UC San Diego

JACOBS SCHOOL OF ENGINEERING

Shu Chien-Gene Lay Department of Bioengineering

Bioengineering: Bioinformatics (BE28)

Transfer Triton Day 2023 Information Packet

Packet Contents

The UCSD Department of Bioengineering

Mission Statement

To provide our students with an excellent education that enables successful, innovative, and lifelong careers in bioengineering industries and professions.

Student Learning Outcomes

Upon completion of the Bioengineering Program, graduates in Bioengineering; Bioengineering: Biotechnology; Bioengineering: BioSystems; and Bioengineering: Bioinformatics are expected to have the desired knowledge, skills, attitudes, and behaviors as indicated below.

- An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
- An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
- An ability to communicate effectively with a range of audiences.
- An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
- An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment , establish goals, plan tasks, and meet objectives.
- An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
- An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.
- An ability to develop innovative thinking to solve bioengineering problems with creativity and entrepreneurship.

Academic Integrity and Research Ethics

The overall mission of the Dept. of Bioengineering is to provide students with an education that enables successful, innovative, and lifelong careers in bioengineering industries and professions, including a recognition of professional and social responsibilities, and sensitivity to ethical and health-related issues.

The UCSD Policy on Academic Integrity states the general rules for student integrity. It establishes the standards that apply to academic course work undertaken by all undergraduate and graduate students of this University. The policy is based on the fundamental tenet that the principle of honesty must be upheld if the integrity of scholarship is to be maintained by an academic community.

Transfer Students in the Bioengineering: Bioinformatics (BINF) Major

1. **BINF Major Flowchart**

Please review the flowchart of required courses to determine your progress in completing courses for your BINF major. Just cross off the UCSD equivalent courses you've already completed at community college, and the flowchart will provide you with an accurate snapshot of your status.

2. **HSS Boxes on Flowchart**

The boxes along the bottom of the flowchart marked "HSS" refer to your college general education (GE) course requirements. Boxes are included to allow for completion of 10 GE courses (40 units); however, depending upon which of the six colleges you are in, you may have to complete more than 10 courses. *(Please contact your college advisor to obtain more detailed information.)*

3. **Following the Flowchart**

Hopefully you'll have completed many of the required lower-division courses at your community college. Since upper division BENG courses are offered only one time a year, it is important to follow your plan to avoid further graduation delay.

4. **CSE 11**

Please note that CSE 8A and 8B are a "stretched out" version of CSE 11, *Introduction to Computer Science*, and may be better suited for you if you have no prior programming experience.

5. **Flowchart: Freshman Year**

Please note that CSE 12, *Basic Data Structures*, might not have been completed at your community college. If you have completed CSE 11, you may enroll in CSE 12 in Fall 2023. If you have not completed CSE 11, enroll in this course for Fall 2023 and enroll in CSE 12 in Winter 2024. CSE 21, *Mathematics, Algorithms, and Systems Analysis*, should be taken after CSE 12. Please note that BENG 1, *Introduction to Bioengineering Seminar*, could not have been taken at your community college. Please enroll in this course in Winter 2024.

6. **Flowchart: Sophomore Year Winter Quarter**

Note that BENG 120, *Organic Chemistry*, could not have been taken at your community college. Please enroll in BENG 120 in Winter 2024. BILD 4, *Introductory Biology Lab*, may not have been offered at your community college. Plan to complete this course as soon as you can.

7. **Flowchart: Sophomore Year Spring Quarter**

Note that BENG 100, *Introduction to Probability and Statistics,* and BENG 102, *Molecular Components of Living Systems*, could not have been taken at your community college. Please enroll in BENG 100 and BENG 102 in Spring 2024. CSE 100 and 185 should also be taken in Spring 2024.

8. **Contacting an Advisor About Your Courses**

Incoming students will be able to ask departmental questions using the Virtual Advising Center beginning in mid-June 2023. The Virtual Advising Center is available under the Advising tab on TritonLink. In the meantime, you may contact our student affairs staff via email at be-uginfo@bioeng.ucsd.edu. Bioengineering Student Affairs is located on the Warren campus in Powell-Focht Bioengineering Hall, room 141 (on the 1st floor right next to the elevators). Our building is just a little west of the 2-story Bear sculpture.

