## BIOCHEMISTRY (BS)

Chair: Phillip M. Sheridan, PhD

## Introduction

Biochemistry graduates enter a variety of professions, including careers in research and industry, the health professions, teaching, technical writing, business, sales, patent law and civil service. A major in biochemistry is an excellent preparation for entrance into medical, dental and pharmacy schools. It also prepares students to enter a range of graduate programs including biochemistry, biotechnology, bioinformatics, medicinal chemistry, bioengineering, business and law.

The Department of Chemistry and Biochemistry offers two tracks that lead to a BS degree in Biochemistry. They are the Biochemistry BS track certified by the American Chemical Society (BCH track certified by ACS) and Biochemistry BS track designed for students who intend to pursue employment in industry (BCH track). Both BCH tracks are appropriate for pre-health professional students.

Advisors in the Department will help you choose the track that best fits your interests and career plans. Students in both program tracks will gain hands-on experience with a wide variety of modern, sophisticated laboratory instrumentation; this helps provide the experience necessary to be competitive in today's job market and/or to gain entrance into highly ranked graduate programs.

Both Biochemistry tracks can be completed with a business minor. This option provides a very useful preparation for employment in sales, marketing, or other industrial professions, as well as preparing students for graduate studies in business or administration.

Qualifications
Students must attain the grade of C or greater in General Chemistry II (CHM 112) and C- or greater in Organic Chemistry II (CHM 228) in order to progress into the major. Several two semester courses (CHM 111 and $\mathrm{CHM} 112, \mathrm{CHM} 227$ and $\mathrm{CHM} 228, \mathrm{BCH} 301$ and BCH 302 ) have a requirement for a minimum grade of C - in the first course to continue with the second course.

## ACADEMIC Advisement

All students have an academic advisor. For students who have declared a major, an advisor is assigned in their respective academic department. For students who are still deciding on a major, they will be assigned a staff member from the Griff Center for Student Success for advisement including course selection prior to registration.

Meetings with academic advisors are required prior to students receiving their PIN for course registration each semester. All students should work closely with their advisor in discussing career expectations, choosing their major electives, developing their entire academic program and planning their co-curricular or supplemental academic experiences.

## Major Experiences

Following their freshman year, and sometimes earlier, chemistry and biochemistry majors are encouraged to become involved in research or other professional projects. Stipends are often available so that work can be done on these projects during the summer and school year in the Department. Summer work in industrial laboratories and research institutions is also available. Our close relationship with local industries and
institutions aids students in job placement before and after graduation. Students may also choose to undertake industrial internships for advanced elective course credit.

## Special Programs Offered by the Department

## Early Assurance Program with University at Buffalo Medical School or Syracuse Medical School <br> Qualified students may apply to the University at Buffalo Medical School or Syracuse University Medical School during their sophomore year. Those accepted will be admitted into the Medical School freshman class after their graduation from Canisius.

## Early Assurance Program with University at Buffalo Dental School

Qualified students may apply to the University at Buffalo Dental School during their sophomore year. Those accepted will be admitted into the Dental School freshman class after their graduation from Canisius.

## Pre-Medical and Pre-Dental

The Chemistry and Biochemistry BS degrees are excellent preparations for entering into medical and dental schools, and a third of the graduates from this Department enter into these programs. Students applying to medical or dental schools must take the Medical College Admission Test (MCAT) or Dental Admission Test (DAT).

## Pre-Pharmacy

For pre-pharmacy students we recommend the Chemistry Health Professions track, since students in this track can meet all pharmacy school entrance requirements. Students applying to most pharmacy schools must take the Pharmacy College Admission Test (PCAT).

## Double Majors

Students who wish to expand their educational opportunities may decide to declare a double major. This decision may be based on career goals, planned graduate studies, and/or other student interests. Before a student declares a double major, it is important to meet with the appropriate academic departments for advisement. In order to declare a double major, the student must complete the Major/Minor Declaration form. This form will be submitted electronically and reviewed and approved by each department chairperson as well as the appropriate associate dean.

Per university policy, each additional major requires a minimum of 15 credits that do not apply to the student's first or subsequent major. Some double major combinations can be completed within the minimum 120 credit hour degree requirement, but in other cases additional course work may be required. Please note that students will receive only one degree unless completing the dual degree (https://catalog.canisius.edu/undergraduate/ academics/curricular-information/) requirement including at least 150 undergraduate credit hours, regardless of the number of majors they complete. Both (all) majors appear on a student's transcript.

