

# BIOMEDICAL SCIENCE & BIOTECHNOLOGY (MS)

## Biomedical Sciences & Biotechnology Overview

The Master's program in Biomedical Sciences and Biotechnology (BSBT) provides students with a broad education and training that will prepare them for research or research-related jobs in academia or industry, or for further training in graduate or professional programs.

The BSBT Program was designed and is recognized by the National Professional Science Master's Association (NPSMA) as a Professional Science Master's Program (PSM), the first such program in the CU system. The program trains students beyond the STEM disciplines of biomedical sciences and biotechnology by requiring training also in arenas that are a) auxiliary to these disciplines, such as scientific writing and project management, and b) informative about biotechnology related components in business and regulatory affairs.

### Microbiology & Immunology Track Overview

The Immunology and Microbiology Program Plan will provide students with a focused education in immunology and microbiology as well as laboratory skills. The goal will be to enhance career advancement in education or industry or prepare a student for a career in research, including further training in graduate and professional programs. Importantly, this program will provide extensive hands-on research experience, where students will be trained in research laboratories located within the department of Immunology and Microbiology at the University of Colorado School of Medicine. Students will complete 38 units that include core course work, electives and participation in cutting-edge research, as well as write and defend a thesis.

### Structural Biology Track Overview

The Structural Biology and Biochemistry track will provide students with graduate level training in structural biology, biophysics biochemistry with an emphasis on laboratory research. Students will acquire a solid foundation and specialized skills in biomedical, biophysical, and structural sciences that will be preparation for further education in graduate and professional programs as well as a career in academic research or industry. The curriculum includes 38 units of core course work, electives and participation in cutting-edge research in the laboratory of an STBB faculty member. Students will demonstrate original investigation showing critical judgment, as well as familiarity with tools and methods of research, through preparation of a dissertation that will be defended prior to obtaining the degree.

## Admission Requirements

### General Track Admission Requirements

- A bachelor's degree with a minimum overall GPA of 3.0
- Official transcripts of all undergraduate work and any previous graduate work
- A completed Graduate School application
- Three academic letters of recommendation
- Letter of intent describing in which way the program could support the student's next career steps and which kind of prior training the

student acquired in biochemistry, molecular biology, cell biology and genetics

- A nonrefundable application fee

Official transcripts from all post-secondary colleges and/or universities should be emailed directly from the issuing institution to: [graduate.school@cuanschutz.edu](mailto:graduate.school@cuanschutz.edu) (preferred)

If sending a physical transcript, please have it mailed directly from the issuing institution to:

University of Colorado Anschutz Medical Campus  
Graduate School  
Mail Stop C296  
Fitzsimons Building, C5000  
13001 E. 17th Place  
Aurora, CO 80045  
International students must meet ALL of the requirements above and those required by International Admissions.

### Microbiology & Immunology Track Admission Requirements

- A bachelor's degree with a minimum GPA of 3.0
- Official General GRE or MCAT (both optional)
- Complete transcripts of undergraduate work and any previous graduate work
- A completed application to Graduate Studies
- Three academic letters of recommendation
- Letter of intent
- Strong background in biological sciences. BA/BA in molecular biology, cell biology, genetics, immunology, microbiology or equivalent specialty

To apply for admission applicants must submit the following:

- Online Graduate School application
  - Personal Statement: A one-page personal statement describing the applicant's career goals and purpose for studying biomedical sciences and biotechnology
  - Resume: The applicant's current resume or curriculum vitae, including professional work/practice since graduating with a bachelor's degree (or equivalent).
  - Personal statement.
  - Three recommendation letters from people who know your professional, academic and/or personal achievements or qualities well.
- Application Fee: A nonrefundable application fee of \$75.00 (U.S. dollars). Checks or money orders should be made payable to the University of Colorado.
- Transcripts: Official transcripts from all post-secondary colleges and/or universities should be sent directly to:
  - Electronic Transcripts should be sent to: [graduate.school@cuanschutz.edu](mailto:graduate.school@cuanschutz.edu) (preferred)
  - If sending a physical transcript, please mail to:

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Aurora, CO 80045

International students must meet ALL of the requirements above and those required by International Admissions.