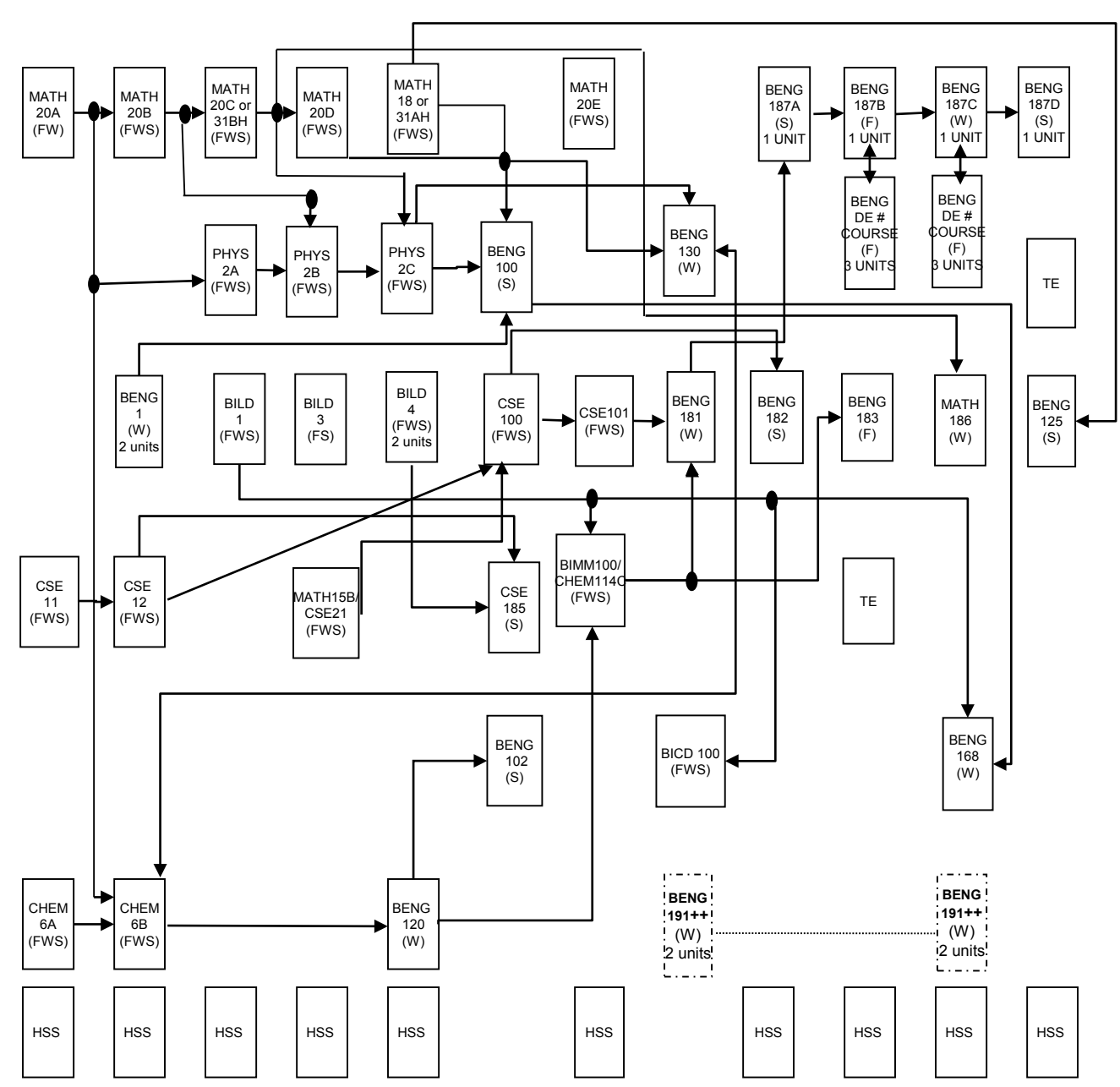
9. **Fall Quarter Orientation**

In Fall 2023, our “New Student Orientation” session will be held during welcome week. (You’ll receive more information about Orientation at a later date.) We will have group Q&A sessions during this time.

BIOENGINEERING: BIOINFORMATICS (BINF) COURSE FLOWCHART

Not Accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering & Technology [EAC/ABET] ~REV. 6-4-18~

(ALL COURSES REQUIRED FOR THE MAJOR MUST BE TAKEN FOR LETTER GRADES.)



++BENG 191 may be taken <u>once</u> and is <u>recommended for Juniors and Seniors</u>, but <u>not</u> required.

<u>Electives:</u>

BENG 199

Additional Courses for Medical School

Bioinformatics students planning to apply to med school take the following courses in addition major requirements:

1. CHEM 6C
2. CHEM 7L
3. CHEM 41A
4. CHEM 41B
5. CHEM 41C
6. CHEM 43A
7. PHYS 2BL
8. PHYS 2CL
9. One of the following: BIBC 100, BIBC 102, CHEM 114A, or CHEM 114B
10. One year of English composition or writing (general education courses dependent on written material for grading should suffice)
11. One course in psychology and sociology (PSYC 1 and SOCI 70) helpful for the MCAT but not a prerequisite
12. Recommended additional coursework
    a. Human Physiology (BIPN 100 and/or BIPN 102)
    b. Cell biology (BICD 110)
    c. Microbiology (BIMM 120)

Most medical schools accept some AP and IB credit for prerequisites. Some medical schools do NOT accept AP/IB credit for prerequisites, and additional upper division coursework may be required. Please consult with a pre-med advisor if you have concerns.

For more information, please visit: https://career.ucsd.edu/plan/explore/pre-health-med/medicine/prepare.html and consider meeting with a pre-med advisor. This information is meant to guide students in planning for a pre-med track, but may not fully encompass all requirements.

Frequently Asked Questions

1. **I was not directly admitted into the Bioengineering department. Is there a way that I can change into any of the "capped" majors later on?**

No. The only way for an incoming transfer student to enter a capped major is to be directly admitted from a community college or other university.

2. **What are the differences among the four majors within the Bioengineering Dept?**

Bioengineering (BENG)*:* This major prepares students for careers in the biomedical device industry and for further education in graduate school. Students completing the B.S. degree in Bioengineering have a broad preparation in traditional topics in engineering, allowing for a variety of career pathways. This program addresses the bioengineering topics of biomechanics, biotransport, bioinstrumentation, bioelectricity, biosystems, and biomaterials, and the complementary fields of systems and integrative physiology. Education in these areas allows application of bioengineering and other scientific principles to benefit human health by advancing methods for effective diagnosis and treatment of disease, e.g., through development of medical devices and technologies. The *BENG* major is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering & Technology [EAC/ABET].