## Minors in Other Disciplines

Minors provide students the opportunity to pursue additional interests but generally do not require as many courses as a major. Minors generally range from five to eight required courses. To receive a minor, the student must complete at least 9 credit hours of coursework distinct from their other credentials (i.e., majors, other minors). The complete list of minors is available on the Canisius website (https://www.canisius.edu/academics/
programs/undergraduate/?type\%5B\%5D=17) and in the catalog (https:// catalog.canisius.edu/undergraduate/minors/) and provides links to each minor. Some majors and minors can be completed within the minimum 120 credit hour degree requirement, but in some cases additional coursework may be required. Students must complete the appropriate minor request form.

## Curriculum

## An Ignatian Foundation

All undergraduate students must complete either the Canisius Core Curriculum (http://catalog.canisius.edu/undergraduate/academics/ curricular-information/core-curriculum/) or the All-College Honors Curriculum (http://catalog.canisius.edu/undergraduate/academics/ curricular-information/all-college-honors-program/). Many schools refer to their college-wide undergraduate requirements as "general education" requirements. We believe that the core curriculum and the honors curriculum are more than a series of required classes; they provide the basis for a Jesuit education both with content and with required knowledge and skills attributes that are central to our mission.

## Free Electives

Students may graduate with a bachelor's degree with more but not less than 120 credit hours. Free electives are courses in addition to the Canisius Core Curriculum or All-College Honors Curriculum and major requirements sufficient to reach the minimum number of credits required for graduation. The number of credits required to complete a bachelor's degree may vary depending on the student's major(s) and minor(s).

## Major Requirements <br> Biochemistry Major with ACS-certification

Biochemistry BS track certified by the American Chemical Society is recommended for students planning to attend graduate school. This track is also appropriate for students who plan careers in the health professions.

| Code | Title Cres | Credits |
| :---: | :---: | :---: |
| CHM 111 \& 111L | General Chemistry I and General Chemistry I Laboratory | 4 |
| $\begin{aligned} & \text { CHM } 112 \\ & \& 112 \mathrm{~L} \end{aligned}$ | General Chemistry II and General Chemistry II Laboratory | 4 |
| $\begin{aligned} & \text { CHM } 227 \\ & \& 227 \mathrm{~L} \end{aligned}$ | Organic Chemistry I and Organic Chemistry I Laboratory | 4 |
| $\begin{aligned} & \text { CHM } 228 \\ & \& 228 \mathrm{~L} \end{aligned}$ | Organic Chemistry II and Organic Chemistry II Laboratory | 4 |
| $\begin{aligned} & \text { CHM } 230 \\ & \& 230 \mathrm{~L} \end{aligned}$ | Analytical Chemistry and Analytical Chemistry Laboratory | 4 |
| CHM 244 | Inorganic Chemistry | 3 |
| $\begin{aligned} & \text { CHM } 301 \\ & \& 301 \mathrm{~L} \end{aligned}$ | Fundamental Physical Chemistry and Fundamental Physical Chemistry Laboratory | 4 |
| $\begin{aligned} & \text { CHM } 302 \\ & \& 302 \mathrm{~L} \end{aligned}$ | Modern Physical Chemistry and Modern Physical Chemistry Laboratory | 4 |
| Select one of the following: |  | 4 |
| $\begin{aligned} & \text { CHM } 334 \\ & \& 334 \mathrm{~L} \end{aligned}$ | Spectrometric Analysis and Spectrometric Analysis Lab |  |
| $\begin{aligned} & \text { CHM } 430 \\ & \& 430 \mathrm{~L} \end{aligned}$ | Instrumental Analytical Chemistry and Instrumental Analytical Chemistry Laboratory |  |
| CHM 420 | Materials Chemistry | 3 |
| CHM 381 | Scientific Literature and Communication | 1 |
| CHM 480 | Communicating Concepts in Chemistry | 1 |