## Structural Biology Track Admission Requirements

- A bachelor's degree with a minimum GPA of 3.0
- Official General GRE or MCAT (both optional)
- Complete transcripts of undergraduate work and any previous graduate work
- A completed application to Graduate Studies
- Three academic letters of recommendation
- Letter of intent
- Training in biology, biochemistry, chemistry, biological chemistry, biophysics

To apply for admission applicants must submit the following:

### Online Graduate School application

- Personal Statement: A one-page personal statement describing the applicant's career goals and purpose for studying biomedical sciences and biotechnology
- Resume: The applicant's current resume or curriculum vitae, including professional work/practice since graduating with a bachelor's degree (or equivalent).
- Personal statement.
- Three recommendation letters from people who know your professional, academic and/or personal achievements or qualities well.

Application Fee: A nonrefundable application fee of \$75.00 (U.S. dollars). Checks or money orders should be made payable to the University of Colorado.

Transcripts: Official transcripts from all post-secondary colleges and/or universities should be sent directly to:

- Electronic Transcripts should be sent to: [graduate.school@cuanschutz.edu](mailto:graduate.school@cuanschutz.edu) (preferred)
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## Curriculum

The Professional Science Master's Program in Biomedical Sciences and Biotechnology requires a total of 38 credits that full-time students can earn in two years. However, students can also enroll part time. An enrollment for a minimum of 5 credits is required for financial aid eligibility.

In addition to the science courses, in the General BSBT Program, students are required to enroll in professional development courses (Plus Courses) such as biomedical entrepreneurship, project management and

regulatory affairs. These Plus Courses provide additional training that is very much valued by employers inside and outside academia.

The mandatory internship requires students to apply their base science and professional training in a hands-on, real-world setting. In consultation with the Program Director, students choose an internship that suits their future career aspirations. For example, students who are interested in a career in research can pursue an internship in an academic lab or a company. Students can also carry out an internship in a biotech business setting, regulatory affairs or technology transfer. Employers inside and outside academia often view the internship as an extended interview, and after graduation, quite a number of our graduates stayed at their internship site for employment. Some students have also used our program successfully as a stepping stone towards medical or DO school or a PhD program.

38 credits are required for graduation in the BSBT-PSM Program, and graduate students must maintain an overall GPA of at least 3.0 ("B"). Courses with the grade of "C" are not accepted for graduation.

## General Track

### First Year

#### Year 1

Fall		Hours
BSBT 6065	Case Studies in Responsible Conduct of Research	1
BSBT 6072	Foundations in Biochemistry	1.5
BSBT 6073	Foundations in Molecular Biology	1.5
BSBT 6074	Foundations in Cell Biology	1.5
BSBT 6075	Foundations in Genetics	1.5
<b>Hours</b>		<b>7</b>

#### Spring

BSBT 6067	Statistics for Biomedical Sciences	2
Choose 1 course from the following:		
BSBT 6071	Introduction to R Programming	
BSBT 6113	Data Science with R	
BSBT 6804	Bioinnovation Regulations	
BIOL 5024	Introduction to Biotechnology	3
BIOL 5125	Molecular Biology Lab	3
<b>Hours</b>		<b>8</b>
<b>Total Hours</b>		<b>15</b>

### Second Year

#### Year 2

Fall		Hours
ENGL 5175	Writing in the Sciences	3
PHSC 7330	Development of Drugs and Biologics	3
<b>Hours</b>		<b>6</b>

#### Spring

BSBT 6061	Project Management	2
BSBT 6801	Biomedical Entrepreneurship	3
BSBT 6939	Internship - Technology and Innovation Section 001	3-6
<b>Hours</b>		<b>8-11</b>
<b>Total Hours</b>		<b>14-17</b>

