

BIOMEDICAL SCIENCE, BA

2nd Major for College Students only.

College students can apply for a second major in Biomedical Science. This will result in a single degree from the College with two majors (note that this option is only for students in the College, not Engineering students).

Students must to complete 12.5 Credit Units of Engineering requirements, taken from the BAS Program (<https://be.seas.upenn.edu/undergraduate/curriculum/bas-requirements/>). Background courses in Mathematics and the Natural Sciences are also required.

Curriculum

Code	Title	Course Units
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Minimal Math and Science Background Required:

Mathematics

MATH 1400	Calculus, Part I
MATH 1410	Calculus, Part II
ENM 2400	Differential Equations and Linear Algebra
or MATH 2400	Calculus, Part III
or MATH 2600	Honors Calculus, Part II
ENM 3750	Biological Data Science I - Fundamentals of Biostatistics
or ENM 3440	Answering Questions with Data, for Everyone
or ESE 4020	Statistics for Data Science
or STAT 4310	Statistical Inference

Science

BIOL 1121	Introduction to Biology - The Molecular Biology of Life
BIOL 1123	Introductory Molecular Biology Laboratory
BIOL 3310	Principles of Human Physiology
CHEM 1012	General Chemistry I
or CHEM 1150	Honors Chemistry I
CHEM 1101	General Chemistry Laboratory I
CHEM 1022	General Chemistry II
or CHEM 1160	Honors Chemistry II
CHEM 1102	General Chemistry Laboratory II
PHYS 0140	Principles of Physics I (without laboratory)
PHYS 0141	Principles of Physics II (without laboratory)

Engineering Requirements

BE 1000	Introduction to Bioengineering	0.5
ENGR 1050	Introduction to Scientific Computing (or CIS 1200 or higher)	1
BE 2000	Introduction to Biomechanics	1
BE 2200	Biomaterials	1
BE 2700	Bioengineering Laboratory Principles	1
BE 3010	Bioengineering Signals and Systems	1
or BE 3060	Cellular Engineering	
or BE 3500	Introduction to Biotransport Processes	
BE 3090	Bioengineering Modeling, Analysis and Design Laboratory I	1
BE 4970	Senior Thesis in Biomedical Science	1

BE 4980	Senior Thesis in Biomedical Science	1
BE Elective (4000 or 5000 level)		2
Engineering Elective ¹		2
Total Course Units		12.5

¹ Engineering Electives (Engineering XXXX) in the Engineering Category can be fulfilled by any course that counts as Engineering per the handbook (<https://ugrad.seas.upenn.edu/student-handbook/courses-requirements/engineering-courses/>). Please note that EAS (Engineering and Applied Science) courses DO NOT count as Engineering.

The degree and major requirements displayed are intended as a guide for students entering in the Fall of 2025 and later. Students should consult with their academic program regarding final certifications and requirements for graduation.

Degree Concentrations

Students may select one of nine concentrations (<http://www.be.seas.upenn.edu/current-students/undergraduates/concentrations.php>).

Concentrations are not required, but are intended to provide students with the option to obtain a more focused education in a particular field of study or sub-topic within a given field. To satisfy the requirements for a concentration, students must select at least 4 courses from any of the categories listed below. At least two courses must be from Bioengineering.

Biomedical Data Science and Computational Medicine

Code	Title	Course Units
Select 2 courses in:		2
BE 4900	Independent Project in Bioengineering ***	
BE 5040	Biological Data Science II: Data Mining Principles for Epigenomics	
BE 5210	Brain-Computer Interfaces	
BE 5300	Theoretical and Computational Neuroscience	
BE 5590	Multiscale Modeling of Chemical and Biological Systems	
BE 5660	Networked Neuroscience	
Select 2 additional courses in:		2
BE 4900	Independent Project in Bioengineering	
BE 5040	Biological Data Science II: Data Mining Principles for Epigenomics	
BE 5210	Brain-Computer Interfaces	
BE 5300	Theoretical and Computational Neuroscience	
BE 5590	Multiscale Modeling of Chemical and Biological Systems	
BE 5660	Networked Neuroscience	
CIS 4210	Artificial Intelligence	
or CIS 5210	Artificial Intelligence	