| CHM 481 | Communicating Research Literature | 1 |
| :--- | :--- | ---: |
| BCH 301 | Introduction to Biochemistry |  |
| \& 301L | and Introduction to Biochemistry Laboratory | 4 |
| BCH 302 | Cellular Biochemistry | 4 |
| BCH 403 Molecular Biology <br> \& 403L and Molecular Biology Laboratory <br> BIO 111 Introductory Biology I <br> \& 111L and Introductory Biology Laboratory I <br> BIO 112 Introductory Biology II <br> \& 112L and Introductory Biology Laboratory II <br> MAT 111 Calculus I <br> MAT 112 Calculus II <br> PHY 223 General Physics for Physical Science Majors I <br> \& 223Land General Physics for Physical Science Majors I <br> Laboratory | 4 |  |
| PHY 224 | General Physics for Physical Science Majors II <br> \& 224L | 4 |

Total Credits

## Biochemistry Track

Biochemistry BS track designed for students who intend to pursue employment in industry. This track is also appropriate for students who plan careers in the health professions.

| Code | Title | Credits |
| :--- | :--- | ---: |
| Required Science Courses |  |  |
| CHM 111 | General Chemistry I <br> \& 111L | 4 |
| CHM 112 | General Chemistry II <br> \& 112L | and General Chemistry II Laboratory |
| CHM 244 | Inorganic Chemistry | 4 |
| CHM 227 | Organic Chemistry I <br> \& 227L | and Organic Chemistry I Laboratory |
| CHM 228 Organic Chemistry II <br> \& 228L and Organic Chemistry II Laboratory | 3 |  |
| CHM 301 | Fundamental Physical Chemistry | 4 |
| Select one of the following: | 4 |  |


| $\begin{aligned} & \text { CHM } 334 \\ & \& 334 \mathrm{~L} \end{aligned}$ | Spectrometric Analysis and Spectrometric Analysis Lab |  |
| :---: | :---: | :---: |
| $\begin{aligned} & \text { CHM } 430 \\ & \& 430 \mathrm{~L} \end{aligned}$ | Instrumental Analytical Chemistry and Instrumental Analytical Chemistry Laboratory |  |
| CHM 381 | Scientific Literature and Communication | 1 |
| CHM 480 | Communicating Concepts in Chemistry | 1 |
| CHM 481 | Communicating Research Literature | 1 |
| Choose one Chemistry (CHM), Biochemistry (BCH), or Biology (BIO) Elective (300- or 400-level course) |  | 3 |
| Choose one Biochemistry (BCH) Elective ${ }^{1}$ |  | 3 |
| $\begin{aligned} & \mathrm{BCH} 301 \\ & \& 301 \mathrm{~L} \end{aligned}$ | Introduction to Biochemistry and Introduction to Biochemistry Laboratory | 4 |
| BCH 302 | Cellular Biochemistry | 3 |
| $\begin{aligned} & \mathrm{BCH} 403 \\ & \& 403 \mathrm{~L} \end{aligned}$ | Molecular Biology and Molecular Biology Laboratory | 4 |
| BIO 111 \& 111L | Introductory Biology I and Introductory Biology Laboratory I | 4 |


| BIO 112 | Introductory Biology II | 4 |
| :--- | :--- | ---: |
| \& 112L | and Introductory Biology Laboratory II |  |
| MAT 111 | Calculus I | 4 |
| MAT 112 | Calculus II ${ }^{2}$ | $3-4$ |
| or MAT 141 | Inferential Statistics and Computers for Science |  |
| or PSY 201 | Basic Statistics for Behavioral Sciences |  |
| PHY 201 | College Physics I |  |
| \& 201L | and College Physics I Laboratory | 4 |
| PHY 202 | College Physics II <br> \& 202L | and College Physics II Laboratory |

Total Credits 69-70
${ }^{1}$ Choose from any 300- or 400 -level BCH course not used to fulfill specific major requirements or CHM 334 (if not used to fulfill spectroscopy requirement), CHM 450, CHM 455, BIO 419, BIO 430, or BIO 444.
${ }^{2}$ Students minoring in business may take ECO 255 in lieu of MAT 112 or MAT 141 or PSY 201.