## Microbiology & Immunology Track

### First Year

#### Year 1

		Hours
<b>Fall</b>		
BSBT 6065	Case Studies in Responsible Conduct of Research	1
BSBT 6072	Foundations in Biochemistry	1.5
BSBT 6073	Foundations in Molecular Biology	1.5
BSBT 6074	Foundations in Cell Biology	1.5
BSBT 6075	Foundations in Genetics	1.5
BMSC 7810	Core Topics in Biomedical Science <sup>Section 002</sup>	2
<b>Hours</b>		<b>9</b>

#### Spring

BSBT 6070	Mini-Research Rotations	3
BSBT 6064	Scientific Writing	1
Choose either:		
MICB 7703	Molecular Mechanisms of Bacterial Disease	
MICB 7701	Molecular Virology and Pathogenesis	3
OR		
IMMU 7662	Immunology	
BMSC 7810	Core Topics in Biomedical Science <sup>Section 006 (Inflammation)</sup>	2
<b>Hours</b>		<b>9</b>

#### Summer

BSBT 6069	Laboratory Research in Immunology and Microbiology	1-6
<b>Hours</b>		<b>1-6</b>
<b>Total Hours</b>		<b>19-24</b>

## Second Year

#### Year 2

		Hours
<b>Fall</b>		
BSBT 6061	Project Management	2
BSBT 6069	Laboratory Research in Immunology and Microbiology	1-6
<b>Hours</b>		<b>3-8</b>

#### Spring

BSBT 6071	Introduction to R Programming	1
BSBT 6067	Statistics for Biomedical Sciences	2
BSBT 6069	Laboratory Research in Immunology and Microbiology	1-6
<b>Hours</b>		<b>4-9</b>
<b>Total Hours</b>		<b>7-17</b>

## Structural Biology Track

### First Year

#### Year 1

		Hours
<b>Fall</b>		
BSBT 6065	Case Studies in Responsible Conduct of Research	1

BSBT 6072	Foundations in Biochemistry	1.5
BSBT 6073	Foundations in Molecular Biology	1.5
BSBT 6074	Foundations in Cell Biology	1.5
BSBT 6075	Foundations in Genetics	1.5
BSBT 6076	Research Explorations	1
STBB 7660	Structure Seminar	1
BMSC 7810	Core Topics in Biomedical Science <sup>Section 001; Core Topics A</sup>	2
<b>Hours</b>		<b>11</b>

#### Spring

STBB 7608 or STBB 7609	Molecular Interactions or Biophysics & Spectroscopy	3
BSBT 6068	Laboratory Research in Structural Biology	1-6
STBB 7631	Molecular Structure A	1.5
BSBT 6076	Research Explorations	1
<b>Hours</b>		<b>6.5-11.5</b>
<b>Total Hours</b>		<b>17.5-22.5</b>

## Second Year

#### Year 2

		Hours
<b>Fall</b>		
STBB 7631	Molecular Structure A <sup>Section 004</sup>	1.5
STBB 7660	Structure Seminar	1
BSBT 6068	Laboratory Research in Structural Biology	1-6
<b>Hours</b>		<b>3.5-8.5</b>

#### Spring

BSBT 6068	Laboratory Research in Structural Biology	1-6
STBB 7660	Structure Seminar	1
<b>Hours</b>		<b>2-7</b>
<b>Total Hours</b>		<b>5.5-15.5</b>

## Learning Objectives

### Learning and Training Goals

Upon successful completion of their studies, students enrolled in the Biomedical Sciences and Biotechnology Master's Program will be able to:

- Apply principles of experimental design and problem solving in the biomedical sciences
- Apply statistical tools for data composition, mining and analysis
- Employ state-of-the-art techniques in biomedical sciences
- Design strategies for rational drug design
- Conduct research in an ethical manner
- Engage in critical analysis of the scientific literature
- Apply the principles of project management
- Understand and operate in the regulatory environment of life science innovation
- Analyze the process of biomedical entrepreneurship in academic, government, and corporate settings
- Write a well-supported, well-reasoned scientific or technical paper

Upon successful completion of their studies, students enrolled in the Biomedical Sciences Graduate Certificate program will be able to:

1. Apply principles of experimental design and problem solving in four focus areas of biomedical sciences.
2. Employ basic tools of R programming.
3. Classify data and use statistical tools to test hypotheses.
4. Recognize and manage ethical challenges related to the responsible conduct of research.

