

Chemistry and Biochemistry

Yong Cai, *Professor and Chairperson*
Irina Agoulnik, *Associate Professor, College of Medicine*
Jose R. Almirall, *Professor*
David A. Becker, *Associate Professor*
John Berry, *Associate Professor*
Konstantin Bukhryakov, *Assistant Professor*
Justin Carmel, *Assistant Professor*
Mrinal Chakraborty, *Assistant Teaching Professor*
David C. Chatfield, *Professor*
Christopher J. Dares, *Assistant Professor*
Anthony P. DeCaprio, *Associate Professor and Director of Forensic Science Certificate Program Chemistry and Biochemistry*
Lauryn DeGreeff-Silk, *Associate Professor*
Milagros Delgado, *Teaching Professor and Coordinator of Laboratories at BBC and Chemistry, Undergraduate Program Director*
Francisco Fernandez-Lima, *Professor and Director of the Advanced Mass Spectrometry Facility*
Kenneth G. Furton, *Professor, Executive Director, Global Forensic and Justice Center, FIU Chief Scientific Officer and Provost Emeritus Designee*
Piero R. Gardinali, *Professor and Director of SERC*
Megan Gillespie, *Assistant Teaching Professor*
Palmer Graves, *Professor Emeritus*
John Hackett, *Professor*
Rudolf Jaffe, *Professor Emeritus*
Jeffrey A. Joens, *Professor*
Konstantinos Kavallieratos, *Professor*
Elwood Kwong-Lam, *Assistant Teaching Professor*
John T. Landrum, *Professor Emeritus*
Watson J. Lees, *Associate Professor and Biochemistry Undergraduate Program Director*
Fenfei Leng, *Professor*
Chenzhong Li, *Professor, Department of Biomedical Engineering*
Joseph Lichter, *Associate Teaching Professor and Director of Pre-Health Professional Advising*
Yuan Liu, *Associate Professor and Biochemistry Graduate Program Director*
Ramon Lopez de la Vega, *Associate Professor and Associate Chair*
Bruce R. McCord, *Professor*
Alexander M. Mebel, *Professor*
Jaroslava Miksovská, *Associate Professor*
Robert Miller, *Assistant Teaching Professor*
Joong-ho Moon, *Professor*
Zaida Morales-Martinez, *Professor Emerita*
Kevin E. O'Shea, *Professor*
Natalia Soares Quinete, *Assistant Professor*
J. Martin E. Quirke, *Professor*
Raphael Raptis, *Professor*
Kathleen S. Rein, *Professor and Chemistry Graduate Program Director*
Barry P. Rosen, *Professor, College of Medicine*
Sandra Stojanovic, *Associate Teaching Professor and Coordinator of Organic Chemistry Laboratories*
Uma Swamy, *Teaching Professor and Coordinator of General Chemistry Laboratories*
Yuk-Ching Tse-Dinh, *Distinguished University Professor, Director, Biomolecular Sciences Institute*
Sonia M. Underwood, *Assistant Professor*
Xiaotang Wang, *Associate Professor*

Stephen Winkle, *Associate Professor*
Stanislaw F. Wnuk, *Professor and Associate Dean for Graduate Education, Robert Stempel School of Public Health*

Graduate Admission Requirements

1. A minimum undergraduate grade point average (GPA) of 3.0/4.0 in chemistry and cognate science courses and submission of official GRE scores are required. International graduate student applicants whose native language is not English are required to submit a score for the Test of English as a Foreign Language (TOEFL) or for the International English Language Testing System (IELTS). A total score of 80 on the iBT TOEFL or 6.5 overall on the IELTS is required.
2. Applicants must send a statement of purpose and arrange to have sent transcripts and three letters of recommendation evaluating the applicant's potential for graduate work. Originals of these items must be sent to the FIU Admissions office as specified at <https://admissions.fiu.edu/how-to-apply/graduate-applicant/index.html>. Prospective candidates should refer to both the above website and <http://casgroup.fiu.edu/chemistry/> for details regarding the application procedure, Which must be completed on-line.
3. Formal admission to the M.S. and Ph.D. programs is granted by the Admissions Office. Awards of teaching assistantships are granted by the Graduate Program Director. Entrance is possible at the beginning of each semester (fall, spring, summer). For consideration for a graduate assistantship applicants need to apply for the Fall semester and all application materials should be received at least five months prior to the desired starting date.
4. Students whose undergraduate degree is not equivalent to the American Chemical Society certified Bachelor of Science degree in chemistry may be required to make up deficiencies. For example, depending on his or her area of specialization, a student may be required to make up deficiencies in quantum mechanics, instrumental analysis, or biochemistry by successfully completing Graduate Physical Chemistry II (CHM 5426), Graduate Analytical Methods (CHM 5150), or Graduate Biological Chemistry (CHM 5305) respectively.
5. Entering graduate students must pass two proficiency exams. Proficiencies are offered in organic, physical, inorganic, analytical, and biochemistry. One pass must be in either organic or physical chemistry; the other is open. The proficiency exams will be administered to incoming graduate students in the week before the fall and spring semesters. If a student fails to receive a pass in a proficiency exam, he or she must show proficiency by completing the appropriate course with a grade of "B" (3.0/4.0) or better. These courses are Graduate Organic Chemistry (CHM 5225), Graduate Physical Chemistry (CHM 5425), Graduate Analytical Methods (CHM 5150), and Graduate Biological Chemistry (CHM 5305). Students are expected to complete proficiency requirements by the end of their first semester.
6. Graduate students must maintain a GPA of 3.0/4.0. Only courses applicable to the graduate program,

excluding those for making up deficiencies or satisfying proficiencies, are counted in the GPA. If the cumulative GPA drops below 3.0 for one semester, the student will be placed on academic probation. A student who fails to raise his or her GPA to 3.0 or higher within one semester will be dismissed from the program.

7. Full-time graduate students generally serve as Teaching Assistants (TA's) in the Department of Chemistry and Biochemistry for their first semester. Ph.D. candidates must serve as TA's for at least one year except in unusual circumstances. TA's are awarded on a competitive basis, require a minimum cumulative GPA of 3.0, and can be continued for up to four years for Ph.D. students who maintain acceptable academic performance. A limited number of Graduate Research Assistantships (RA's) may be available.

Transfer of Credits and Financial Support

Transfer of credits. Students having an M.S. in chemistry may transfer as many as 36 credits towards their Ph.D. degree. However, no more than six of those credits will count toward fulfillment of the formal course work requirement. More than six credits for formal course work can be transferred only with special permission of the Graduate Committee, in which case the number of additional course work credits required will depend on the student's performance in courses, the date courses were completed, and the area of Ph.D. concentration.

Financial Support. Full-time graduate students in good academic standing are eligible for financial support. Teaching and research assistantships are available on a competitive basis. Inquiries concerning application to the program and availability of financial support should be directed to the Chemistry Graduate Program Director.

Master of Science in Chemistry

Degree Requirements

- A minimum of 32 credits of course work. A grade of "C" or higher must be obtained in all courses, and a cumulative grade point average of 3.0 or higher which must be maintained. The course work must include:
 - At least nine credits of chemistry in at least two of the six major areas of chemistry (Analytical, Biochemistry, Environmental, Inorganic, Organic, and Physical) from the core listed below:

Core Courses (three credits each)

Analytical

CHM 5138	Advanced Mass Spectrometry
CHM 5156	Advanced Chromatography
CHM 5165	Chemometrics and Sampling
CHM 6157	Advanced Analytical Chemistry

Biochemistry

BCH 6108	Biochemical Techniques
CHM 6036	Advanced Biochemistry I
CHM 6037	Advanced Biochemistry II (Molecular Genetics)
CHM 5506	Physical Biochemistry

Environmental

CHM 5423	Atmospheric Chemistry
CHM 5765	Aquatic Chemistry

CHM 6281	Environmental Organic Chemistry
CHM 6340	Organic Geochemistry
OCC 5050	Chemical Oceanography
CHM 6088	Environmental Chemistry of Trace Elements

Inorganic

CHM 5251	Organometallic Chemistry
CHM 5440	Kinetics and Catalysis
CHM 5540	Group Theory in Chemistry
CHM 5650	Physical Inorganic Chemistry

Organic

CHM 5236	Spectroscopic Techniques and Structure Elucidation
CHM 5250	Organic Synthesis
CHM 5263	Physical Organic Chemistry

Physical

CHM 5423	Atmospheric Chemistry
CHM 5490	Physical Spectroscopy
CHM 5540	Group Theory in Chemistry
CHM 5586	Computational Chemistry
CHM 6461	Statistical Thermodynamics
CHM 6480	Quantum Mechanics

Courses not listed above may be counted as core course with prior departmental approval.

