

BIOLOGICAL ENGINEERING (COURSE 20)

20.001 Introduction to Professional Success and Leadership in Biological Engineering (New)

Prereq: None
U (Fall, Spring)
1-0-2 units

Interactive introduction to the discipline of Biological Engineering through presentations by alumni practitioners, with additional panels and discussions on skills for professional development. Presentations emphasize the roles of communication through writing and speaking, building and maintaining professional networks, and interpersonal and leadership skills in building successful careers. Provides practical advice about how to prepare for job searches and graduate or professional school applications from an informed viewpoint. Prepares students for UROPs, internships, and selection of BE electives.

L. Griffith

20.002 Metakaryotic Biology and Epidemiology

Subject meets with 20.A02
Prereq: None
U (Fall)
2-0-4 units

Introduces non-eukaryotic metakaryotic cells that serve as the stem cells of human fetal/juvenile growth and development. Considers their peculiar modes of genome organization in chromosomal rings, replication via dsRNA/DNA intermediates and amitotic segregation. Explores the hypothesis that high mutation rates in these cells lead to cancers and atherosclerotic plaques and account for the increasing death rates observed with human age.

W. Thilly

20.020 Introduction to Biological Engineering Design Using Synthetic Biology

Subject meets with 20.385
Prereq: None
Acad Year 2017-2018: Not offered
Acad Year 2018-2019: U (Spring)
3-3-3 units

Project-based introduction to the engineering of synthetic biological systems. Throughout the term, students develop projects that are responsive to real-world problems of their choosing, and whose solutions depend on biological technologies. Lectures, discussions, and studio exercises will introduce components and control of prokaryotic and eukaryotic behavior; DNA synthesis, standards, and abstraction in biological engineering; and issues of human practice, including biological safety, security, ethics, and ownership, sharing, and innovation. Preference to freshmen.

N. Kuldell

20.102 Stem Cells in Organogenesis, Carcinogenesis, and Atherogenesis

Subject meets with 20.215
Prereq: Calculus II (GIR), Biology (GIR), Chemistry (GIR)
U (Fall)
3-0-9 units

Study of the amitotic metakaryotic stem cells in fetal/juvenile organogenesis and wound healing. Explores their roles as stem cells in clonal diseases such as cancers and atherosclerosis. Application of a hypermutable/mutator stem cell model to the analysis of age-specific mortality from clonal diseases. Students taking 20.215 do additional research and computer modeling.

E. V. Gostjeva, W. G. Thilly

20.104[JJ] Environmental Cancer Risks, Prevention, and Therapy

Same subject as 1.081[JJ]
Prereq: Calculus II (GIR), Biology (GIR), Chemistry (GIR)
U (Spring)
3-0-9 units

Analysis of the history of cancer and vascular disease mortality rates in predominantly European- and African-American US cohorts, 1895-2010, to discover specific historical shifts. Shifts identified are explored in terms of contemporaneously changing environmental risk factors: air-, food- and water-borne chemicals; subclinical infections; diet and lifestyles. Role of occupational data identifying general risk factors. Considers the hypotheses that environmental factors affect metakaryotic stem cell mutation rates in fetuses and juveniles and/or the growth rates of preneoplastic stem cells in adults. Interaction of environmental and inherited risks. Introduces the use of metakaryocidal drugs to treat cancer in clinical trials.

W. Thilly, R. McCunney

20.106[]] Systems Microbiology

Same subject as 1.084[]]

Prereq: Chemistry (GIR), Biology (GIR)

U (Fall)

3-0-9 units

Introductory microbiology from a systems perspective - considers microbial diversity and the integration of data from a molecular, cellular, organismal, and ecological context to understand the interaction of microbial organisms with their environment. Special emphasis on specific viral, bacterial, and eukaryotic microorganisms and their interaction with animal hosts with focus on contemporary problems in areas such as vaccination, emerging disease, antimicrobial drug resistance, and toxicology.

E. Alm, J. Niles

20.109 Laboratory Fundamentals in Biological Engineering

Prereq: Biology (GIR), Chemistry (GIR), 6.0002, 18.03, 20.110[]]

U (Fall, Spring)

2-8-5 units. Institute LAB

Introduces experimental biochemical and molecular techniques from a quantitative engineering perspective. Experimental design, data analysis, and scientific communication form the underpinnings of this subject. Examples of discovery-based experimental modules include DNA engineering in which students design, construct, and use genetic material; parts engineering, which emphasizes protein design and quantitative assessment of protein performance; systems engineering, in which students consider genome-wide consequences of genetic perturbations; and biomaterials engineering, in which students use biologically-encoded devices to design and build materials. Students complete some laboratory time online in advance of each class. Enrollment limited; priority to Course 20 majors.