## Courses

### BIOL 5024 - Introduction to Biotechnology (3 Credits)

Introduces aspects of biotechnology within a historical context, including medical, forensic, agricultural and microbial biotechnology. Addresses principles behind state-of-the-field techniques in recombinant DNA technology, bioinformatics, proteomics and genomics. Biotechnology regulations and ethics will also be discussed. Restriction: Restricted to degree granting graduate programs on the downtown campus as well as the School of Medicine on the Anschutz Medical campus. Cross-listed with BIOL 4024. Max hours: 3 Credits.

Grading Basis: Letter Grade

Restriction: Restricted to degree granting graduate programs on the downtown campus as well as the School of Medicine on the Anschutz Medical campus.

### BIOL 5125 - Molecular Biology Lab (3 Credits)

Provides hands-on experiences in molecular biology and an appreciation for using the tools of molecular biology to study biological systems.

Emphasis is placed on DNA cloning, PCR, mRNA and protein detection in the context of gene editing. Experimental design and the theories underlying the techniques are also discussed. Restriction: Restricted to degree granting graduate programs on the downtown campus as well as the School of Medicine on the Anschutz Medical campus. Cross-listed with BIOL 4125. Term offered: spring. Max hours: 3 Credits.

Grading Basis: Letter Grade

Restriction: Restricted to degree granting graduate programs on the downtown campus as well as the School of Medicine on the Anschutz Medical campus.

Typically Offered: Spring.

### BSBT 6061 - Project Management (2 Credits)

Provides training in initiating, executing & closing a project, including the management of scope, time, cost, human resources, communication, risk and more. Highly interactive intensive course prepares students for Certified Project Management exam (internationally recognized certification). Taught by Project Management Professional.

Grading Basis: Letter Grade

Typically Offered: Fall, Spring, Summer.

### BSBT 6064 - Scientific Writing (1 Credit)

Taught by a biomedical researcher and a professional writing instructor, this 15-hour (3-week) course focuses on developing a framework for successful scientific writing practices, including how to effectively structure arguments, how to write grant proposals and more.

Grading Basis: Letter Grade

Typically Offered: Fall, Spring, Summer.

### BSBT 6065 - Case Studies in Responsible Conduct of Research (1 Credit)

Anyone conducting research using federal funding must study RCR. You'll learn expectations and regulations that permeate science. You'll understand consequences of violations to individuals and society. We'll explore misconduct through interactive video, written and video case studies, and other engaging activities.

Grading Basis: Letter Grade

Typically Offered: Fall, Spring, Summer.

### BSBT 6067 - Statistics for Biomedical Sciences (2 Credits)

Learn how and when to apply statistical procedures to answer scientific questions relevant to biomedicine, and how to critically assess statistical data for validity.

Grading Basis: Letter Grade

Typically Offered: Fall, Spring, Summer.

### BSBT 6068 - Laboratory Research in Structural Biology (1-6 Credits)

The Course BSBT 6068, Laboratory Research, with allow graduate students to engage in laboratory research training in the biomedical sciences with focus on structural biology.

Grading Basis: Letter Grade

Repeatable. Max Credits: 15.

Typically Offered: Fall, Spring, Summer.

### BSBT 6069 - Laboratory Research in Immunology and Microbiology (1-6 Credits)

The Course BSBT 6069, Laboratory Research, with allow graduate students to engage in laboratory research training in the biomedical sciences with focus on immunology and microbiology.

Grading Basis: Letter Grade

Repeatable. Max Credits: 6.

Typically Offered: Fall, Spring, Summer.

### BSBT 6070 - Mini-Research Rotations (1-3 Credits)

The Course BSBT 6070, Mini-Research Rotations, with allow graduate students to learn in three different laboratories about research in immunology and microbiology.

Grading Basis: Letter Grade with IP

Typically Offered: Fall, Spring.