- At least six credits of additional graduate-level courses approved by the thesis committee in consultation with the Graduate Program Director with the following guidelines:
 - The courses must be 5000 or 6000 level chemistry courses (CHM prefix) or approved cognates (up to a maximum of six credits).
 - The following do not count toward satisfaction of this requirement: proficiency courses and courses taken to make up for undergraduate-level deficiencies in chemistry (including CHM 5150, CHM 5225, CHM 5305, CHM 5425, and CHM 5426); and courses corresponding to research, seminar, colloquium, supervised teaching, and thesis completion (CHM 6910L, CHM 6935, CHM 6936, CHM 6940, CHM 6970, and CHM 6971).
 - Full-time graduate students are required to register for one credit of CHM 6940 (Supervised Teaching) each semester they serve as teaching assistants.
 - Full-time graduate students are required to register for one credit of CHM 6935 (Graduate Seminar) or one credit of CHM 6936 (Chemistry Colloquium) each fall and spring semester.
 - At least one credit of CHM 6936 (Chemistry Colloquium) is required. Each student must present a seminar on their proposed research at the colloquium for a letter grade in their second semester of graduate study.
 - At least eight credits of CHM 6970 (Thesis Research) involving independent thesis research under the direction of a faculty member in the Department.
 - At least two credits of CHM 6971 (Thesis) taken in the semester in which the M.S. thesis is to be defended.
- Satisfactory public presentation and defense of a research thesis, evaluated by the student's Thesis

Committee. The Thesis Committee will consist of the research advisor and a randomly-assigned committee member appointed by the Graduate Program Director, both from the Department's graduate faculty, and one additional member with expertise in the student's research area. At least one committee member must be tenured in the Department. The Committee may include more members, but they will be non-voting.

Master of Science in Chemistry with Report Option Degree Requirements

1. A minimum of 32 credits of course work. A grade of "C" or higher must be obtained in all courses, and a cumulative grade point average of 3.0 or higher which must be maintained. The course work must include:
 - a) At least nine credits of graduate-level CHM courses as core courses with the following requirements:
 - i. The courses must be 5000 or 6000 level CHM courses.
 - ii. The following do not count toward satisfaction of this requirement: proficiency courses and courses taken to make up for undergraduate-level deficiencies in chemistry (including CHM 5150, CHM 5225, CHM 5305, CHM 5425, and CHM 5426); and courses corresponding to research, seminar, colloquium, supervised teaching, and thesis completion (CHM 6910L, CHM 6935, CHM 6936, CHM 6940, CHM 6970, and CHM 6971).
 - b) At least nine credits of additional graduate-level courses approved by the student's committee in consultation with the Graduate Program Director with the following guidelines:
 - i. The courses must be 5000 or 6000 level chemistry courses or approved cognates.
 - ii. The following do not count toward satisfaction of this requirement: proficiency courses and courses taken to make up for undergraduate-level deficiencies in chemistry (including CHM 5150, CHM 5225, CHM 5305, CHM 5425, and CHM 5426); and courses corresponding to research seminar, colloquium, supervised teaching, and thesis completion (CHM 6910L, CHM 6935, CHM 6936, BCH 7930, CHM 6940, CHM 6970, and CHM 6971).
 - c) Full-time graduate students are required to register for one credit of CHM 6940 (Supervised Teaching) each semester they serve as teaching assistants.
 - d) Full-time graduate students are required to register for one credit of CHM 6935 (Graduate Seminar) or one credit of CHM 6936 (Chemistry Colloquium) each fall and spring semester.
 - e) At least one credit of CHM 6936 (Chemistry Colloquium) is required. Each student must present a seminar on their proposed research at the colloquium for a letter grade.
 - f) At least eight credits of CHM 6970 (Thesis Research) or CHM 7910 (Dissertation Research) involving independent research under the direction of a faculty member in the Department.
2. Satisfactory completion of a research report approved by the student's thesis/dissertation committee and the department's graduate program director. A submitted

manuscript, a report written for the candidacy exam, or a stand-alone research report could satisfy the report requirement.

Combined BS/MS in Chemistry Degree Pathway

To be considered for admission to the combined bachelor's/master's degree pathway, students must have completed at least 75 credits in the bachelor's degree program at FIU and meet the admissions criteria for the graduate degree program to which they are applying. Students need only apply once to the combined degree pathway; the application is submitted to Graduate Admissions typically before the student starts the last 30 credits of the bachelor's degree program. A student admitted to the combined degree pathway will be considered to have undergraduate status until the student applies for graduation from their bachelor's degree program. Upon conferral of the bachelor's degree, the student will be granted graduate status and be eligible for graduate assistantships. Only 5000-level or higher courses, and no more than the number of credits specified by the program catalog, may be applied toward both degrees.

Admission Requirements

1. Current enrollment in the Bachelor of Science program in chemistry at FIU.
2. Current GPA of 3.2 or higher.
3. Official GRE general test scores.
4. Three letters of recommendation.
5. Approval of the Chemistry Graduate Committee.

Completion Requirements

Completed Bachelor of Science degree in chemistry at FIU Required:

1. 9 credits (3 courses) selected from graduate chemistry core courses. Required courses must be completed with an average of "B" or higher, and only one course may receive a grade less than "B-".
2. Electives: 3 courses selected from the Chemistry Graduate Elective Offerings.
3. 9 credits of Thesis Research and 2 credits of Thesis. 1 credit of Colloquium.
4. Overlap: Up to 3 graduate level courses (9 credits) may be used to satisfy both the Bachelor's and Master's degree requirements.

Combined BS in Chemistry/MS in Forensic Science Degree Pathway

To be considered for admission to the combined bachelor's/master's degree pathway, students must have completed at least 75 credits in the bachelor's degree program at FIU and meet the admissions criteria for the graduate degree program to which they are applying. Students need only apply once to the combined degree pathway; the application is submitted to Graduate Admissions typically before the student starts the last 30 credits of the bachelor's degree program. A student admitted to the combined degree pathway will be considered to have undergraduate status until the student applies for graduation from their bachelor's degree program. Upon conferral of the bachelor's degree, the

student will be granted graduate status and be eligible for graduate assistantships. Only 5000-level or higher courses, and no more than the number of credits specified by the program catalog, may be applied toward both degrees.

Admission Requirements

1. Current enrollment in the Bachelor of Science program in chemistry at FIU.
2. Current GPA of 3.2 or higher.
3. Official GRE general test scores.
4. Three letters of recommendation.
5. Approval of the Chemistry Graduate Committee.

Completion Requirements

Completed Bachelor of Science degree in chemistry at FIU

Coursework

Required Courses:

BSC 5406	Forensic Biology
CHS 5542	Forensic Chemistry
CHS 5535	Forensic Analysis

1. Required courses must be completed with an average of "B" or higher, and only one course may receive a grade of less than "B-".
2. Electives: 5 courses selected from the Forensic Science Graduate Elective Offerings.
3. 6 credits of Thesis Research and 1 credit of Thesis.
4. 1 credit of Colloquium.
5. Overlap: Up to 3 graduate level courses (9 credits) may be used to satisfy both the Bachelor's and Master's degree requirements.