CIS 4500	Database and Information Systems
CIS 5200	Machine Learning
CIS 5450	Big Data Analytics
CBE 5250	Molecular Modeling and Simulations
ESE 3050	Foundations of Data Science
ESE 5420	Statistics for Data Science
BIOM 5350	Introduction to Bioinformatics
or CIS 5350	Introduction to Bioinformatics
or MTR 5350	Introduction to Bioinformatics
BIOL 4511	Biological Data Analysis
BIOL 5536	Fundamentals of Computational Biology
or CIS 5360	Fundamentals of Computational Biology
or GCB 5360	Fundamentals of Computational Biology
GCB 5370	Advanced Computational Biology
STAT 9915	Seminar in Advanced Application of Statistics

Total Course Units 4

Biomedical Devices

Code	Title	Course Units
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Select 2 courses in: 2

BE 4700	Medical Devices
BE 4720	Medical Device Development *
BE 4900	Independent Project in Bioengineering ***
BE 5020	From Biomedical Science to the Marketplace
BE 5140	Rehab Engineering and Design
BE 5180	Optical Microscopy
BE 5210	Brain-Computer Interfaces
BE 5280	Applied Medical Innovation I *
BE 5290	Applied Medical Innovation II *
BE 5510	Biomicrofluidics
BE 5560	Molecular Diagnostics for Precision Medicine
BE 5700	Biomechanics

Select 2 additional courses in: 2

BE 4700	Medical Devices
BE 4720	Medical Device Development *
BE 4900	Independent Project in Bioengineering ***
BE 5020	From Biomedical Science to the Marketplace
BE 5140	Rehab Engineering and Design
BE 5180	Optical Microscopy
BE 5210	Brain-Computer Interfaces
BE 5280	Applied Medical Innovation I *
BE 5290	Applied Medical Innovation II *
BE 5510	Biomicrofluidics
BE 5560	Molecular Diagnostics for Precision Medicine
BE 5700	Biomechanics
ESE 2150	Electrical Circuits and Systems
ESE 5050	Feedback Control Design and Analysis

or MEAM 5110	Feedback Control Design and Analysis
ESE 5290	Introduction to Micro- and Nano-electromechanical Technologies
MEAM 1010	Introduction to Mechanical Design *
MEAM 2010	Machine Design and Manufacturing
MEAM 5100	Design of Mechatronic Systems
MEAM 4150	Product Design
or OIDD 4150	Product Design
MEAM 5140	Design for Manufacturability
MEAM 5200	Introduction to Robotics

Total Course Units 4

Cellular/Tissue Engineering and Biomaterials

Code	Title	Course Units
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Select 2 courses in: 2

BE 3300	Self-Assembly of Soft Materials
BE 4900	Independent Project in Bioengineering ***
BE 5120	Bioengineering III: Biomaterials
BE 5400	Principles of Molecular and Cellular Bioengineering
BE 5530	Principles, Methods, and Applications of Tissue Engineering
BE 5580	Principles of Biological Fabrication
BE 5650	Developmental Engineering of Tissues
BE 5690	Systems Biology of Cell Signaling Behavior
BE 5780	Principles of Controlled Release Systems

Select 2 additional courses in: 2

BE 3300	Self-Assembly of Soft Materials
BE 4900	Independent Project in Bioengineering ***
BE 5120	Bioengineering III: Biomaterials
BE 5400	Principles of Molecular and Cellular Bioengineering
BE 5530	Principles, Methods, and Applications of Tissue Engineering
BE 5580	Principles of Biological Fabrication
BE 5650	Developmental Engineering of Tissues
BE 5690	Systems Biology of Cell Signaling Behavior
BE 5780	Principles of Controlled Release Systems
CBE 4300	Introduction to Polymers
or MSE 4300	Introduction to Polymers
CBE 5570	Stem Cells, Proteomics and Drug Delivery - Soft Matter Fundamentals
MEAM 5140	Design for Manufacturability
MSE 5850	Materials for Bioelectronics
or BE 5850	Materials for Bioelectronics
MSE 5180	Structure and Function of Biological Materials