Bioengineering: Biotechnology (BTEC)*:* This major prepares students for careers in the biotechnology industry and for further education in graduate school. The curriculum has a strong engineering foundation with emphasis on biochemical process applications. This program addresses the bioengineering topics of biochemistry, metabolism, kinetics, biotransport, biosystems, bioreactors, bioseparations, tissue engineering, and the complementary fields of cellular physiology. Education in these areas allows application of bioengineering and physicochemical principles to cellular and molecular biology, with the applications that benefit human health. The *BTEC* major is accredited by [EAC/ABET].

Bioengineering: Bioinformatics (BINF)*:* Bioinformatics is the study of the flow of information (genetic, metabolic, and regulatory) in living systems to provide an understanding of the properties of cells and organisms. This major has been developed by the Departments of Bioengineering, Chemistry and Biochemistry, Computer Science and Engineering, and Division of Biology. The bioinformatics major in bioengineering emphasizes systems engineering and model-based approaches to interpreting and integrating bioinformatics data. The bioinformatics major prepares students for careers in the pharmaceutical, biotechnology, and biomedical software industries, and for further studies in graduate school. The *BINF* major is not accredited by a Commission of [EAC/ABET].

Bioengineering: BioSystems (BSYS)*:* This major focuses on the interaction and integration of components in complex biological and engineering assemblages, and how the function and interactions of these components affect overall performance. The major draws on foundations of classical electrical and systems engineering, with biological applications at levels of the molecular and cellular to the physiological and whole organism, and provides an alternative to other bioengineering majors that emphasize mechanical, chemical, and computational approaches. The major prepares students for careers in the bioengineering industry, in research and development, and for further education in graduate, medical, and business schools. The *BSYS* major is accredited to a [EAC/ABET].

3. **Is it possible to do research as an undergraduate?**

Yes. As a student with lower-division standing, upon completion of 30 UCSD units with a 3.0 GPA, you may request to work with a faculty member and enroll in a BENG 99 (Independent Study for Undergraduates) course. Additionally, when you achieve upper-division standing and have completed a total of 90 units with a 2.5 GPA, you are encouraged to participate in research with a faculty member by

enrolling in a BENG 199 course. Please refer to the Research Labs listing to see an up to date list of our faculty who you may have the option of doing research with.

4. **Can I graduate in two years with a major in the Bioengineering Department?**

Not usually for transfers. Our department's major flowcharts are designed to be completed in four years for students *who enter as freshmen*. Additionally, depending upon which of the 6 UCSD colleges you are in, you will possibly need to plan on taking summer school courses in order to satisfy all *"Major"* and *"College"* (General Education breadth) requirements. Engineering students are expected to take a minimum of 16 units (4 classes) most quarters, and either take an increased course load for a few quarters or enroll in some summer session courses at various times during their academic career. While the 6 colleges and the departments are committed to encouraging and assisting students to finish as quickly as possible, it typically takes transfer students 3 years to graduate.

5. **How do I know which of my courses will transfer to UCSD from a California community college?**

Please use www.assist.org to view the transfer equivalencies between your community college and UC San Diego for your major. If a course you took is not listed as equivalent, you may petition the course for credit with the appropriate department. For example, if you wish to petition to have a Chemistry course you took at community college count for CHEM 40A (Organic Chemistry) you may submit a petition to the Chemistry department. Petitions will only be submitted to the Bioengineering department for courses you believe to be equivalent to Bioengineering courses. Community college courses are typically only eligible for lower division course credit (1-99) at UCSD.

6. **I transferred from another 4-year institution or non-California community college. How will I know which of my courses articulate?**

The UCs unfortunately do not have articulation agreements with each other, nor with any other 4 year university or out of state community college. You will need to wait until your transcript is processed by admissions over the summer to see which of your courses articulated. This information will be available to view under your Academic History on TritonLink in mid to late summer. If a course you took does not show an articulation, then you will need to directly petition the department that offers the course in the subject you are petitioning.

7. **What is needed for a petition?**

You should aim to provide as much information as possible, including:

- Name/title/author/edition of the textbook used for the course
- Syllabus for the course
- Any homework assignments/tests (optional, but recommended)
- Undergraduate Student Petition (available under the Forms tab on TritonLink) filled out describing why you believe the course is similar to what you believe to be our equivalent (similar subjects covered, textbook, homework, etc.,) and the course that you believe it to be equivalent to as well as where you took the course. A strong petition draws on the similarities between course descriptions (see the UCSD Course Catalog). Please bear in mind that the response rate will vary by department and may take up to a month.

I. Technical Elective (TE) Course Policy

All Bioengineering majors must complete 8 units of technical elective credit to satisfy their major requirements. The number of units that must have "engineering" as the primary component depends on the major, as listed below.

MAJOR	Total # of TE Units Required	Minimum # of TE Units with Engineering Content Required
BENG	8	4 units
BTEC	8	6 units
BINF	8	8 units
BSYS	8	8 units

Courses that have "engineering" as its primary component, and are normally approved, include most 4-unit, upper-division (100 series) courses taken for a letter grade, not required for the major and taught in one of the departments of the Jacobs School of Engineering. ALL proposed technical electives must be approved by the Bioengineering Student Affairs office ***prior to*** enrollment in the course to verify technical elective credit.