Doctor of Philosophy in Chemistry

Degree Requirements

1. A minimum of 75 credits of course work. A grade of "C" or higher must be obtained in all courses, and a cumulative GPA of 3.0 or higher must be maintained. The course work must include:
 - a. At least nine credits of chemistry courses, including courses from at least two of the six major areas of chemistry (Analytical, Biochemistry, Environmental, Inorganic, Organic, and Physical) selected from the core courses listed above (see M.S. in Chemistry 1a).
 - b. At least nine credits of additional graduate-level chemistry courses approved by the dissertation committee in consultation with the Graduate Program Director. The guidelines listed above in sections 1b(1) and 1b(2) for the M.S. degree also apply to these courses.
 - c. Full-time graduate students, prior to reaching candidacy, are required to register for one credit of CHM 6940 (Supervised Teaching) each semester they serve as teaching assistants.
 - d. Full-time graduate students are required to register for CHM 6935 (Graduate Seminar) or one credit of CHM 6936 (Chemistry Colloquium) each fall and spring semester
 - e. At least one credit of CHM 6936 (Chemistry Colloquium) is required. Each student must present a seminar on their proposed research at

the colloquium for a letter grade by the end of their third semester of graduate study.

- f. At least eight credits of CHM 7910 (Dissertation Research) involving independent dissertation research under the direction of a faculty member in the Department are required.
 - g. At least 15 credits of CHM 7980 (Ph.D. Dissertation) are to be taken after the student has advanced to candidacy.
2. Satisfactory completion of cumulative examinations. The student will begin taking the cumulative examinations after completing the proficiency requirements but no later than the beginning of the student's second semester. Seven examinations, each lasting three hours, will be given per year. The student must pass four out of ten consecutively-offered exams for admission to candidacy.
 3. Satisfactory presentation and defense of a Preliminary Oral examination. The preliminary oral examination occurs in the fifth semesters (excluding summers). The examination will be conducted by the Dissertation Committee, be based on the student's dissertation research progress and future plans and should include at least one original aim conceived and developed independently by the student. The examination will include questions from the student's major field and cognate fields. After fulfilling this requirement, passing the cumulative examinations, and completing all required course work, the student advances to candidacy.
 4. Satisfactory public presentation and defense of a research dissertation, evaluated by the Dissertation Committee. The student's Dissertation Committee will consist of the research advisor (a FIU graduate faculty member who holds dissertation advisor status), a member from outside the Department, or School, but within FIU, a randomly-assigned member appointed by the Graduate Program Director from the Department's graduate faculty, and at least two additional committee members with expertise in the student's research area. At least three members of the Dissertation Committee, including the major research advisor, must be graduate faculty members from the Department of Chemistry and Biochemistry, and at least two of these three members must be tenured. The Committee may include additional members, but they will be non-voting.
 5. Award of an M.S. en route to Ph.D.: Individuals directly admitted into the Ph.D. program may apply to be awarded an M.S. degree in Chemistry. To be eligible students must have completed requirements of the MS in Chemistry with report option track. Upon certification by the student's advisor, dissertation committee, and the departmental graduate committee that these requirements have been met the student will be eligible to receive an M.S. in Chemistry with report option track.

Doctor of Philosophy in Chemistry with a Chemistry Education Track

Degree Requirements:

1. A minimum of 75 credits of coursework. A grade of "C" or higher must be obtained in all courses, and a cumulative GPA of 3.0 or higher must be maintained.

The coursework must include:

- a. A minimum of twelve credits of chemistry courses, with a minimum of nine of these credits being Chemistry core courses. Students must select an area of concentration (Analytical, Biochemistry, Inorganic, Organic, Physical). Six credits of chemistry coursework must come from the area of concentration and six credits from outside the area of concentration.
- b. At least nine credits of education research courses, including one course from each of the categories of courses listed below.

Foundations of Education Research:

EDF 6481 Educ. Research Methodology
SCE 7761 Research in Science Education

Quantitative Research Methods:

EDF 6472 Introduction to Data Analysis
STA 6166 Stat. Methods in Research I
STA 6167 Stat. Methods in Research II

Qualitative Research Methods:

EDF 6475 Qualitative Foundations in Educational Research

- c. At least three credits of advanced methodology courses, dependent on the focus of the dissertation project. Suggested courses appear in the list below, but others can be approved of by the dissertation committee in consultation with the Graduate Program Director.

Advanced Methodology Courses:

EDF 7476 Advanced Methods of Qualitative Educational Research
EDF 6486 Advanced Data Analysis in Quantitative Educational Research
EDF 7489 Hierarchical Linear Modeling in Educational Research
STA 5507 Nonparametric Methods
STA 6244 Data Analysis 1
STA 6247 Data Analysis 2
STA 6505 Analysis of Categorical Data
STA 6746 Multivariate Statistical Analysis
STA 6990 Multivariate Analysis 1

- d. Full-time graduate students, prior to reaching candidacy, are required to register for one credit of CHM 6940 (Supervised Teaching) each semester they serve as teaching assistants.
 - e. Full-time graduate students are required to register for CHM 6935 (Graduate Seminar), or one credit of CHM 6936 (Chemistry Colloquium) each fall and spring semester
 - f. At least one credit of CHM 6936 (Chemistry Colloquium) is required. Each student must present a seminar on their proposed research at the colloquium for a letter grade by the end of their third semester of graduate study.
 - g. At least eight credits of CHM 7910 (Dissertation Research) involving independent dissertation research under the direction of a faculty member in the Department are required.
 - h. At least 15 credits of CHM 7980 (Dissertation Research) are to be taken after the student has advanced to candidacy.
2. Satisfactory completion of cumulative examinations. The student will begin taking the cumulative examinations after completing the proficiency

requirements but no later than the beginning of the student's second semester. Seven examinations, each lasting three hours, will be given per year. The student must pass four out of ten consecutively offered exams for admission to candidacy. At least three of the exams must be from their area of concentration.

3. Satisfactory presentation and defense of an original research proposal (on a topic not related to the student's specific doctoral research project) and a satisfactory completion of a Preliminary Oral examination. The original proposal presentation and preliminary oral examination occur in the fourth and fifth semesters, respectively (excluding summers), and at least three months apart. The examination will be conducted by the Dissertation Committee, be based on the student's dissertation research and include questions from the student's major field and cognate fields. After fulfilling this requirement, passing the cumulative examinations, and completing all required coursework, the student advances to candidacy.
4. Satisfactory public presentation and defense of a research dissertation, evaluated by the Dissertation Committee. The student's Dissertation Committee will consist of the research advisor (a Fill graduate faculty member who holds dissertation advisor status), a member from outside the Department, or School, but within Fill, a randomly-assigned member appointed by the Graduate Program Director from the Department's graduate faculty, and at least two additional committee members with expertise in the student's research area. At least three members of the Dissertation Committee, including the major research advisor, must be graduate faculty members from the Department of Chemistry and Biochemistry, and at least two of these three members must be tenured. The Committee may include additional members, but they will be non-voting.
5. Award of an M.S. en route to Ph.D.: Individuals directly admitted into the Ph.D. program may apply to be awarded an M.S. degree in Chemistry. To be eligible students must have completed requirements of the MS in Chemistry with report option track. Upon certification by the student's advisor, dissertation committee, and the departmental graduate committee that these requirements have been met the student will be eligible to receive an M.S. in Chemistry with report option track

Doctor of Philosophy in Chemistry with an Environmental Chemistry Track

Degree Requirements

1. A minimum of 75 credit hours. A grade of C or higher must be obtained in all graded courses, and a cumulative GPA of 3.0 or higher must be maintained. The course of study must include:
 - a. 12 credit hours of Environmental Chemistry core courses including four of the following six courses, each of which is worth three credit hours:

CHM 5423	Atmospheric Chemistry
CHM 5765	Aquatic Chemistry
CHM 6281	Environmental Organic Chemistry
CHM 6340	Organic Geochemistry