Total Course Units 4

Biomedical Imaging and Radiation Physics

Code	Title	Course Units
Select 2 courses in:		2
BE 4900	Independent Project in Bioengineering ***	
BE 5180	Optical Microscopy	
BE 5370	Biomedical Image Analysis	
BE 5470	Fundamental Techniques of Imaging	
BE 5810	Techniques of Magnetic Resonance Imaging	
BE 5830	Physics of Medical / Molecular Imaging	
BE 6500	Advanced Biomedical Imaging Applications	
Select 2 additional courses in:		2
BE 4900	Independent Project in Bioengineering ***	
BE 5180	Optical Microscopy	
BE 5370	Biomedical Image Analysis	
BE 5470	Fundamental Techniques of Imaging	
BE 5810	Techniques of Magnetic Resonance Imaging	
BE 5830	Physics of Medical / Molecular Imaging	
BE 6500	Advanced Biomedical Imaging Applications	
MPHY 6030	Image-Based Anatomy	
MPHY 6070	Radiation Biology	
PHYS 4421	Modern Optics	
Total Course Units		4

Systems and Synthetic Biology

Code	Title	Course Units
Select 2 courses in:		2
BE 4900	Independent Project in Bioengineering ***	
BE 5270	Immune Engineering	
BE 5400	Principles of Molecular and Cellular Bioengineering	
BE 5580	Principles of Biological Fabrication	
BE 5590	Multiscale Modeling of Chemical and Biological Systems	
BE 5650	Developmental Engineering of Tissues	
BE 5690	Systems Biology of Cell Signaling Behavior	
Select 2 additional courses in:		2
BE 4900	Independent Project in Bioengineering ***	
BE 5270	Immune Engineering	
BE 5400	Principles of Molecular and Cellular Bioengineering	
BE 5580	Principles of Biological Fabrication	
BE 5590	Multiscale Modeling of Chemical and Biological Systems	
BE 5650	Developmental Engineering of Tissues	
BE 5690	Systems Biology of Cell Signaling Behavior	
CBE 4790	Biotechnology and Biochemical Engineering	
CBE 4800	Laboratory in Biotechnology and Biochemical Engineering	
CBE 5170	Principles of Genome Engineering	

CBE 5270	Advancements and Applications in Genome Editing and Engineering	
CBE 5540	Engineering Biotechnology	
CBE 5570	Stem Cells, Proteomics and Drug Delivery - Soft Matter Fundamentals	
MEAM 6630	Mechanics of Macromolecules	
BIOL 5262	Biological Foundations for Bioengineering and Biotechnology: Genomics and Omics Technologies	
Total Course Units		4

Neuroengineering

Code	Title	Course Units
Select 2 courses in:		2
BE 4900	Independent Project in Bioengineering ***	
BE 5210	Brain-Computer Interfaces	
BE 5300	Theoretical and Computational Neuroscience	
BE 5660	Networked Neuroscience	
Select 2 additional courses in:		2
BE 4900	Independent Project in Bioengineering ***	
BE 5210	Brain-Computer Interfaces	
BE 5300	Theoretical and Computational Neuroscience	
BE 5660	Networked Neuroscience	
NRSC 2249	Cognitive Neuroscience	
or PSYC 1230	Cognitive Neuroscience	
NRSC 2110	Molecular and Cellular Neurobiology	
or BIOL 2110	Molecular and Cellular Neurobiology	
BIOL 4110	Neural Systems and Behavior	
or BIOL 5110	Neural Systems and Behavior	
BIOL 4142	Neurobiology of Learning and Memory *	
NRSC 2205	Cellular Basis of Learning and Memory *	
NRSC 3334	Computational Neuroscience Lab	
NRSC 4425	Neurotechnology: From Concept to Clinic	
NGG 5720	Electrical Language of Cells	
NGG 5730	Systems Neuroscience	
Total Course Units		4