Fall: A. Belcher, B. Engelward, M. Jonas, N. Lyell, L. McClain

Spring: A. Belcher, L. Samson, M. Jonas, N. Lyell, L. McClain

20.110[]] Thermodynamics of Biomolecular Systems

Same subject as 2.772[]]

Prereq: Calculus II (GIR), Chemistry (GIR), Physics I (GIR)

U (Fall, Spring)

5-0-7 units. REST

Equilibrium properties of macroscopic and microscopic systems. Basic thermodynamics: state of a system, state variables. Work, heat, first law of thermodynamics, thermochemistry. Second and third law of thermodynamics: entropy and its statistical basis, Gibbs function. Chemical equilibrium of reactions in gas and solution phase. Macromolecular structure and interactions in solution. Driving forces for molecular self-assembly. Binding cooperativity, solvation, titration of macromolecules.

Fall: M. Birnbaum C. Voigt

Spring: E. Alm, C. Voigt

20.129[]] Biological Circuit Engineering Laboratory

Same subject as 6.129[]]

Prereq: Biology (GIR), Calculus II (GIR)

U (Spring)

2-8-2 units. Institute LAB

See description under subject 6.129[]]. Enrollment limited.

T. Lu, R. Weiss

20.200 Biological Engineering Seminar

Prereq: Permission of instructor

G (Fall, Spring)

1-0-2 units

Can be repeated for credit.

Weekly one-hour seminars covering graduate student research and presentations by invited speakers. Limited to BE graduate students.

B. Engelward

20.201 Fundamentals of Drug Development

Prereq: Permission of instructor

G (Fall)

4-0-8 units

Addresses the scientific basis for the development of new drugs. First half of term begins with an overview of the drug discovery process, followed by fundamental principles of pharmacokinetics, pharmacodynamics, metabolism, and the mechanisms by which drugs cause therapeutic and toxic responses. Second half applies principles to case studies and literature discussions of current problems with specific drugs, drug classes, and therapeutic targets.

P. C. Dedon, M. A. Murcko, R. Sasisekharan

20.202 In vivo Models: Principles and Practices

Prereq: Permission of instructor

G (Spring)

1-1-4 units

Selected aspects of anatomy, histology, immuno-cytochemistry, in situ hybridization, physiology, and cell biology of mammalian organisms and their pathogens. Subject material integrated with principles of toxicology, in vivo genetic engineering, and molecular biology. A lab/demonstration period each week involves experiments in anatomy (in vivo), physiology, and microscopy to augment the lectures. Offered first half of spring term.

J. G. Fox, B. Marini, M. Whary

20.203[] Neurotechnology in Action

Same subject as 9.123[]
 Prereq: Permission of instructor
 G (Spring)
 3-6-3 units

See description under subject 9.123[].

A. Jasanoff, E. Boyden, M. Jonas

20.205[] Principles and Applications of Genetic Engineering for Biotechnology and Neuroscience

Same subject as 9.26[]
 Prereq: 7.28, 7.32, or 20.020; 9.01 or 9.09[]
 U (Spring)
 3-0-9 units

See description under subject 9.26[].

F. Zhang

20.207 Biotechnologies in Infectious Disease

Prereq: 7.06, permission of instructor
 Acad Year 2017-2018: Not offered
 Acad Year 2018-2019: G (Spring)
 3-0-9 units

Team-based exploration of current and emerging technologies used in the surveillance, diagnosis, understanding, treatment and prevention of infectious diseases, drawing on basic science and bio-engineering principles. In a term-long project, student teams develop novel technologies to solve major problems in global infectious disease, with a trajectory to a start-up company. Industry experts and academic entrepreneurs present case studies throughout the term, including technology innovations, regulatory sciences, intellectual property and clinical development. Term culminates with team presentations to a panel of industry and scientific leaders.

P. C. Dedon, R. Sasisekharan

20.213 DNA Damage and Genomic Instability

Prereq: 5.07[], 7.05, permission of instructor
 G (Spring; second half of term)
 3-0-3 units

Focuses on biochemistry and molecular mechanisms of DNA replication and DNA repair. Analyzes chemistry of DNA damaging events, and analyzes mutagenic and toxic consequences of modifications to DNA structure. Also presents the contrasting perspective that normal DNA processing leads to mutations. Moves from analysis and discussion of key DNA repair pathways to connections between DNA repair and human diseases. Discusses in-depth the chemistry and biochemistry of DNA metabolism. Includes current literature related to the molecular mechanisms of radiation and chemotherapy.