OCC 5050 Chemical Oceanography
 CHM 6088 Environmental Chemistry of Trace Elements

b. Two chemistry core courses chosen from the following

CHM 5156 Advanced Chromatography
 CHM 5138 Advanced Mass Spectrometry
 CHM 5236 Spectroscopic Techniques and Structure Determination

CHM 6157 Advanced Analytical Chemistry
 CHM 5165 Chemometrics and Sampling
 CHM 5260 Physical Organic Chemistry

c. At least one elective. The elective must be approved by the student's Dissertation Committee, and Environmental Chemistry Graduate Committee. This committee consists of the Environmental Chemistry Graduate Program Director, the Chemistry Graduate Program Director, and two Departmental faculty members active in research in environmental science.

d. Full time graduate students prior to reaching candidacy, are required to register for one credit of CHM 6940 (Supervised Teaching) each semester they serve as a teaching assistant.

e. Full time graduate students are required to register for one credit of CHM 6935 (Graduate Seminar) or one credit of CHM 6936 (Chemistry Colloquium) each Fall and Spring semester.

f. At least one credit of CHM 6936 (Chemistry Colloquium) is required. Each student must present a seminar on their proposed research at the colloquium for a letter grade by the end of their third semester of graduate study.

g. At least eight credit hours of CHM 7910 (Dissertation Research) involving independent dissertation research under the direction of a faculty member in the Department.

h. At least 15 credits of CHM 7980 (Ph.D. Dissertation) to be taken after the student has advanced to candidacy.

i. A maximum of 36 credits may be transferred from a completed Master's degree from another graduate program with the approval of the Graduate Committee. However, only six credit hours can be counted towards the formal academic coursework requirement (1 a-c). Students must elect an appropriate course load in accordance with their research topic, and in agreement with their Graduate Committee and the Departmental Graduate Advisor.

2. Satisfactory completion of cumulative exams. The students will begin taking the cumulative examinations after completing the proficiency requirements but no later than the beginning of the student's second semester. Seven exams, each lasting three hours, will be given each year. The student must pass four out of 10 consecutively offered exams for admission to candidacy.

3. Satisfactory presentation and defense of a preliminary oral examination. The preliminary oral examination occurs in the fifth semester (excluding summers). The examination will be conducted by the Dissertation Committee, be based on the student's dissertation research progress and future plans and should include at least one original aim conceived and developed independently by the student. The

examination will include questions from the student's major field and cognate fields. After fulfilling this requirement, completing all required course work, the student advances to candidacy.

4. Satisfactory public presentation and defense of a research dissertation, evaluated by the Dissertation Committee. The student's Dissertation Committee will consist of the research advisor (an FIU graduate faculty member who holds dissertation advisor status), a member from outside the Department or School but within FIU, a randomly selected member appointed by the Graduate Program Director from the Department's graduate faculty, and at least two additional committee members with expertise in the student's research area. At least three members of the Dissertation Committee, including the major research advisor, must be graduate faculty members from the Department of Chemistry and Biochemistry, and at least two of these three members must be tenured. The Committee may include additional members, but they will be non-voting.

5. Award of an M.S. en route to Ph.D.: Individuals directly admitted into the Ph.D. program may apply to be awarded an M.S. degree in Chemistry. To be eligible students must have completed requirements of the MS in Chemistry with report option track. Upon certification by the student's advisor, dissertation committee, and the departmental graduate committee that these requirements have been met the student will be eligible to receive an M.S. in Chemistry with report option track.

Doctor of Philosophy in Chemistry with a Forensic Science Track

To be admitted into the Ph.D. program in Chemistry with a Forensic track, a candidate must:

1. Hold a Bachelor's degree in chemistry, forensic science or a relevant discipline from an accredited college or university approved by the Chemistry graduate committee. The minimum requirement is a bachelors degree in a natural science with a least 7 semester courses (28 hours including labs) of chemistry courses including physical chemistry, analytical chemistry and biochemistry. Any deficiencies must be completed before being fully accepted to the Ph.D. program;
2. Have a 3.0/4.0 average or higher during the last two years of the undergraduate program or a Master's degree in a relevant discipline;
3. Official Graduate Record Exam (GRE) scores;
4. Arrange to have three letters of recommendation sent to the Graduate Program Director evaluating the applicant's potential for graduate work;
5. Pass at least two proficiency exams in either analytical or biochemistry and either organic or physical chemistry – students who have not taken physical chemistry must take one semester of physical chemistry to make up the deficiency;
6. International graduate student applicants whose native language is not English are required to submit a score for the Test of English as a Foreign Language (TOEFL) or for the International English Language Testing System (IELTS). A total score of 80 on the iBT TOEFL or 6.5 overall on the IELTS is required.

All admissions to the Chemistry Ph.D. program must be recommended by the chemistry graduate committee and signed off by the chemistry graduate program director.

Degree Requirements

1. A minimum of 75 credits or course work. A grade of "C" or higher must be obtained in all courses, and a cumulative GPA of 3.0 or higher must be maintained. Students must choose either the Analytical or the Biochemistry concentration. The course of study must include:

a. Twelve credits of required classes that depend on the concentration (each of the following courses is worth three credits):

Analytical Chemistry/Trace Concentration

BSC 5406	Forensic Biology	3
CHS 5542	Forensic Chemistry	3
CHS 5539	Forensic Toxicology	3
CHS 5545	Chem Anl. Explosives	3
	or	
CHS 5538	Chem Anl. of Drugs	3

Biochemistry/DNA Analysis Concentration

BSC 5406	Forensic Biology	3
CHS 5542	Forensic Chemistry	3
CHS 5536	Forensic DNA Chemistry	3
PCB 5685	Population Genetics	3

b. Two chemistry core courses chosen from the following: Advanced Chromatography (CHM 5156); Advanced Mass Spectrometry (CHM 5138); Spectroscopic Techniques (CHM 5236); Organic Chemistry of Nucleic Acids (CHM 5302); Physical Biochemistry (CHM 5506); Advanced Analytical Chemistry (CHM 6157); Chemometrics & Sampling (CHM 5165); Advanced Biological Chemistry (CHM 6982).

c. At least one elective. The list of approved electives is maintained by the Chemistry and Forensic Graduate Committees.

d. Full-time graduate students, prior to reaching candidacy, are required to register for one credit of CHM 6940 (Supervised Teaching) each semester they serve as teaching assistants.

e. Full-time graduate students are required to register for CHM 6935 (Graduate Seminar) or one credit of CHM 6936 (Chemistry Colloquium) each fall and spring semester.

f. At least one credit of CHM 6936 (Chemistry Colloquium) is required. Each student must present a seminar on their proposed research at the colloquium for a letter grade by the end of their third semester of graduate study.

g. At least eight credits of CHM 7910 (Dissertation Research) involving independent dissertation research under the direction of a faculty member in the Department.

h. At least 15 credits of CHM 7980 (Ph.D. Dissertation) is to be taken after the student has advanced to candidacy.

2. Satisfactory completion of cumulative exams. The students will begin taking the cumulative examinations after completing the proficiency requirements but no later than the beginning of the student's second semester. Seven exams, each lasting three hours, will be given each year. The

student must pass four out of 10 consecutively offered exams for admission to candidacy

- Satisfactory presentation and defense of a Preliminary Oral examination. The preliminary oral examination occurs in the fifth semesters (excluding summers). The examination will be conducted by the Dissertation Committee, be based on the student's dissertation research progress and future plans and should include at least one original aim conceived and developed independently by the student. The examination will include questions from the student's major field and cognate fields. After fulfilling this requirement, passing the cumulative examinations, and completing all required course work, the student advances to candidacy.
- Satisfactory public presentation and defense of a research dissertation, evaluated by the Dissertation Committee. The composition of the Dissertation Committee is as described in section 4 for the Ph.D. in Chemistry (no track) above.
- Award of an M.S. en route to Ph.D.: Individuals directly admitted into the Ph.D. program may apply to be awarded an MS degree in Forensic Science or an MS degree in Chemistry. To be eligible students must have completed requirements of the relevant Master's program. Upon certification by the student's advisor, dissertation committee, and the Chemistry and Forensic Science graduate committees that these requirements have been met the student will be eligible to receive the relevant M.S. degree.