### BSBT 6071 - Introduction to R Programming (1 Credit)

Introduction to the statistical programming language R geared primarily to biomedical science students with little to no previous programming experience. Basic features of R as a programming language and as scientific computing platform. Basics of data cleaning, visualization, and analysis.

Grading Basis: Letter Grade

Typically Offered: Spring.

### BSBT 6072 - Foundations in Biochemistry (1.5 Credits)

This short course provides a condensed and fast-paced overview of the fundamentals in biochemistry including research strategies and techniques. The course aims to enhance the students' ability to engage in critical scientific reasoning and problem-solving and to prepare students for the scientific analyses and discussions.

Grading Basis: Letter Grade

Typically Offered: Fall.

### BSBT 6073 - Foundations in Molecular Biology (1.5 Credits)

This short course provides a condensed and fast-paced overview of the fundamentals in molecular biology including research strategies and techniques. The course aims to enhance the students' ability to engage in critical scientific reasoning and problem-solving and to prepare students for the scientific analyses and discussions.

Grading Basis: Letter Grade

Typically Offered: Fall.

### BSBT 6074 - Foundations in Cell Biology (1.5 Credits)

This short course provides a condensed and fast-paced overview of the fundamentals in cell biology including research strategies and techniques. The course aims to enhance the students' ability to engage in critical scientific reasoning and problem-solving and to prepare students for the scientific analyses and discussions.

Grading Basis: Letter Grade

Typically Offered: Fall.

**BSBT 6075 - Foundations in Genetics (1.5 Credits)**

This short course provides a condensed and fast-paced overview of the fundamentals in genetics including research strategies and techniques. The course aims to enhance the students' ability to engage in critical scientific reasoning and problem-solving and to prepare students for the scientific analyses and discussions.

Grading Basis: Letter Grade

Typically Offered: Fall.

**BSBT 6076 - Research Explorations (1 Credit)**

This course allows for exploration of SBB research labs in a "mini-rotation" format, through meeting faculty, reading literature and participating in lab group meetings and research in order to choose a research lab and prepare a short research proposal.

Grading Basis: Letter Grade

Typically Offered: Fall, Spring.

**BSBT 6801 - Biomedical Entrepreneurship (3 Credits)**

The course addresses the essential elements of bioscience and health innovation and entrepreneurship. Prerequisites: An undergraduate degree in science, technology, business, engineering or math. Cross-listed with ENTP 6801

Grading Basis: Letter Grade

A-GRAD Restricted to graduate students only.

Typically Offered: Spring.

**BSBT 6804 - Bioinnovation Regulations (3 Credits)**

This course is designed to familiarize biomedical scientists and those interested in the business of science with the fundamentals of U.S. and international regulatory affairs regarding drug discovery and medical devices. Focus is the development of products, such as drugs, devices, diagnostic tests, and health information software, to receive U.S. and international regulatory clearance or approval for commercialization.

Grading Basis: Letter Grade

Typically Offered: Fall.

**BSBT 6939 - Internship - Technology and Innovation (3-6 Credits)**

The internship provides hands-on learning opportunities for graduate students in institutions related to technology/biotechnology, computer science, engineering, innovation and entrepreneurship. Requisite: (Formerly IDPT 6939) Enrollment with permission only, contact [inge.wefes@ucdenver.edu](mailto:inge.wefes@ucdenver.edu). Instructor Consent required.

Grading Basis: Letter Grade with IP

Repeatable. Max Credits: 6.

A-GRAD Restricted to graduate students only.

Additional Information: Report as Full Time.

Typically Offered: Fall, Spring, Summer.

**ENGL 5175 - Writing in the Sciences (3 Credits)**

Provides rhetorical analyses of scientific discourse and student practice in writing research reports and proposals. Restriction: Restricted to students at the graduate level (including non-degree and Anschutz Medical Campus programs). Cross-listed with ENGL 4175. Max hours: 3 Credits.

Grading Basis: Letter Grade

Restriction: Restricted to students at the graduate level (including non-degree and Anschutz Medical Campus programs).