## Roadmap

Recommended Semester Schedule for Major Course Requirements
BCH ACS Certified Track

| Freshman |  |
| :--- | :--- |
| Fall | Spring |
| CHM 111 | CHM 112 |
| \& 111L | \& 112 L |
| BIO 111 | BIO 112 |
| \& 111L | \& 112 L |
| MAT 111 | MAT 112 |
| Sophomore |  |
| Fall | Spring |
| CHM 227 | CHM 228 |
| \& 227L | $\& 228$ L |
| CHM 244 | PHY 224 |
|  | $\& 224$ L |

PHY 223
\& 223L
Junior

| Fall | Spring |
| :--- | :--- |
| BCH 301 | BCH 302 |
| \& 301L |  |
| CHM 381 | CHM 230 |
|  | \& 230L |
|  | CHM 480 |
| Senior |  |
| Fall | Spring |
| CHM 301 | CHM 430 |
| \& 301L | $\& 430 L^{1}$ |
| CHM 334 | CHM 302 |
| \& 334L | $\& 302 \mathrm{~L}$ |
| CHM 481 | BCH 403 |
|  | $\& 403 \mathrm{~L}$ |
|  | CHM 420 |

Either CHM 334/CHM 334L or CHM 430/CHM 430L is required.

## BCH ACS Certified Track with Business Minor

Freshman

| Fall | Spring |
| :--- | :--- |
| CHM 111 | CHM 112 |
| \& 111L | \& 112 L |
| BIO 111 | BIO 112 |
| \& 111L | \& 112 L |
| MAT 111 | MAT 112 |
| Sophomore |  |
| Fall | Spring |
| CHM 227 | CHM 228 |
| \& 227L | \& 228L |
| CHM 244 | ECO 102 |
| ECO 101 | MAT 141 or ECO 255 |
| PHY 223 | PHY 224 |
| \& 223L | $\& 224$ L |

Junior

| Fall | Spring |
| :--- | :--- |
| BCH 301 | BCH 302 |
| \& 301L |  |
| CHM 381 | CHM 230 |
|  | \& 230L |
|  | CHM 480 |
|  | MGT 101 |
| Senior |  |
| Fall | Spring |
| CHM 301 | CHM 430 |
| \& 301L | $\& 430$ $^{1}$ |
| CHM 334 | CHM 302 |
| \& 334L | $\& 302$ L |
| CHM 481 | BCH 403 |
|  | $\& 403$ L |
| ACC 201 | FIN 201 |
| MKT 201 | CHM 420 |

1 Either CHM $334 / \mathrm{CHM} 334 \mathrm{~L}$ or $\mathrm{CHM} 430 / \mathrm{CHM} 430 \mathrm{~L}$ is required.

## BCH Track

Freshman

| Fall | Spring |
| :--- | :--- |
| CHM 111 | CHM 112 |
| \& 111L | \& 112 L |
| BIO 111 | BIO 112 |
| \& 111L | \& 112 L |
| MAT 111 | MAT 141 or 112 |
| Sophomore |  |
| Fall | Spring |
| CHM 227 | CHM 228 |
| \& 227L | \& 228L |
| PHY 201 | PHY 2O2 |
| \& 201L | $\& 202$ L |


| Junior |  |
| :---: | :---: |
| Fall | Spring |
| BCH 301 | BCH 302 |
| \& 301L |  |
| CHM 244 | CHM 480 |
| CHM 381 | BCH elective |
| Senior |  |
| Fall | Spring |
| CHM 301 | $\begin{aligned} & \text { CHM } 430 \\ & \& 430 L^{1} \end{aligned}$ |
| CHM 334 | BCH 403 |
| \& $334 \mathrm{~L}^{1}$ | \& 403L |
| CHM 481 | CHM Elective or BCH Elective |

## BCH Track with Business Minor

Freshman

| Fall | Spring |
| :---: | :---: |
| CHM 111 | CHM 112 |
| \& 111L | \& 112L |
| BIO 111 | BIO 112 |
| \& 111L | \& 112L |
| MAT 111 | MAT 141 or ECO 255 |
| Sophomore |  |
| Fall | Spring |
| CHM 227 | CHM 228 |
| \& 227L | \& 228L |
| PHY 201 | PHY 202 |
| \& 201L | \& 202L |
| ECO 101 | ECO 102 |
| Junior |  |
| Fall | Spring |
| BCH 301 | BCH 302 |
| \& 301L |  |
| CHM 244 | CHM 480 |
| CHM 381 | MGT 101 |
|  | BCH elective |
| Senior |  |
| Fall | Spring |
| CHM 301 | CHM 430 |
|  | \& 430L ${ }^{1}$ |
| CHM 334 | BCH 403 |
| \& $334 L^{1}$ | \& 403L |
| CHM 481 | CHM or BCH Elective |
| ACC 201 | FIN 201 |

MKT 201
1 Either CHM 334/CHM 334L or CHM 430/CHM 430L is required.