Doctor of Philosophy in Chemistry with a Radiochemistry Track

Admission Requirements

To be admitted into the Ph.D. program in Chemistry with the Radiochemistry Track, a candidate must:

- Hold a Bachelor's degree in chemistry or a relevant discipline from an accredited college or university approved by the Chemistry Department Graduate Committee. The minimum requirement is a Bachelor's degree in a natural science with a least 7 semester courses (28 hours including labs) of chemistry courses including: physical chemistry, analytical chemistry and biochemistry. Any deficiencies must be completed before being fully accepted to the Ph.D. program.
- Have a 3.0/4.0 average or higher during the last two years of the undergraduate program or a Master's degree in a relevant discipline.
- Submit general GRE scores. There is no minimum requirement for the overall GRE score, but the applicants with an average percentile rank of 60 on the verbal and quantitative parts of the GRE will be preferentially considered.
- Arrange to have three letters of recommendation sent to the Radiochemistry Graduate Program Director, each evaluating the applicant's potential for graduate work.
- Pass at least two proficiency exams in either analytical or biochemistry and either organic or physical chemistry.
- Receive approval from the Radiochemistry Graduate Committee.

7. International graduate student applicants whose native language is not English are required to submit a score for the Test of English as a Foreign Language (TOEFL) or for the International English Language Testing System (IELTS). Minimum required scores is 550 on the paper-based TOEFL, 80 on the internet-based TOEFL (iBT) or 6.5 overall on the IELTS.
8. All admissions to the Chemistry Ph.D. program must be approved by the Chemistry Department Graduate Committee and signed off by the Chemistry Graduate Program Director.

Degree Requirements

1. A minimum of seventy five (75) credits or course work. A grade of "C" or higher must be obtained in all courses, and a cumulative GPA of 3.0 or higher must be maintained. The course of study must include at least 21 credits of approved course work from the following three groups.

a. Six credits of required classes:

CHS 5110	Topics in Radiochemistry	3
CHS 6111	Advanced Radiochemistry	3

b. A minimum of six credits from the following list.

CHM 6480	Quantum Mechanics	3
CHM 6157	Advanced Analytical Chemistry	3
CHM 5156	Advanced Chromatography	3
PHZ 5340	Particle Interactions and Detection	3
CHM 5540	Group Theory In Chemistry	3
CHM 5650	Physical Inorganic Chemistry	3
CHM 6491	Applications of Synchrotron Radiation and Electron Based Techniques	3
CHM 5681	Special Topics in Inorganic Chemistry	3
CHM 5236	Spectroscopic Techniques and Structure Elucidation	3
*PHY 6645	Advanced Quantum Mechanics	3
	*Could substitute for CHM 6480	

c. Additional electives from the following list, or with graduate committee approval, as needed to meet the course requirement:

CHM 6088	Environmental Chemistry of Trace Elements	3
CHM 5165	Chemometrics and Sampling	3
CHM 5490	Physical Spectroscopy	3
CHM 6461	Statistical Thermodynamics	3
CHM 5440	Kinetics and Catalysis	3
CHM 5586	Computational Chemistry	3
CHM 5263	Physical Organic Chemistry	3
CHM 5506	Physical Biochemistry	3
CHM 5251	Oganometallic Chemistry	3
PHZ 5730	Biophysical Effects of Radiation	3
PHZ 5732	Clinical and Medical Dosimetry	3

- d. Full-time graduate students, prior to reaching candidacy, are required to register for one credit of CHM 6940 (Supervised Teaching) each semester they serve as teaching assistants.
- e. Full-time graduate students are required to register for CHM 6935 (Graduate Seminar) or one credit of CHM 6936 (Chemistry Colloquium) each fall and spring semester.
- f. At least one credit of CHM 6936 (Chemistry Colloquium) is required. Each student must present a seminar on their proposed research to the dissertation committee by the end of their third semester of graduate study.

- g. At least eight credits of CHM 7910 (Dissertation Research) involving independent dissertation research under the direction of a faculty member in the Department.
- h. At least 15 credits CHM 7980 (Ph.D. Dissertation) is to be taken after the student has advanced to candidacy.

2. Satisfactory completion of cumulative exams. The students will begin taking the cumulative examinations after completing the proficiency requirements but no later than the beginning of the student's second semester. Six exams, each lasting three hours, will be given each year. The student must pass four out of 10 consecutively offered exams for admission to candidacy. Cumulative exams in the area of Nuclear and Radiochemistry will be added to existing specialties.
3. Satisfactory presentation and defense of a Preliminary Oral examination. The preliminary oral examination occurs in the fifth semester (excluding summers). The examination will be conducted by the Dissertation Committee, be based on the student's dissertation research progress and future plans and should include at least one original aim conceived and developed independently by the student. The examination will include questions from the student's major field and cognate fields. After fulfilling this requirement, passing the cumulative examinations, and completing all required course work, the student advances to candidacy.
4. Satisfactory public presentation and defense of a research dissertation, evaluated by the Dissertation Committee. The student's Dissertation Committee will consist of the research advisor (an FIU graduate faculty member who holds dissertation advisor status), a member from outside the Department or School but within FIU, a randomly selected member appointed by the Graduate Program Director from the Department's graduate faculty, and at least two additional committee members with expertise in the student's research area. At least three members of the Dissertation Committee, including the major research advisor, must be graduate faculty members from the Department of Chemistry and Biochemistry, and at least two of these three members must be tenured. The Committee may include additional members, but they will be non-voting.
5. Award of an M.S. en route to Ph.D.; Individuals directly admitted into the Ph.D. program may apply to be awarded an M.S. degree in Chemistry. To be eligible students must have completed requirements of the MS in Chemistry with report option track. Upon certification by the student's advisor, dissertation committee, and the departmental graduate committee that these requirements have been met the student will be eligible to receive an M.S. in Chemistry with report option track.

PhD Program in Biochemistry

The PhD in Biochemistry is offered by the Biochemistry Ph.D. Program, which is co-sponsored by the Department of Chemistry and Biochemistry, the Department of Biological Sciences, and the Herbert Wertheim College of Medicine. The core of graduate courses will provide a firm foundation in the theory and techniques of biochemistry,

and molecular biology (molecular genetics), with full integration of the core disciplines of chemistry, biology and related fields. With this foundation, students will be prepared to specialize in either biochemistry or molecular biology.

Admission Requirements

1. Hold a BS degree in Biology or Chemistry or the equivalent from an accredited college or university. Previous completion of at least 28 credits, including labs, of chemistry or biology courses at the upper division level is required. The following courses are recommended as background regardless of undergraduate major: biochemistry or molecular biology, two semesters of organic chemistry, and two semesters of general biology. Students are expected to have taken either physical chemistry or genetics as an undergraduate. Students not having taken at least one of these courses will be required to make up this deficiency either before or during their first year of graduate study by taking appropriate coursework.
2. A GPA of at least 3.0 (on a four-point scale) during the last 60 credits of the undergraduate program.
3. Official Graduate Record Exam (GRE) scores.
4. Three letters of recommendation evaluating the applicant's potential for graduate and research work.
5. A statement of purpose/research interests.
6. Receive approval from the Biochemistry Graduate Committee.
7. Foreign students whose native language is not English must obtain a score of 80 or higher on the TOEFL iBT or 550 on the paper TOEFL or a 6.5 on the IELTS.

Degree Requirements

The PhD in Biochemistry requires a minimum 75 semester hours beyond the baccalaureate degree. The Dissertation Advisor and Committee will assist the student to choose a curriculum suitable to the student's interests, goals and background. This will include selection of electives as well as suggestions for other courses that may be needed to develop skills critical for the student's research and career goals, especially quantitative skills. A grade of C or higher must be earned in all courses.