Any portion of the TE requirement not fulfilled by "engineering" courses must be fulfilled by "science" courses. Courses that have "science" as its primary component and are normally approved are 4-unit, upper-division (100 series) courses taken for a letter grade, not required for the major and taught in the departments of Biological Sciences, Chemistry/Biochemistry, or Physics. Courses having a lab component are acceptable.

BENG 199, *Independent Study Research* courses may also be used toward satisfaction of the TE requirement. Students interested in doing research via BENG 199 courses must enroll with the same faculty member in two quarters of BENG 199. Doing so will satisfy both the TE course requirement and the required engineering component.

"Teams in Engineering Sciences" (TIES) courses may also be used to satisfy the TE requirement for all departmental majors. The ENG 100D and ENG 100L courses are considered as "engineering"-type TE courses. Students will receive 8 units of TE credit after passing 1 quarter of ENG 100D (4 units) taken concurrently with ENG 100L (2 units), and passing 1 additional quarter of ENG 100L (2 units each), thus satisfying the TE course requirements for the major.

BENG 196 may be used to fulfill 4 units of technical elective requirements for all majors. Please see the Student Affairs office for instructions on enrolling in this course. **BENG 197 or BENG 198** courses may not be used to satisfy TE requirements in any majors in the Department of Bioengineering.

Additional Technical Elective Information:
https://bioengineering.ucsd.edu/undergrad/programs/technical-electives

II. 5 Year Bachelors/Masters Degree

The Department of Bioengineering (BENG) offers a five-year process leading to Bachelor of Science and Master of Science degrees in Bioengineering. It is available to undergraduate students who are enrolled in any of the major programs offered by BENG. The purpose of the BS/MS is to allow interested students to obtain the MS degree within one year following completion of the BS degree. **The program is open only to UCSD undergraduates and is only for the MS degree, not the M.Eng degree.** Application to this program is a two-step process.

Program Information

Twelve units of Bioengineering graduate level courses must be completed during the student's senior undergraduate year, ***in addition*** to the requirements for the bachelor's degree.

- These twelve units will count toward the requirements for the master's degree **only** and must be taken for a letter grade. The student *may* take up to six graduate level courses during their senior year; six is the maximum that can be transferred per OGS requirements.

The student will arrange a schedule of courses for the senior year that will fulfill the requirements for the BS degree while also serving the program planned for the MS degree. Students are expected to meet the requirements for the MS degree in one year (three consecutive academic quarters) from the date of the receipt of the BS degree.

- Students are encouraged to meet with the Undergraduate and Graduate Coordinators to plan the undergraduate and graduate courses to be taken during the senior year. *Enrollment in graduate level courses is done manually and requires authorization from the Graduate Coordinator.*

Admission Requirements

To be eligible, students must have completed the first two quarters of their junior year (according to the "Junior" section of their major flowchart) in residence at UCSD and have an upper-division GPA of 3.5 or better. However, it should be noted that meeting and even exceeding minimum requirements does not *guarantee* admission. Transfer students are eligible to apply if they meet the junior standing requirement.

More information: Five-Year BS/MS Program | Shu Chien - Gene Lay Department of Bioengineering

More information about Bioengineering graduate programs: Graduate Students | Shu Chien - Gene Lay Department of Bioengineering

III. Research Labs

Biodynamics	Jeff Hasty
Bioinformatics and Systems Biology	Shankar Subramaniam
Biomaterials	Brian Aguado
Biomaterials and Regenerative Medicine	Karen Christman
Cardiac Mechanics	Andrew McCulloch
Cardiovascular Disease	Francisco Contijoch
Cardiovascular Imaging	Elliot McVeigh
Cartilage Tissue Engineering	Robert Sah
Composition of Biomolecules	Rob Knight
Computational Genomics and Stem Cell Biology	Sheng Zhong
Computational Genomics	Ludmil Alexandrov
Functional Cardiovascular Engineering	Pedro Cabrales
Genomics and Systems Biotechnology	Xiaohua Huang
Gene Regulation and Imaging	Bogdan Bintu
Health and Performance Indicators	Benjamin Smarr
Integrated Systems Neuroengineering	Gert Cauwenberghs
Microcirculation	Geert Schmid-Schoenbein
Multiscale Modeling of Pulmonary Arterial Hypertension	Daniela Valdez-Jasso
Nanoscale Bioengineering	Ester Kwon
Nanosensors and Devices for Biomedical Systems	Ratnesh Lal
Neural Engineering	Gabriel Silva
Optical Bioimaging and Spectroscopy	Lingyan Shi
Stem Cell Biology and Bioengineering Laboratory	Adam Engler
Systems Biology and Genetic Circuits	Bernhard Palsson
Systems Biology and Disease	Stephanie Fraley
Synthetic Biology and Stem Cell Engineering	Prashant Mali

See the full list of Bioengineering faculty here: Faculty | Shu Chien - Gene Lay Department of Bioengineering