Multiscale Biomechanics

Code	Title	Course Units
Select 2 courses in:		2
BE 4900	Independent Project in Bioengineering ***	
BE 5210	Brain-Computer Interfaces	
BE 5300	Theoretical and Computational Neuroscience	
BE 5660	Networked Neuroscience	
Select 2 additional courses in:		2
BE 4900	Independent Project in Bioengineering ***	
BE 5210	Brain-Computer Interfaces	
BE 5300	Theoretical and Computational Neuroscience	

BE 5660	Networked Neuroscience	
NRSC 2249	Cognitive Neuroscience or PSYC 1230Cognitive Neuroscience	
NRSC 2110	Molecular and Cellular Neurobiology or BIOL 2110Molecular and Cellular Neurobiology	
BIOL 4110	Neural Systems and Behavior or BIOL 5110Neural Systems and Behavior	
BIOL 4142	Neurobiology of Learning and Memory *	
NRSC 2205	Cellular Basis of Learning and Memory *	
NRSC 3334	Computational Neuroscience Lab	
NRSC 4425	Neurotechnology: From Concept to Clinic	
NGG 5720	Electrical Language of Cells	
NGG 5730	Systems Neuroscience	
Total Course Units		4

Therapeutics, Drug Delivery & Nanomedicine

Code	Title	Course Units
Select 2 courses in:		2
BE 4900	Independent Project in Bioengineering ***	
BE 5100	Biomechanics and Biotransport	
BE 5140	Rehab Engineering and Design	
BE 5500	Continuum Tissue Mechanics	
BE 5700	Biomechatronics	
BE 5610	Musculoskeletal Biology and Bioengineering	
Select 2 additional courses in:		2
BE 4900	Independent Project in Bioengineering	
BE 5100	Biomechanics and Biotransport	
BE 5140	Rehab Engineering and Design	
BE 5500	Continuum Tissue Mechanics	
BE 5700	Biomechatronics	
BE 5610	Musculoskeletal Biology and Bioengineering	
Total Course Units		4

Immune Engineering

Code	Title	Course Units
Select 2 courses in:		2
BE 4900	Independent Project in Bioengineering ***	
BE 5120	Bioengineering III: Biomaterials	
BE 4260	Immunology for Bioengineers (students cannot count both BIOL 4004 and BE 4260/ BE 5260 towards concentration) or BE 5260 Immunology for Bioengineers or BIOL 4004 Immunobiology	
BE 5270	Immune Engineering	
BE 5570	Quantitative Principles of Drug Design	
Select two additional courses in:		2
BE 4900	Independent Project in Bioengineering ***	
BE 5120	Bioengineering III: Biomaterials	

BE 4260	Immunology for Bioengineers (students cannot count both BIOL 4004 and BE 4260/ BE 5260 towards concentration)	
or BE 5260	Immunology for Bioengineers	
or BIOL 4004	Immunobiology	
BE 5270	Immune Engineering	
BE 5570	Quantitative Principles of Drug Design	
ENGR 4500	Modern Biotechnology for Engineers	
IMUN 5060	Immune Mechanisms	
IMUN 5070	Immunopathology	
IMUN 6090	Vaccines and Immune Therapeutics	
or CAMB 6090	Vaccines and Immune Therapeutics	
REG 6180	Introduction to Vaccine Development	
Total Course Units		4

Footnotes

* Students may count only one of the asterisked courses per concentration.

** Students may only "double count" TWO courses for multiple concentrations.

*** Students may only count one Independent Study (BE 4900 or BE 4920).