MAJOR IN CHEMICAL AND BIOLOGICAL ENGINEERING, BIOMANUFACTURING CONCENTRATION

An education in chemical and biological engineering provides the intellectual foundation for our graduates to work on solutions to society's biggest problems (both current and future problems). For example, our graduates could go on to develop innovative materials and products, to design new devices to improve animal or human health or environmental health, and to design processes for the safe production of chemicals and biochemicals, the production of alternative energy sources, and prevention of hazardous waste. The possibilities are limitless. Chemical and biological engineering is a powerful blend of basic sciences and the skills to quantitatively describe, predict, and control all changes of matter. Our curriculum is based on the sciences of physics, chemistry, biology, and mathematics. It includes engineering science and design methods, as well as humanities and social sciences. The Chemical and Biological Engineering program provides an environment that promotes a sense of professionalism, the development of project management skills, and an appreciation for the value of life-long learning. Graduates of our program are well prepared to enter a variety of professions, or to pursue further advanced education. The broad, strong scientific basis of chemical and biological engineering has kept our graduates consistently near or at the top in salary and demand among B.S. graduates.

Biomanufacturing Concentration

Biomanufacturing is a broad and growing field that combines biology and engineering to produce valuable products on a large scale using living organisms like bacteria, yeast, or mammalian cells.#It is a field that has significant impact on various industries such as pharmaceuticals, agriculture, food and beverage production, and other bioproducts such as fuels, chemicals, and materials. The biomanufacturing concentration offers students a chemical and biological engineering foundation with specialized training in biomanufacturing.#Coursework will focus on further building biological and engineering core competencies in various areas of biomanufacturing. These courses will enable and encourage students to solve complex engineering problems in biomanufacturing. #Professionals in this field are in demand to develop and manage bioproduction processes. It is a field that is constantly evolving and holds promise for addressing various global challenges, such as healthcare, energy, and sustainability.

The Chemical and Biological Engineering major is accredited by the Engineering Accreditation Commission of ABET (http://abet.org/).

Requirements Effective Fall 2024

Students may enroll in either the standalone major or (at most) one of the concentrations under the Major in Chemical and Biological Engineering.

Freshman

		AUCC	Credits
CBE 160	MATLAB for Chemical and Biological Eng		1
CHEM 111	General Chemistry I (GT-SC2)	3A	4
CHEM 112	General Chemistry Lab I (GT-SC1)	3A	1
CHEM 113	General Chemistry II		3
CHEM 114	General Chemistry Lab II		1
CO 150	College Composition (GT-CO2)	1A	3
LIFE 102	Attributes of Living Systems (GT-SC1)	3A	4
MATH 160	Calculus for Physical Scientists I (GT-MA1)	1B	4
MATH 161	Calculus for Physical Scientists II (GT-MA1)	1B	4
PH 141	Physics for Scientists and Engineers I (GT-SC1)	3A	5
Select one group from the following:			3
Group A:			
CBE 101	Introduction to Chemical and Biological Engr		
Group B:			
CBE 101A	Introduction to Chemical and Biological Engr: Lecture		
CBE 101B	Introduction to Chemical and Biological Engr: Laboratory		
Group C:			
CBE 104A	Study Abroad--Denmark: Intro to Chemical and Biological Engineering		
	Total Credits		**33**

Sophomore

CBE 201	Material and Energy Balances	3
CBE 205	Fundamentals of Biological Engineering	3
CBE 210	Thermodynamic Process Analysis	3

CHEM 341	Modern Organic Chemistry I		3
CHEM 343	Modern Organic Chemistry II		3
CHEM 344	Modern Organic Chemistry Laboratory		2
MATH 261	Calculus for Physical Scientists III		4
MATH 340	Intro to Ordinary Differential Equations		4
PH 142	Physics for Scientists and Engineers II (GT-SC1)	3A	5
Diversity, Equity, and Inclusion (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#diversity-equity-inclusion)		1C	3
	Total Credits		**33**

Junior

BC 351	Principles of Biochemistry		4
CBE 310	Molecular Concepts and Applications		3
CBE 320	Chemical and Biological Reactor Design		3
CBE 330	Process Simulation		3
CBE 331	Momentum Transfer and Mechanical Separations		3
CBE 332	Heat and Mass Transfer Fundamentals		3
CBE 393	Professional Development Seminar		1
Bioscience Elective (see list below)			3
Technical Elective (see list below)			3
Advanced Writing (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#advanced-writing)		2	3
Arts and Humanities (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-humanities)		3B	3
	Total Credits		**32**

Senior

CBE 333	Chemical and Biological Engineering Lab I		2
CBE 430	Process Control and Instrumentation		3
CBE 442	Separation Processes		4
CBE 443	Chemical and Biological Engineering Lab II		2
CBE 451	Chemical and Biological Engineering Design I	4A,4B,4C	3
CBE 452	Chemical and Biological Engineering Design II	4A,4B,4C	3
Engineering Elective (see list below)			3
Technical Elective (see list below)			3
Arts and Humanities (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-humanities)		3B	3
Historical Perspectives (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#historical-perspectives)		3D	3
Social and Behavioral Sciences (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#social-behavioral-sceinces)		3C	3
	Total Credits		**32**
	Program Total Credits:		**130**

Bioscience Electives

Select a minimum of 3 credits from the following.

Code	Title	Credits
MIP 300	General Microbiology	3

Technical Electives

Select a minimum of 6 credits from the following, or select additional credits from the Bioscience Electives or Engineering Electives lists.