Undergraduate Student Resources

Academic	Well-Being	Cultural/Community
Bioengineering Student Affairs Office https://bioengineering.ucsd.edu/undergrad/advising **IDEA Engineering Student Center** (Inclusion, Diversity, Excellence, Achievement) https://jacobsschool.ucsd.edu/idea/ **Academic Internship Program** (AIP) https://aip.ucsd.edu/ **Study Abroad Office** https://studyabroad.ucsd.edu/ **Career Center** https://career.ucsd.edu/ Pre-Med Advising: https://career.ucsd.edu/advising/pre-health-med/index.html **Office of Academic Support and Instructional Studies** (OASIS) https://oasis.ucsd.edu/ **Office of Financial Aid and Scholarships** (OFAS) https://fas.ucsd.edu/	**Office for Students with Disabilities** (OSD) https://osd.ucsd.edu/ **Counseling and Psychological Services** (CAPS) https://caps.ucsd.edu/ **CARE at the Sexual Assault Resource Center** (CARE at SARC) https://care.ucsd.edu/ **The Hub Basic Needs Center** https://basicneeds.ucsd.edu/ **Student Health Services** https://studenthealth.ucsd.edu/	**Asian, Pacific Islander, Middle Eastern, Desi American Programs and Services** (APIMEDA) https://apimeda.ucsd.edu/ **Veterans Resource Center** https://svrc.ucsd.edu/ **Intertribal Resource Center** https://itrc.ucsd.edu/ **LGBT Resource Center** https://lgbt.ucsd.edu/ **Cross Cultural Center** https://ccc.ucsd.edu/ **Women's Center** https://women.ucsd.edu/ **Undocumented Student Center** https://uss.ucsd.edu/ **Black Resource Center** https://brc.ucsd.edu/ **Raza Resource Centro** https://raza.ucsd.edu/

Bioengineering Student Organizations

- Biomedical Engineering Society - https://bmes.ucsd.edu/
- Engineering World Health - https://ewh.ucsd.edu/
- International Society for Pharmaceutical Engineering - http://ispeucsd.weebly.com/
- Gender Minorities in Bioengineering - https://gmbe.ucsd.edu/
- Undergraduate Bioinformatics Club - https://ubicucsd.github.io/

Bioinformatics Major Requirements

(Note: All course descriptions and prerequisites are from the 2022-23 Catalog).

Freshman Year Courses

Fall Quarter

MATH 20A. Calculus for Science and Engineering (4) Foundations of differential and integral calculus of one variable. Functions, graphs, continuity, limits, derivative, tangent line. Applications with algebraic, exponential, logarithmic, and trigonometric functions. Introduction to the integral. (Two credits given if taken after MATH 1A/10A and no credit given if taken after MATH 1B/10B or MATH 1C/10C. Formerly numbered MATH 2A.) ***Prerequisites:*** Math Placement Exam qualifying score, or AP Calculus AB score of 3 (or equivalent AB subscore on BC exam), or SAT II MATH 2C score of 650 or higher, or MATH 4C or MATH 10A.

CSE 11. Introduction to Computer Science and Object-Oriented Programming: Java (4) Accelerated introductory programming including an object-oriented approach. Covers basic programming topics from CSE 8A including variables, conditionals, loops, functions/methods, structured data storage, and mutation. Also covers topics from CSE 8B including the Java programming language, class design, interfaces, basic class hierarchies, recursion, event-based programming, and file I/O. Basics of command-line navigation for file management and running programs. Zero units of credit offered for CSE 11 if CSE 8B taken previously or concurrently. Recommended preparation: Significant prior programming experience (for example, high school AP CSA). Students should consult the "CSE Course Placement Advice" web page for assistance in choosing a first CSE course. ***Prerequisites:*** restricted to undergraduates. Graduate students will be allowed as space permits.

CHEM 6A. General Chemistry I (4)
First quarter of a three-quarter sequence intended for science and engineering majors. Topics include atomic theory, bonding, molecular geometry, stoichiometry, types of reactions, and thermochemistry. May not be taken for credit after CHEM 6AH. Recommended: proficiency in high school chemistry and/or physics. ***Corequisite:*** MATH 10A or 20A or prior enrollment.

Winter Quarter

MATH 20B. Calculus for Science and Engineering (4) Integral calculus of one variable and its applications, with exponential, logarithmic, hyperbolic, and trigonometric functions. Methods of integration. Infinite series. Polar coordinates in the plane and complex exponentials. (Two units of credits given if taken after MATH 1B/10B or MATH 1C/10C.) ***Prerequisites****:* AP Calculus AB score of 4 or 5, or AP Calculus BC score of 3, or MATH 20A with a grade of C– or better, or MATH 10B with a grade of C– or better, or MATH 10C with a grade of C– or better.

CSE 12. Basic Data Structures and Object-Oriented Design (4) Use and implementation of basic data structures including linked lists, stacks, and queues. Use of advanced structures such as binary trees and hash tables. Object-oriented design including interfaces, polymorphism, encapsulation, abstract data types, pre-/post-conditions. Recursion. Uses Java and Java Collections. ***Prerequisites****:* CSE 8B or CSE 11; restricted to undergraduates. Graduate students will be allowed as space permits.

CHEM 6B. General Chemistry II (4) Second quarter of a three-quarter sequence intended for science and engineering majors. Topics include covalent bonding, gases, liquids, and solids, colligative properties, physical and chemical equilibria, acids and bases, solubility. May not be taken for credit after CHEM 6BH. ***Prerequisites:*** CHEM 6A or 6AH and MATH 10A or 20A. Recommended: concurrent or prior enrollment in MATH 10B or 20B.