**BMSC 7810 - Core Topics in Biomedical Science (2 Credits)**

Sections focus on different core topics in biomedical science, and will address subject areas such as protein structure and function, neurobiology, embryology, stem cell research, and cancer biology. Students can enroll in multiple Core Topic Courses topics in one semester. Previously offered as IDPT 7810.

Grading Basis: Letter Grade

Repeatable. Max Credits: 20.

AMC-PHD PhD Students only

Typically Offered: Fall.

**IMMU 7662 - Immunology (6 Credits)**

This course covers the basic principles of the immune system. Included are discussions on (I) the innate and adaptive immune responses, (II) the molecular and cellular basis of immune specificity and (III) aspects of clinical immunology.

Grading Basis: Letter Grade

A-GRAD Restricted to graduate students only.

Typically Offered: Spring.

**MICB 7701 - Molecular Virology and Pathogenesis (3 Credits)**

Topics in this course include viral structure and genome organization, replication and expression of viral genomes, mechanism of action of tumor viruses, molecular aspects of virus-host cell interactions, animal models of infectious diseases and pathogenesis of human viruses.

Prereq: MICB 7706, MICB 7705 are desirable but not required. Restriction: Permission of Instructor.

Grading Basis: Letter Grade

A-GRAD Restricted to graduate students only.

Typically Offered: Spring.

**MICB 7703 - Molecular Mechanisms of Bacterial Disease (3 Credits)**

The course focuses on molecular processes that bacteria utilize to cause disease in humans. The course content will use specific examples from pathogenic bacteria to illustrate common virulence mechanisms utilized to initiate, maintain and survive interactions with host cells. Prereq: Recommended Fundamentals of Microbiology Restrictions: Permission of the instructor.

Grading Basis: Letter Grade

A-GRAD Restricted to graduate students only.

Typically Offered: Spring.

**PHSC 7330 - Development of Drugs and Biologics (3 Credits)**

A survey course designed to introduce students to pharmacokinetic and pharmacodynamics principals used in drug research and development by faculty of the Skaggs School of Pharmacy, Department of Pharmaceutical Sciences. The Phoenix Winnonlin Computer software, is used to complete homework. Offered in Fall only in even-numbered years. Crosslisted with TXCL 7330.

Grading Basis: Letter Grade

A-GRAD Restricted to graduate students only.

Typically Offered: Fall.

**STBB 7608 - Molecular Interactions (3 Credits)**

Provides chemical/physical basis for protein structure, folding, function & stability; presents methods/principles of protein/peptide purification & enzyme catalysis including electron transfer & mutagenesis. The role of molecular dynamics & use of molecular simulations in the investigations of protein-ligand/protein-protein interactions. Cross-listed with PHSC 7608.

Grading Basis: Letter Grade

A-GRAD Restricted to graduate students only.

Typically Offered: Spring.



**STBB 7609 - Biophysics & Spectroscopy (1.5 Credits)**

This course aims to provide the students with a deep understanding of the application of different biophysical techniques to study interactions of biomolecules with each other or with small molecules. The course will supply the students with the needed tools to be able to design their own biophysical experiments to tackle a particular question.

Grading Basis: Letter Grade

A-GRAD Restricted to graduate students only.

Typically Offered: Spring.

**STBB 7631 - Molecular Structure A (1.5 Credits)**

Gain an in-depth understanding of the underlying principles of an NMR experiment, so that student can turn NMR theory into NMR practice for their research.

Grading Basis: Letter Grade

A-GRAD Restricted to graduate students only.

Typically Offered: Fall.

**STBB 7660 - Structure Seminar (1 Credit)**

Seminar series provides a forum for the presentation of scientific experiments and information in structural biology by faculty, postdoctoral fellows and graduate students.

Grading Basis: Letter Grade

A-GRAD Restricted to graduate students only.

Typically Offered: Fall, Spring.

## Policies

Please refer to the Graduate School Policies page (<http://catalog.ucdenver.edu/cu-anschutz/schools-colleges-programs/graduate-school/#policiestext>).

## Contact Us

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