. Theoretical and/or experimental research done in an area of chemistry over two semesters (~150 research hours). The topic depends upon the student's interest: however, it should be compatible with a faculty member's area of expertise. Students must write and orally defend a thesis. In special cases, a student may register for 0.5 unit for each of two semesters. *Prerequisite: Senior standing, although students at all levels are considered individually; a research contract must be completed prior to registration. May be repeated for credit up to 1.00 unit. Cannot be audited. Cannot be taken Credit/No Credit.*

493 Seminar No credit. This course offers the student the opportunity to hear guest speakers discuss a variety of subjects within the general discipline of chemistry. *Pass/Fail Required.*

495/496 Independent Study Variable credit up to 1.00 unit. Independent study is available to those students who wish to continue their learning in an area after completing the regularly offered courses in that area. *May be repeated for credit up to 4.00 units. Cannot be audited. Cannot be taken Credit/No Credit.*

498 Internship Seminar Variable credit up to 1.00 unit. This scheduled weekly interdisciplinary seminar provides the context to reflect on concrete experiences at an off-campus internship site and to link these experiences to academic study relating to the political, psychological, social, economic and intellectual forces that shape our views on work and its meaning. The aim is to integrate study in the liberal arts with issues and themes surrounding the pursuit of a creative, productive, and satisfying professional life. Students receive 1.0 unit of academic credit for the academic work that augments their concurrent internship fieldwork. This course is not applicable to the Upper-Division Graduation Requirement. Only 1.0 unit may be assigned to an individual internship and no more than 2.0 units of internship credit, or internship credit in combination with co-operative education credit, may be applied to an undergraduate degree. *Prerequisite: Junior or senior standing, 2.5 GPA, ability to complete 120 hours at internship site, approval of the CES internship coordinator, and completion of learning agreement. May be repeated for credit up to 2.00 units. Cannot be audited. Cannot be taken Credit/No Credit.*