BENG 1. Introduction to Bioengineering (2) An introduction to bioengineering that includes lectures and hands-on laboratory for design projects. The principles of problem definition, engineering inventiveness, team design, prototyping, and testing, as well as information access, engineering standards, communication, ethics, and social responsibility will be emphasized. P/NP grades only. ***Prerequisites:*** none. (W)

Spring Quarter

MATH 20C. Calculus and Analytic Geometry for Science and Engineering (4) Vector geometry, vector functions and their derivatives. Partial differentiation. Maxima and minima. Double integration. (Two units of credit

given if taken after MATH 10C. Credit not offered for both MATH 20C and 31BH. Formerly numbered MATH 21C.) ***Prerequisites:*** AP Calculus BC score of 4 or 5, or MATH 20B with a grade of C– or better.

PHYS 2A. Physics—Mechanics (4) A calculus-based science-engineering general physics course covering vectors, motion in one and two dimensions, Newton's first and second laws, work and energy, conservation of energy, linear momentum, collisions, rotational kinematics, rotational dynamics, equilibrium of rigid bodies, oscillations, gravitation. Students continuing to PHYS 2B/4B will also need MATH 20B. ***Prerequisites:*** MATH 10A-B or 20A or 20B or 20C or 31BH. Recommended preparation: prior or concurrent enrollment in MATH 20B.

BILD 1. The Cell (4) An introduction to cellular structure and function, to biological molecules, bioenergetics, to the genetics of both prokaryotic and eukaryotic organisms, and to the elements of molecular biology. ***Recommended preparation***: prior completion of high school- or college-level chemistry course.

Sophomore Year Courses

Fall Quarter

MATH 20D. Introduction to Differential Equations (4) Ordinary differential equations: exact, separable, and linear; constant coefficients, undetermined coefficients, variations of parameters. Systems. Series solutions. Laplace transforms. Techniques for engineering sciences. Computing symbolic and graphical solutions using Matlab. (Formerly numbered MATH 21D.) May be taken as repeat credit for MATH 21D. ***Prerequisites:*** MATH 20C (or MATH 21C) or MATH 31BH with a grade of C– or better.

PHYS 2B. Physics—Electricity and Magnetism (4) Continuation of PHYS 2A covering charge and matter, the electric field, Gauss's law, electric potential, capacitors and dielectrics, current and resistance, electromotive force and circuits, the magnetic field, Ampere's law, Faraday's law, inductance, electromagnetic oscillations, alternating currents and Maxwell's equations. Students continuing to PHYS 2C will also need MATH 20C or 31BH. ***Prerequisites:*** PHYS 2A or 4A and MATH 20B or 20C or 31BH. Recommended preparation: prior or concurrent enrollment in MATH 20C or 31BH.

BILD 3. Organismic and Evolutionary Biology (4) The first principles of evolutionary theory, classification, ecology, and behavior; a phylogenetic synopsis of the major groups of organisms from viruses to primates.

CSE 21. Mathematics for Algorithms and Systems (4) This course will provide an introduction to the discrete mathematical tools needed to analyze algorithms and systems. Enumerative combinatorics: basic counting principles, inclusion-exclusion, and generating functions. Matrix notation. Applied discrete probability. Finite automata. ***Prerequisites****:* CSE 20 or MATH 15A or MATH 31CH; students who have completed MATH 154 or MATH 184 or MATH 188 previously or concurrently may not receive credit for CSE 21; restricted to undergraduates. Graduate students will be allowed as space permits.

Winter Quarter

MATH 18. Linear Algebra (4) Matrix algebra, Gaussian elimination, determinants. Linear and affine subspaces, bases of Euclidean spaces. Eigenvalues and eigenvectors, quadratic forms, orthogonal matrices, diagonalization of symmetric matrices. Applications. Computing symbolic and graphical solutions using Matlab. Students may not receive credit for both MATH 18 and 31AH. ***Prerequisites:*** Math Placement Exam qualifying score, or AP Calculus AB score of 3 (or equivalent AB subscore on BC exam), or SAT II Math Level 2 score of 650 or higher, or MATH 4C, or MATH 10A, or MATH 20A. Students who have not completed listed prerequisites may enroll with consent of instructor.

PHYS 2C. Physics—Fluids, Waves, Thermodynamics, and Optics (4) Continuation of PHYS 2B covering fluid mechanics, waves in elastic media, sound waves, temperature, heat and the first law of thermodynamics, kinetic theory of gases, entropy and the second law of thermodynamics, Maxwell's equations, electromagnetic waves, geometric optics, interference and diffraction. Students continuing to PHYS 2D will need MATH 20D. ***Prerequisites:*** PHYS 2A or 4A, and MATH 20C or 31BH. Recommended preparation: prior or concurrent enrollment in MATH 20D. Prior completion of PHYS 2B is strongly recommended.

BILD 4. Introductory Biology Lab (2) Students gain hands-on experience and learn the theoretical basis of lab techniques common to a variety of biological disciplines such as biochemistry, molecular biology, cell biology, and

bioinformatics. Students will work in groups, learning how to collect, analyze, and present data while using the scientific method to conduct inquiry-based laboratory experiments. Material lab fees will apply.