Coursework Requirements

Required Core Courses (16 credits)

BCH 6831	Introduction to Biochemical Research	3
BCH 6108	Biochemical Techniques	3
CHM 6036	Advanced Biochemistry I	3
PCB 6025	Molecular and Cellular Biology I	3
CHM 6037	Advanced Biochemistry II (Molecular Genetics)	3
or		
PCB 6027	Molecular and Cellular Biology II	3
CHM 6802	Research Ethics	1
Biochemistry Graduate Seminar Requirement		
BCH 7930*	Biochemistry Graduate Seminar	1or0

*Full time graduate students are required to register for BCH 7930 each fall and spring semester. Prior to Advancement to Candidacy they will register for 1 credit of BCH 7930 each semester. After the student has advanced to candidacy, the student will register for the 0 credit course each semester.

Additional Required Courses (22 credits)

BSC 5945	Supervised Teaching in Biology	2
or		
CHM 6940	Supervised Teaching	2
BSC 6913	Student Research Laboratory	1
or		
CHM 6910L	Graduate Research in Chemistry (taken during lab rotations)	1
CHM 7910	Dissertation Research	4
BSC 7980/CHM 7980	PhD Dissertation	15

Electives*

BSC 6415	Animal Cells in Culture	3
BSC 6415L	Animal Cells in Culture Lab	2
CHM 5302	Organic Chemistry of Nucleic Acids	3
CHM 5325	Physical Chemistry of Proteins	3
CHM 5351	Computer Modeling of Biological Molecules	3
CHM 5440	Kinetics and Catalysis	3
CHM 5503	Physical Chemistry of Nucleic Acids	3
CHM 5506	Physical Biochemistry	3
CHS 5536	Forensic DNA Chemistry	3
MCB 6935	Advanced Topics in Microbiology	3
PCB 5665	Human Genetics	3
PCB 5665L	Human Genetics Lab	2
PCB 5725	Membrane Signal Transduction	3
PCB 5786	Membrane Physiology	3
PCB 6236	Comparative Immunology	3
PCB 6526	Advanced Molecular Biology	3
PCB 6566	Chromosome Structure and Function	3
PCB 6786	Membrane Biophysics	3
PCB 6935	Advanced Topics in Genetics	3
BCH 6130C	DNA Synthesis and Amplification	1
BCH 6132C	Electrophoresis	1
BCH 6133C	DNA Sequencing	1
MCB 5315C	Prokaryotic Cloning	2

***The PhD in Biochemistry requires a minimum 75 semester hours beyond the baccalaureate degree. Rotation and Choosing an Advisor**

Rotation and Choosing an Advisor

Students will spend 4-5 weeks in the laboratories of three Biochemistry faculty. Some flexibility in length of rotation is acceptable. In most cases, the rotations will be completed during the first semester of study, but an extension into the second semester is possible. At the end of each rotation, the student and the faculty member will complete an evaluation form. After completing a minimum of three rotations, students will submit an ordered list of three advisors they would like to work with. The Biochemistry Graduate Committee will make the research advisor assignments.

Supervised Teaching

Two semesters of supervised teaching or documentation of the equivalent amount of teaching experience is required. Concurrent enrollment in BSC 5945/CHM 6940 Supervised Teaching is required.

Completion of Candidacy Exam

The Candidacy Exam consists of two parts: 1) a written Qualifying Examination and 2) presentation of an Original Research Proposal followed by a Preliminary Oral Exam. The written Qualifying Exam will be administered at the end of the third semester of study (excluding summers), by which time all core courses should have been

completed. The exam will be designed primarily to test material mastered in core courses. After passing the written Qualifying Exam, the student will present and defend an original research proposal (on a topic not related to the student's specific doctoral research project) and undergo an oral exam.

Presentation of Formal Proposal of the Dissertation Topic

Each student must present a public seminar on their proposed research. This is done in the context of a one-credit course (BSC 7961 or CHM 6936) for a letter grade.

Submission and Defense of Dissertation

All students must submit a dissertation based upon original research in biochemistry. After submission of the dissertation and completion of all other prescribed work, the candidate will give a public presentation of the completed research and be given a final oral examination by the Dissertation Committee.

Course Descriptions

Definition of Prefixes

BCH-Biochemistry (Biophysics); CHM-Chemistry; CHS-Chemistry-Specialized; OCC - Chemical Oceanography F-Fall semester offering; S-Spring semester offering; SS Summer semester offering.

BCH 5045 Survey of Biochemistry (3). For students NOT specializing in biochemistry. Topics will cover the structure, function, biosynthesis and synthesis of biological molecules, biological macromolecules and macromolecular assemblies. Prerequisite: CHM 2211.

BCH 6108 Biochemical Techniques (3). Introduction to theories of basic biochemical techniques commonly used in a biochemistry laboratory. Prerequisite: One semester of biochemistry.

BCH 6831 Introduction to Biochemical Research (3). An overview of the analysis of biochemical data and experimental design. Prerequisite: Graduate standing.

BCH 7930 Biochemistry Graduate Seminar (0-1). Presentations and discussions of current topics in the biochemical sciences. Corequisite: Graduate standing.

CHM 5138 Advanced Mass Spectrometry (3). Intensive examination of the processes and techniques involved in creating, controlling and measuring ionic species by mass spectrometry. Theory of mass spectrometry, methods of ionization, instrumental designs, quantitative mass spectrometry, meta-stable ions, and tandem mass spectrometry. Prerequisites: CHM 4130, CHM 4130L or Permission of Instructor.

CHM 5139C Mass Spectrometry Workshop (2). Basic description of processes and techniques involved in creating, controlling and measuring elemental or molecular ionic species by mass spectrometry techniques. WS designed to provide hands on experience. Prerequisite: CHM 4130.

CHM 5150 Graduate Analytical Methods (3). Analysis of analytical data, electrochemistry, spectro-analytical techniques, chromatography, survey of new analytical methods. Prerequisites: Graduate standing or permission of the instructor. (F,S)

CHM 5156 Advanced Chromatography (3). Intensive examination of the contemporary practice of chromatography including available chromatographic techniques, their selection and application. Prerequisites: CHM 4130 or permission of the instructor.

CHM 5165 Chemometrics and Sampling (3). Methods of evaluating analytical chemistry data. Planning sampling design for water, air and solids. Sample preparation and extraction techniques. Prerequisite: CHM 4130.

CHM 5225 Graduate Organic Chemistry (3). Advanced topics in organic chemistry. Structure of organic molecules, reaction mechanisms, organic synthesis, and natural product chemistry. Prerequisites: Graduate standing or permission of the instructor. (F,S)

CHM 5236 Spectroscopic Techniques and Structures Elucidation (3). Advanced techniques for the spectroscopic identification of organic compounds. Interpretation of spectral information for determination of structures of various classes of organic compounds. Prerequisites: CHM 4220 and CHM 4230L.

CHM 5250 Organic Synthesis (3). Use of classical and modern reactions in the design and construction of complex organic molecules including natural products. Some topics covered will be construction reactions, refunctionalization, stereochemistry and conformational analysis. Prerequisites: CHM 4220 or permission of the instructor.

CHM 5251 Organometallic Chemistry (3). Fundamentals and applications of organometallic chemistry. Structures and bonding, ligand types, organometallic reactions, physical methods of characterization. Prerequisites: CHM 4611, CHM 3411.

CHM 5252 Asymmetric Synthesis (3). Recent advances in asymmetric synthesis for the selective design and construction of tetrahedral stereocenters. Focus on principles of configuration in transition state assemblies. Prerequisite: CHM 4220.

CHM 5263 Physical Organic Chemistry (3). A series of topics will be discussed including molecular orbital theory as it pertains to organic molecules, kinetic and thermodynamic approaches to the study of reaction mechanisms, quantitative approaches to conformational analysis, etc. Prerequisites: CHM 4220 and physical chemistry or permission of the instructor.

CHM 5280 Natural Products Chemistry and Biosynthesis (3). Studies of the chemical origins (biosynthesis), properties, and synthesis of the various classes of naturally occurring compounds: terpenes, steroids, alkaloids, acetogenins. Prerequisites: CHM 4220 or permission of the instructor.