Code	Title	Credits
BC 406A	Investigative Biochemistry: Protein Biochemistry	2
BC 406C	Investigative Biochemistry: Cellular Biochemistry	2
BC 411	Physical Biochemistry	4
BC 441	3D Molecular Models for Biochemistry	1
BC 463	Molecular Genetics	3
BC 465	Molecular Regulation of Cell Function	3
BIOM 533/CIVE 533	Biomolecular Tools for Engineers	3

GES 542	Biobased Fuels, Energy, and Chemicals	3
LIFE 210	Introductory Eukaryotic Cell Biology	3
MIP 334	Food Microbiology	3
MIP 450	Microbial Genetics	3

Engineering Electives

Select a minimum of 3 credits from the following.

Code	Title	Credits
BIOM 422	Quantitative Systems and Synthetic Biology	3
CBE 504/BIOM 504	Fundamentals of Biochemical Engineering	3
CBE 505	Biochemical Engineering Laboratory	1
CBE 522/BIOM 522	Bioseparation Processes	3
CBE 540/CIVE 540	Advanced Biological Wastewater Processing	3
CBE 560	Engineering of Protein Expression Systems	3
CBE 570	Biomolecular Engineering/Synthetic Biology	3

Major Completion Map

Students may enroll in either the standalone major or (at most) one of the concentrations under the Major in Chemical and Biological Engineering.

Distinctive Requirements for Degree Program:

TO PREPARE FOR FIRST SEMESTER: The curriculum for this major assumes students enter college prepared to take calculus.

Freshman

Semester 1		**Critical**	**Recommended**	**AUCC**	**Credits**
CBE 160	MATLAB for Chemical and Biological Eng	X			1
CHEM 111	General Chemistry I (GT-SC2)	X		3A	4
CHEM 112	General Chemistry Lab I (GT-SC1)	X		3A	1
LIFE 102	Attributes of Living Systems (GT-SC1)	X		3A	4
MATH 160	Calculus for Physical Scientists I (GT-MA1)	X		1B	4
Select one group from the following:		X			3
Group A:					
CBE 101	Introduction to Chemical and Biological Engr				
Group B:					
CBE 101A	Introduction to Chemical and Biological Engr: Lecture				
CBE 101B	Introduction to Chemical and Biological Engr: Laboratory				
Group C:					
CBE 104A	Study Abroad--Denmark: Intro to Chemical and Biological Engineering				
	Total Credits				**17**
Semester 2		**Critical**	**Recommended**	**AUCC**	**Credits**
CHEM 113	General Chemistry II	X			3
CHEM 114	General Chemistry Lab II	X			1
CO 150	College Composition (GT-CO2)	X		1A	3
MATH 161	Calculus for Physical Scientists II (GT-MA1)	X		1B	4
PH 141	Physics for Scientists and Engineers I (GT-SC1)	X		3A	5
	Total Credits				**16**

Sophomore

Semester 3		**Critical**	**Recommended**	**AUCC**	**Credits**
CBE 201	Material and Energy Balances	X			3
CBE 205	Fundamentals of Biological Engineering	X			3
CHEM 341	Modern Organic Chemistry I	X			3
MATH 261	Calculus for Physical Scientists III	X			4
Diversity, Equity, and Inclusion (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#diversity-equity-inclusion)				1C	3
	Total Credits				**16**
Semester 4		**Critical**	**Recommended**	**AUCC**	**Credits**
CBE 210	Thermodynamic Process Analysis	X			3
CHEM 343	Modern Organic Chemistry II	X			3
CHEM 344	Modern Organic Chemistry Laboratory	X			2
MATH 340	Intro to Ordinary Differential Equations	X			4

PH 142	Physics for Scientists and Engineers II (GT-SC1)	X		3A	5
	Total Credits				**17**
Junior					
Semester 5		**Critical**	**Recommended**	**AUCC**	**Credits**
BC 351	Principles of Biochemistry	X			4
CBE 310	Molecular Concepts and Applications	X			3
CBE 330	Process Simulation	X			3
CBE 331	Momentum Transfer and Mechanical Separations	X			3
Advanced Writing (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#advanced-writing)		X		2	3
	Total Credits				**16**
Semester 6		**Critical**	**Recommended**	**AUCC**	**Credits**
CBE 320	Chemical and Biological Reactor Design	X			3
CBE 332	Heat and Mass Transfer Fundamentals	X			3
CBE 393	Professional Development Seminar	X			1
Bioscience Elective (see list on Program Requirements tab)		X			3
Technical Elective (see list on Program Requirements tab)		X			3
Arts and Humanities (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-humanities)				3B	3
	Total Credits				**16**
Senior					
Semester 7		**Critical**	**Recommended**	**AUCC**	**Credits**
CBE 333	Chemical and Biological Engineering Lab I	X			2
CBE 442	Separation Processes	X			4
CBE 451	Chemical and Biological Engineering Design I	X		4A,4B,4C	3
Technical Elective (see list on Program Requirements tab)		X			3
Arts and Humanities (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#arts-humanities)			X	3B	3
	Total Credits				**15**
Semester 8		**Critical**	**Recommended**	**AUCC**	**Credits**
CBE 430	Process Control and Instrumentation	X			3
CBE 443	Chemical and Biological Engineering Lab II	X			2
CBE 452	Chemical and Biological Engineering Design II	X		4A,4B,4C	3
Engineering Elective (see list on Program Requirements tab)		X			3
Historical Perspectives (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#historical-perspectives)		X		3D	3
Social and Behavioral Sciences (http://catalog.colostate.edu/general-catalog/all-university-core-curriculum/aucc/#social-behavioral-sciences)		X		3C	3
The benchmark courses for the 8th semester are the remaining courses in the entire program of study.		X			
	Total Credits				**17**
	Program Total Credits:				**130**