BENG 120. Organic Chemistry Structural and Design Principles (4) Structural and design principles of carbon compounds. Structure and stereochemistry. Functional groups and chemical transformations. Structure and design principles of biomolecules. Molecules of life and their organization. ***Prerequisites:*** CHEM 6A and 6B; majors only or consent of department. (W)

Spring Quarter

BENG 100. Statistical Reasoning for Bioengineering Applications (4) General introduction to probability and statistical analysis, applied to bioengineering design. Topics include preliminary data analysis, probabilistic models, experiment design, model fitting, goodness-of-fit analysis, and statistical inference/estimation. Written and software problems are provided for modeling and visualization. ***Prerequisites:*** BENG 1, MATH 18 or MATH 31AH or MATH 20F, MATH 20C or MATH 31BH, and MATH 20D, and PHYS 2A-B-C, or consent of department. (S)

CSE 100. Advanced Data Structures (4) High-performance data structures and supporting algorithms. Use and implementation of data structures like (un)balanced trees, graphs, priority queues, and hash tables. Also, memory management, pointers, recursion. Theoretical and practical performance analysis, both average case and amortized. Uses C++ and STL. Credit not offered for both MATH 176 and CSE 100. Equivalent to MATH 176. Recommended preparation: background in C or C++ programming. ***Prerequisites:*** CSE 12 and CSE 15L and CSE 21 or MATH 154 or MATH 184A and CSE 5A or CSE 30 or ECE 15 or MAE 9; restricted to undergraduates. Graduate students will be allowed as space permits.

CSE 185. Advanced Bioinformatics Laboratory (4) This course emphasizes the hands-on application of bioinformatics to biological problems. Students will gain experience in the application of existing software, as well as in combining approaches to answer specific biological questions. Topics include sequence alignment, fast database search, comparative genomics, expression analysis, computational proteomics, genome-wide association studies, next-generation sequencing, genomics, and big data. Students may not receive credit for CSE 185 and BIMM 185. Restricted to CS27, BI34, BE28, and CH37 majors. *Prerequisites:* CSE 11 or CSE 8B and CSE 12 and MATH 20C or MATH 31BH and BILD 1 and BIEB 123 or BILD 4 or BIMM 101 or CHEM 109.

BENG 102. Molecular Components of Living Systems (4) Introduction to molecular structures. Macromolecules and assemblies-proteins, nucleic acids, and metabolites. Principles of design of simple and complex components of organelles, cells, and tissues. **Prerequisites:** BENG 120 or consent of department. (S)

Junior Year Courses

Fall Quarter

MATH 20E. Vector Calculus (4) Change of variable in multiple integrals, Jacobian, Line integrals, Green's theorem. Vector fields, gradient fields, divergence, curl. Spherical/cylindrical coordinates. Taylor series in several variables. Surface integrals, Stoke's theorem. Gauss' theorem. Conservative fields. ***Prerequisites:*** MATH 18 or MATH 20F or MATH 31AH and MATH 20C (or MATH 21C) or MATH 31BH with a grade of C– or better.

CSE 101. Design and Analysis of Algorithms (4) Design and analysis of efficient algorithms with emphasis of nonnumerical algorithms such as sorting, searching, pattern matching, and graph and network algorithms. Measuring complexity of algorithms, time and storage. NP-complete problems. ***Prerequisites****:* CSE 21 or MATH 154 or MATH 158 or MATH 184 or MATH 188 and CSE 12 or DSC 30; restricted to undergraduates. Graduate students will be allowed as space permits.

BIMM 100/CHEM 114C. Molecular Biology: Molecular mechanisms and applications of the central dogma. Genome structure and function. Transcription and translation. Regulation of gene expression. Use of DNA technology in basic and applied biology. Note: Students will not receive credit for both BIMM 100 and CHEM 114C. *Prerequisites:* BILD 1 and BIBC 103 or BILD 4 or BILD 70 or BIMM 101 and BENG 120 or CHEM 40A or CHEM 40AH and BENG 120 or CHEM 40B or CHEM 40BH.

Winter Quarter

BENG 130. Biotechnology Thermodynamics and Kinetics (4) An introduction to physical principles that govern biological matter and processes, with engineering examples. Thermodynamic principles, structural basis of life, molecular reactions and kinetics, and models to illustrate biological phenomena. ***Prerequisites:*** CHEM 6B, MATH 20A, 20B, 20D, PHYS 2A, 2B, 2C; majors only or consent of department. (W)

BENG 181. Molecular Sequence Analysis (4) (Cross-listed as BIMM 181 and CSE 181.) This course covers the analysis of nucleic acid and protein sequences, with an emphasis on the application of algorithms to biological problems. Topics include sequence alignments, database searching, comparative genomics, and phylogenetic and clustering analyses. Pairwise alignment, multiple alignment, DNA sequencing, scoring functions, fast database search, comparative genomics, clustering, phylogenetic trees, gene finding/DNA statistics. This course open to bioinformatics majors only. ***Prerequisites:*** CSE 100 or MATH 176 and CSE 101 and BIMM 100 or CHEM 114C. Students may receive credit for one of the following: CSE 181, BIMM 181, or BENG 181.

BICD 100. Genetics (4) An introduction to the principles of heredity emphasizing diploid organisms. Topics include Mendelian inheritance and deviations from classical Mendelian ratios, pedigree analysis, gene interactions, gene mutation, linkage and gene mapping, reverse genetics, population genetics, and quantitative genetics. ***Prerequisites:*** BILD 1 and BILD 3.