CHM 5285 Marine Natural Products: Chemistry and Pharmacology/Toxicology (3). Identification, isolation, and characterization of toxic and other biologically active compounds from marine sources.

CHM 5302 Organic Chemistry of Nucleic Acids (3). Organic chemistry of ribose sugars, nucleotide heterocyclic bases, mechanism-based inhibitors of enzymes involve in nucleic acid metabolism, and chemical synthesis of DNA. Prerequisites: CHM 4220 or permission of the instructor.

CHM 5305 Graduate Biological Chemistry (3). Structures of biological molecules; Biochemical reaction mechanisms; Enzyme kinetics; Biomolecular thermodynamics; Biomolecular spectroscopy. Prerequisites: Graduate standing or permission of instructor.

CHM 5306 Special Topics in Biological Chemistry (3). Investigation of one or more areas of biologically related chemistry. Prerequisites: CHM 4305 or permission of the instructor.

CHM 5325 Physical Chemistry of Proteins (3). Protein structures, dynamics and functions. Use of spectroscopic methods. Thermodynamics of protein folding and ligand binding. Enzyme Kinetics. Prerequisites: Biological Chemistry and Physical Chemistry or permission of instructor.

CHM 5351 Computer Modeling of Biological Molecules (3). Introduces use of computers in studying biological macromolecules. Simulations, visualization methods, software, databases. Prerequisite: CHM 3411, Biochemistry recommended.

CHM 5380 Special Topics in Organic Chemistry (VAR). An intensive examination of one or more areas selected by instructor and students. Prerequisites: CHM 4220 and physical chemistry or permission of the instructor.

CHM 5423 Atmospheric Chemistry (3). Chemical processes in atmospheres. Photochemistry, chemical kinetics, tropospheric and stratospheric chemical reactions, anthropogenic effects on the earth's atmosphere and chemistry of planetary atmospheres. Prerequisites: CHM 3411, or permission of the instructor.

CHM 5425 Graduate Physical Chemistry (4). Prequantum physics, the Schrodinger equation and its solutions, atoms and molecules, rotational, vibrational, and electronic spectroscopy. Prerequisites: Graduate standing or permission of the instructor.

CHM 5426 Graduate Physical Chemistry II (4). Gas laws; thermodynamics and equilibrium, electrochemistry, and chemical kinetics. Prerequisite: Graduate standing or permission of the instructor.

CHM 5440 Kinetics and Catalysis (3). Theory of elementary reactions, activated complex theory, mechanisms of complex reactions. Prerequisites: CHM 3411, MAP 3302.

CHM 5450 Advanced Polymer Chemistry (3). Advanced aspects of polymer chemistry. Properties, synthesis, uses and characterization of various polymeric materials. Prerequisites: CHM 2210 and CHM 2211. Corequisite: Graduate Standing.

CHM 5490 Physical Spectroscopy (3). Introduction to atomic and molecular quantum states, selection rules, and fundamental principles of spectroscopy. Introduction to group theory and to the theory of UV/visible, infrared, Raman, microwave, NMR, photo-electron, and mass spectroscopies, and the applications of these methods to the determination of fundamental physical properties and the structure of organic and inorganic molecules. Prerequisite: Physical Chemistry.

CHM 5490L Physical Spectroscopy Lab (1). The theory of spectroscopy and the use of modern instrumentation to

investigate molecular structure. Prerequisites: CHM 2211, 2211L. Corequisites: PHY 4604 or CHM 5490.

CHM 5503 Physical Chemistry of Nucleic Acids (3). Physical chemistry of nucleic acids including spectroscopic determination of structures of DNAs, RNAs, and DNA protein complexes and thermodynamic and kinetic studies of nucleic acid-ligand complexes and nucleic acid structures. Prerequisites: CHM 4305 or permission of the instructor.

CHM 5506 Physical Biochemistry (3). Physical properties of biomolecules, molecular conformation; thermodynamic, kinetic, and spectroscopic properties of biomolecules. Prerequisites: CHM 4305 or permission of the instructor.

CHM 5517 Solid State (3). Crystalline form of solids, lattice dynamics, metals, insulators, semiconductors, and dielectric materials. Prerequisites: CHM 5490 or PHY 4604.

CHM 5540 Group Theory in Chemistry (3). The fundamental theory is developed with emphasis given to representations. Specific applications covered, with emphasis on molecular orbital theory and spectroscopy. Prerequisite: CHM 3411.

CHM 5586 Computational Chemistry (3). Surveys computational methods for studying issues pertinent to organic and biological chemistry. Emphasis on developing an understanding of principles and putting methods to use. Includes methods for studying reaction thermodynamics, reaction mechanisms and NMR spectral properties. Prerequisites: CHM 3410, CHM 3411.

CHM 5620 Graduate Inorganic Chemistry (3). Atomic structure, periodicity, bonding and structure of inorganic compounds, solution chemistry, ligand field theory, organometallic chemistry, and specific chemistry of the elements. Prerequisite: Graduate standing or permission of instructor.

CHM 5650 Physical Inorganic Chemistry (3). Introduction to use of physical methods to determine the structure of inorganic compounds. Prerequisites: CHM 4611 or permission of the instructor.

CHM 5681 Special Topics in Inorganic Chemistry (VAR). An intensive examination of one or more areas selected by instructor and students. Prerequisites: CHM 4611 or permission of the instructor.

CHM 5765 Aquatic Chemistry (3). Redox chemistry, chemistry of sediments, organic biogeochemistry, chemodynamics, and fates of organic pollutants in aqueous environments. Prerequisites: CHM 2211, CHM 4130, or permission of the instructor.

CHM 5812 Learning Theories: Three-Dimensional Learning (3). An investigation of Three-Dimensional Learning and how it can be used to synthesize information learned in their chemistry courses. Also emphasizes assessment of scientific practices and core ideas.

CHM 5932 Special Topics (3). A course covering selected special topics in chemistry.

CHM 5934 Special Topics in Analytical Chemistry (VAR). An intensive examination of one or more areas selected by instructor and students. Core course Prerequisites: CHM 4130 or permission of the instructor.

CHM 5936 Special Topics in Environmental Chemistry (3). An intensive examination of one or more areas selected by the instructor and students. Prerequisite: Permission of the instructor.

CHM 5938 Special Topics in Physical Chemistry (VAR). An intensive examination of one or more areas selected by instructor and students. Prerequisites: CHM 3411 or permission of the instructor.

CHM 6036 Advanced Biochemistry I (3). Overview of the structure and function of Biomacromolecules, i.e., proteins, enzymes, and nucleic acids emphasizing the current literature. Prerequisites: One semester of biochemistry or consent of the instructor.

CHM 6037 Advanced Biochemistry II (Molecular Genetics) (3). Introduction to biochemical pathways regulation and intra- and extracellular communication on the molecular level. Prerequisite: CHM 6036.

CHM 6088 Environmental Chemistry of Trace Elements (3). Occurrence, transformation, detection, speciation, and other aspects of trace elements in the environment.

CHM 6157 Advanced Analytical Chemistry (3). Modern analytical methods, applications, and instrumentation. Topics include spectroscopy, chromatography, electrochemistry, optimization theory, and computerized instrumentation. Prerequisites: CHM 4130 or permission of the instructor.

CHM 6166 Hyphenated Analytical Techniques (3). Covers hyphenated analytical techniques required for the analysis of trace elements and organic compounds in environmental and biomedical sciences. Prerequisites: CHM 4130 or equivalent.

CHM 6167 Modern Analytical Methods for Surface and Structural Interrogation (3). Beam interactions with surfaces, gas-phase post-ionization separations, analytical instrumentation for biological and structural mass spectrometry. Prerequisite: CHM 4130.

CHM 6176 Macromolecular Biosensors (3). An introduction to the principles of macromolecular biosensors. Bio-recognition elements, immobilization methods, sensor design and integration, and recent advances in sensor technology. Prerequisite: CHM 4130.