## Learning Goals and Objectives

## Student Learning Goal 1:

Knowledge; Demonstrate an understanding of fundamental chemical concepts.
Students will:

- Objective A Demonstrate broad knowledge of chemical concepts.
- Objective B Analyze and predict the effects of chemical changes.


## Student Learning Goal 2: <br> Professional Skills; Work effectively in a professional or laboratory setting. <br> Students will:

- Objective A Carry out experiments (follow directions, manipulate materials and lab apparatus, record data).
- Objective B Use modern instrumentation (prepare samples, operate systems, troubleshoot common problems, organize and label data).
- Objective C Demonstrate knowledge of chemical, instrumental and workplace safety.


## Student Learning Goal 3: <br> Communication; Be proficient in the communication of chemical information. <br> Students will: <br> - Objective A Construct and deliver an effective oral presentation. <br> - Objective B Write an effective, properly formatted scientific report. <br> - Objective C Identify, access and use chemical and biochemical literature sources.

## Courses

BCH 301 Introduction to Biochemistry
3 Credits
Structure and function of biological molecules. Topics include proteins, carbohydrates, nucleic acids, lipids,enzyme kinetics, ligand binding, recombinant DNA technology and cell membrane structure and transport.Three lectures and one recitation per week.
Prerequisite: BIO 111 \& minimum grade of C- in CHM 228.
Offered: every fall.
BCH 301L Introduction to Biochemistry Laboratory 1 Credit
One four-hour lab per week.
Prerequisite: BCH 301 (or concurrent registration).
Offered: every fall.
BCH 302 Cellular Biochemistry
3 Credits
The more biological aspects of biochemistry. Topics include signal transduction, bioenergetics, metabolism of carbohydrates, lipids, proteins and metabolic control,emphasizing hormones. Three lectures and one recitation per week.
Prerequisite: minimum grade of C - in BCH 301.
Offered: every spring.
BCH 403 Molecular Biology 3 Credits
Biochemical processes at the cellular and molecular level. Topics include
DNA structure in chromosomes, replication, repair, and recombination, DNA transcription, RNA structure and function, protein translation and regulation of these processes.
Prerequisite: minimum grade of C - in BCH 301.
Offered: spring of odd-numbered years.

BCH 403L Molecular Biology Laboratory
1 Credit
One four-hour lab per week.
Prerequisite: BCH 301 L \& BCH 403 (or concurrent registration in
BCH 403).
Fulfills College Core: Advanced Writing-Intensive
Offered: spring of odd-numbered years.
BCH 415 Biochemistry of Viruses 3 Credits
Fundamental biochemical description of the structure and properties of viruses. Topics include different types of viruses, the underlying biochemical principles for host-virus interactions, and how viruses can cause diseases.
Prerequisite: BCH 301.
Offered: spring of even-numbered years.
BCH 450 Research in Biochemistry 3 Credits
Independent research under the direction of the biochemistry faculty.
Students are required to spend 9 hours per week conducting research.
BCH 450 may be taken in place of a biochemistry elective without
lab. Research and consultation times to be arranged after approval of department chair.
Prerequisite: permission of department chair.
Offered: fall \& spring.
BCH 451 Research in Biochemistry 4 Credits
Independent research under the direction of the biochemistry faculty.
Students are required to spend 12 hours per week conducting research.
BCH 451 may be taken in place of a biochemistry elective with lab. Research and consultation times to be arranged after approval of department chair. Prerequisite: permission of department chair.
Offered: fall \& spring.
BCH 499 Independent Study

## 3 Credits

Independent study under the direction of the biochemistry professor.
Independent studies require an application and approval by the associate

## dean.

Prerequisite: permission of the instructor, department chair, \& associate dean.
Offered: fall \& spring.