Spring Quarter

BENG 187A. Bioengineering Design Project: Planning (1) General engineering design topics including project planning and design objectives, background research, engineering needs assessment, technical design specifications, engineering standards, and design requirements and constraints. Introduction to biomedical and biotechnology design projects. Career and professional advising. Majors must enroll in the course for a letter grade in order to count the sequence toward the major. No exceptions will be approved. ***Prerequisites:*** BENG 112A or BENG 152 or BENG 168; bioengineering, bioengineering: biotechnology, or bioengineering: biosystems majors only or consent of department. (S)

BENG 182. Biological Databases (4) (Cross-listed as BIMM 182, CSE 182, and Chem 182.) This course provides an introduction to the features of biological data, how that data is organized efficiently in databases, and how existing data resources can be utilized to solve a variety of biological problems. Object-oriented databases, data modeling and description, survey of current biological database with respect to above, implementation of database focused on a biological topic. This course open to bioinformatics majors only. ***Prerequisites:*** CSE 100 or MATH 176. Students may receive credit for one of the following: CSE 182, BENG 182, or BIMM 182.

Senior Year Courses

Fall Quarter

BENG 187B. Bioengineering Design Project: Development (1) Development of an original bioengineering design for solution of a problem in biology or medicine. Analysis of economic issues, manufacturing and quality assurance, ethics, safety, design constraints, government regulations, and patent requirements. Oral presentation and formal engineering reports. Career and professional advising. Majors must enroll in the course for a letter grade in order to count the sequence toward the major. No exceptions will be approved. ***Prerequisites:*** BENG 187A; concurrent enrollment in one of BENG 119A, BENG 126A, BENG 127A, BENG 128A, BENG 129A, BENG 139A, BENG 147A, BENG 148A, BENG 149A, BENG 169A, or BENG 179A; bioengineering, bioengineering: biotechnology, or bioengineering: biosystems majors only or consent of instructor. (F)

BENG 183. Applied Genomic Technologies (4) Principles and technologies for using genomic information for biomedical applications. Technologies will be introduced progressively, from DNA to RNA to protein to whole cell systems. The integration of biology, chemistry, engineering, and computation will be stressed. Topics include technology for the genome, DNA chips, RNA technologies, proteomic technologies, aphysiomic and phenomic technologies, and analysis of cell function. ***Prerequisites:*** BIMM 100 or CHEM 114C, or consent of department. (F)

Winter Quarter

BENG 187C. Bioengineering Design Project: Implementation (1) Approaches to implementation of senior design project, including final report. Teams will report on construction of prototypes, conduct of testing, collection of data, and assessment of reliability and failure. Majors must enroll in the course for a letter grade in order to count the

sequence toward the major. No exceptions will be approved. ***Prerequisites:*** BENG 187B; concurrent enrollment in one of the following lab sections: BENG 119B, BENG 126B, BENG 127B, BENG 128B, BENG 129B, BENG 139B, BENG 147B, BENG 148B, BENG 149B, BENG 169B, or BENG 179B; bioengineering, bioengineering: biotechnology, or bioengineering: biosystems majors only or consent of instructor. (W)

MATH 186. Probability and Statistics for Bioinformatics (4) This course will cover discrete and random variables, data analysis and inferential statistics, likelihood estimators and scoring matrices with applications to biological problems. Introduction to Binomial, Poisson, and Gaussian distributions, central limit theorem, applications to sequence and functional analysis of genomes and genetic epidemiology. (Credit not offered for MATH 186 if ECON 120A, ECE 109, MAE 108, MATH 181A, or MATH 183 previously or concurrently. Two units of credit offered for MATH 186 if MATH 180A taken previously or concurrently.) ***Prerequisites****:* MATH 20C or MATH 31BH, or consent of instructor.

BENG 168. Biomolecular Engineering (4) Basic molecular biology and recombinant DNA technologies. Structure and function of biomolecules that decode genomes and perform energy conversion, enzymatic catalysis, and active transport. Metabolism of macromolecules. Molecular diagnostics. Design, engineering, and manufacture of proteins, genomes, cells, and biomolecular therapies. ***Prerequisites:*** BILD 1 and BENG 100, or consent of department. (W)

Spring Quarter

BENG 187D. Bioengineering Design Project: Presentation (1) Oral presentations of design projects, including design, development, and implementation strategies and results of prototype testing. Majors must enroll in the course for a letter grade in order to count the sequence toward the major. No exceptions will be approved. ***Prerequisites:*** BENG 187C; bioengineering, bioengineering: biotechnology, or bioengineering: biosystems majors only or consent of instructor. (S)

BENG 125. Modeling and Computation in Bioengineering (4) Computational modeling of molecular bioengineering phenomena: excitable cells, regulatory networks, and transport. Application of ordinary, stochastic, and partial differential equations. Introduction to data analysis techniques: power spectra, wavelets, and nonlinear time series analysis. ***Prerequisites:*** BENG 122A or BENG 123 or consent of department. (S)

BENG 191/291. Senior Seminar I: Professional Issues in Bioengineering (2)** (Conjoined with BENG 291.) Instills skills for personal and organizational development during lifelong learning. Student prepares portfolio of personal attributes and experiences, prepares for career interviews plus oral report of interviewing organizational CEO. Graduate students will prepare a NIH small business research grant. ***Prerequisites: consent of instructor. (F)

Two ("A" & "B") Design Elective Courses (6 units total) - Seniors work in teams on a project to design a solution to a multidisciplinary bioengineering problem suggested by professionals in bioengineering industry, academia, or medicine.

****Two 4-unit Technical Elective courses**
Required for all students

**Recommended but not required; may be taken once.*
***See departmental Student Affairs Office for additional information.*