CHM 6281 Environmental Organic Chemistry (3). Characteristics, origin, fate and transformation of organic compounds in air, water, sediments and biota. Prerequisites: CHM 2211, CHM 3411, or permission of the instructor.

CHM 6340 Organic Geochemistry (3). Organic geochemistry of recent and ancient environments. Characteristics, origin, and transformation of organic matter in the geosphere, including formation of crude oil. Prerequisites: CHM 2211, CHM 3411, CHM 4130, GLY 1010, or permission of the instructor.

CHM 6382 Advanced Biological Chemistry (3). In depth exploration of one or more biological chemistry areas, for example, use of multinuclear NMR in examining nuclear acids and proteins; biosynthesis of toxins, roles of porphyrins. Topics covered vary with instructor. Prerequisites: Biological Chemistry and Physical Chemistry or permission of instructor.

CHM 6449 Photochemistry (3). Fundamentals of photochemistry. Excited states, energy, and electron transfer processes, photo-oxidation, reactive species, and environmental photochemistry. Prerequisites: CHM 4220 or permission of the instructor.

CHM 6461 Statistical Thermodynamics (3). Principles of statistical thermodynamics. Ensembles, classical and quantum statistics, ideal and nonideal gases, equilibrium, crystals, liquids, and polymers. Prerequisites: CHM 3411 or permission of the instructor.

CHM 6480 Quantum Mechanics (3). Introduction to quantum mechanics. The Schrodinger equation and its solutions, approximation methods, spin, symmetry, structure of atoms and molecules. Prerequisites: CHM 3411 or permission of the instructor.

CHM 6491 Applications of Synchrotron and Electron Based Techniques (3). X-ray and synchrotron techniques, including general theory, X-ray diffraction, small and wide angle scattering, imaging and microscopy, transmission electron microscopy, and EELS spectroscopy. Prerequisite: Graduate Standing in chemistry or related area or permission of instructor.

CHM 6511 Polymer Chemistry (3). A quantitative study of polymers. Mechanism of formation, configuration of polymer chains, and the relationship between physical properties and chemical constitution. Prerequisite: CHM 3411 or permission of the instructor.

CHM 6621 Inorganic Reaction Mechanisms (3). Review of kinetics and determination of mechanism. Study of mechanism of reactions of coordination complexes including electron transfer reactions, ligand substitution reactions, coordinated ligand reactions of importance in homogeneous catalysis. Prerequisite: Physical Chemistry I (Kinetics).

CHM 6802 Research Ethics (1). Ethical issues in biochemical research. Scientific misconduct, professional integrity, intellectual property, authorship and publication. Corequisite: Graduate standing.

CHM 6905 Independent Study in Chemistry (1-6). Independent study and problems in an area of chemistry, under faculty supervision. May be repeated. Prerequisite: Permission of the instructor.

CHM 6910L Graduate Research in Chemistry (VAR). The student works directly with a professor on a research project. Credit is assigned on the basis of four hr/wk per credit hour. Results to be presented as a seminar. Permission of the instructor.

CHM 6935 Graduate Seminar (0-1). An examination of various current research topics in chemistry. Prerequisite: Graduate standing.

CHM 6936 Chemistry Colloquium (1). Analysis of current developments and topics presented by faculty members and registered students. Prerequisite: Admission to graduate program in chemistry.

CHM 6940 Supervised Teaching (1-3). Graduate student serves as lecturer and demonstrator in undergraduate laboratories coordinated and supervised by a faculty member. May be repeated. A maximum of three hours may apply to the Master's degree. Prerequisite: Good graduate standing.

CHM 6949 Industrial Internship (3). A semester of supervised work in an outside laboratory. Prerequisite: Permission of the instructor.

CHM 6970 Thesis Research (1-10). Research toward completion of Master's Thesis. Repeatable. Prerequisite: Permission of the department.

CHM 6971 Master's Thesis (1-6). Completion of thesis. Prerequisite: Permission of major professor.

CHM 7910 Dissertation Research (1-10). Research towards the completion of a doctoral dissertation. Repeatable. Prerequisite: Graduate Standing.

CHM 7980 Ph.D. Dissertation (1-12). Completion of doctoral dissertation. Prerequisite: Permission of Major Professor and Doctoral Candidacy. May be repeated.

CHS 5435 Pharmacology and Toxicology of Drugs (3). Provides an in-depth understanding of basic pharmacological and toxicological principles of drug action from a molecular, mechanistic, and physiochemical viewpoint. Prerequisite: Graduate standing.

CHS 5502 Forensic Chemistry for Teachers (3). Incorporates concepts and techniques from the application of analytical chemistry, molecular biology, biochemistry, toxicology, and microscopy to forensic casework. Exposure to teaching resources in these areas and case study format of presentation. Open to education majors only. Prerequisites: CHM 3120, CHM 3120L, CHM 2211, and CHM 2211L or permission of instructor.

CHS 5535 Forensic Analysis (3). Advanced topics on the role that physical evidence plays in their criminal justice system. Topics include crime scene methods, laboratory management and the legal framework as it relates towards physical evidence. Prerequisites: CHM 3120, CHM 3120L, CHM 2211, CHM 2211L, or permission of the instructor. (Does not count towards chemistry elective requirement).

CHS 5535L Forensic Analysis Lab (1). Laboratory to accompany Forensic Analysis CHS 5535. Prerequisites: CHM 3120, CHM 3120L, CHM 2211, CHM 2211L or permission of the instructor.

CHS 5536 Forensic DNA Chemistry (3). Chemical basis for current methodologies of DNA analysis. DNA sequencing, PCR, STR, AFLP, mass spectrometry. Prerequisites: CHM 4304 or permission of instructor.

CHS 5538C Chemistry and Analysis of Drugs (3). Introduction to the chemistry of drugs of abuse, including reactivity, synthesis and the principles of analysis from solid doses and from body fluids. Laboratory analysis through the determination of unknown samples. Prerequisites: CHM 4130, CHM 4130L, CHM 4304, CHM 4304L.

CHS 5539 Forensic Toxicology (3). Provides the basic concepts of forensic toxicology as it applies to drug and body fluid analysis. Prerequisites: CHM 2211+L, CHM 3120+L, CHM 4305+L (BCH 3033+L) or permission of instructor.

CHS 5542 Forensic Chemistry (3). Advanced analytical methods in Forensic Chemistry for application to the analysis of controlled substances, materials (ie., paint, glass, and fibers), flammable and explosives residues with an emphasis on new methods and method development.

CHS 5545 Chemistry and Analysis of Explosives (3). Chemistry and reactivity, including thermochemistry, of modern industrial and military explosives' with an emphasis on the analysis of explosives residues from post-blast debris and from samples of environmental interest. Prerequisites: CHM 4130, CHM 4130L.

CHS 5110 Topics in Radiochemistry (3). Principles and applications of radiochemistry. Types of radionuclides, decay modes, radiation detection, counting statistics, dose determination, hazards, and applications. Prerequisites: Graduate student status and CHM 3411 or equivalent.

CHS 6111 Advanced Radiochemistry (3). Radioanalytical techniques, applications of radioisotopes and tracers, nuclear reactor, the chemistry of transuranic elements, the nuclear fuel cycle and advanced solvent extraction processes. Prerequisite: CHS 5110.

CHS 6905 Independent Study in Forensic Science (1-6). Independent study and problems in an area of forensic science under faculty supervision. Prerequisite: Permission of instructor.

CHS 6946 Graduate Forensic Internship (1-6). Internship in an operational forensic laboratory, contributing in a specific manner on an assigned research project. Six hours a week minimum residence time per credit in the lab under the supervision of a host lab scientist and a faculty member is required. A final written report and presentation required. Prerequisite: Core courses in Forensic M.S. Program.

OCC 5050 Chemical Oceanography (3). Interaction of chemical processes in marine systems with biological, geological, and physical processes. Prerequisites: Graduate standing or permission of the instructor.