B. P. Engelward

20.215 Macroepidemiology, Population Genetics, and Stem Cell Biology of Human Clonal Diseases

Subject meets with 20.102
 Prereq: Calculus II (GIR), 1.00
 G (Fall)
 3-0-15 units

Studies the logic and technology needed to discover genetic and environmental risks for common human cancers and vascular diseases. Includes an introduction to metakaryotic stem cell biology. Analyzes large, organized historical public health databases using quantitative cascade computer models that include population stratification of stem cell mutation rates in fetal/juvenile tissues and growth rates in preneoplastic colonies and atherosclerotic plaques. Means to test hypotheses (CAST) that certain genes carry mutations conferring risk for common cancers via genetic analyses in large human cohorts.

W. G. Thilly

20.219 Selected Topics in Biological Engineering

Prereq: Permission of instructor
 G (Fall, Spring)
 Units arranged
 Can be repeated for credit.

Detailed discussion of selected topics of current interest. Classwork in various areas not covered by regular subjects.

Staff

20.260 Analysis and Presentation of Complex Biological Data

Prereq: Permission of instructor
 Acad Year 2017-2018: Not offered
 Acad Year 2018-2019: U (IAP)
 2-0-2 units

Illustrates best practices in the statistical analysis of complex biological datasets and the graphical representation of such analyses. Covers fundamental concepts in probability and statistical theory as well as principles of information design. Provides mathematical concepts and tools that enable students to make sound judgments about the application of statistical methods and to present statistical results in clear and compelling visual formats. Assignments focus on key concepts and their application to practical examples. Assumes basic knowledge of calculus and programming in MATLAB or R.

P. Blainey

20.300 Advanced Workshop in Biological Engineering Communication: Professors Share Their Practices

Prereq: Permission of instructor
 Acad Year 2017-2018: Not offered
 Acad Year 2018-2019: U (IAP)
 3-0-0 units

Working scientists and engineers discuss best practices for written, visual, and oral communication in the classroom, the lab, and the workplace. In a series of lectures, successful academics and industry professionals share how they prepare papers, talks, and graphics. Recitations allow deeper exploration of the lecture topics. With faculty guidance, students develop their own projects during workshops. Emphasizes systematic approaches and transferable skills such as effective drafting and revision. Topics include creating compelling visuals to represent data and concepts; formal/informal writing, from research papers to cover letters; and developing memorable talks and presentations. Examples drawn from biological engineering research. Enrollment limited; preference to Course 20 majors.

E. Alm, J. Goldstein, A. Stachowiak

20.305[J] Principles of Synthetic Biology

Same subject as 6.580[J]
 Subject meets with 6.589[J], 20.405[J]
 Prereq: None
 Acad Year 2017-2018: Not offered
 Acad Year 2018-2019: U (Fall)
 3-0-9 units

Introduces the basics of synthetic biology, including quantitative cellular network characterization and modeling. Considers the discovery and genetic factoring of useful cellular activities into reusable functions for design. Emphasizes the principles of biomolecular system design and diagnosis of designed systems. Illustrates cutting-edge applications in synthetic biology and enhances skills in analysis and design of synthetic biological applications. Students taking graduate version complete additional assignments.

R. Weiss

20.309[J] Instrumentation and Measurement for Biological Systems

Same subject as 2.673[J]
 Subject meets with 20.409
 Prereq: Biology (GIR), Physics II (GIR), 6.0002, 18.03; or permission of instructor
 U (Fall, Spring)
 3-6-3 units

Sensing and measurement aimed at quantitative molecular/cell/tissue analysis in terms of genetic, biochemical, and biophysical properties. Methods include light and fluorescence microscopies, and electro-mechanical probes (atomic force microscopy, optical traps, MEMS devices). Application of statistics, probability, signal and noise analysis, and Fourier techniques to experimental data. Enrollment limited; preference to Course 20 undergraduates.

Fall: P. Blainey, S. Manalis, E. Frank, S. Wasserman, J. Bagnall
Spring: E. Boyden, P. So, S. Wasserman, J. Bagnall, E. Frank

20.310[J] Molecular, Cellular, and Tissue Biomechanics

Same subject as 2.797[J], 3.053[J], 6.024[J]
 Prereq: 2.370 or 2.772[J]; 18.03 or 3.016; Biology (GIR)
 U (Fall)
 4-0-8 units

Develops and applies scaling laws and the methods of continuum mechanics to biomechanical phenomena over a range of length scales. Topics include structure of tissues and the molecular basis for macroscopic properties; chemical and electrical effects on mechanical behavior; cell mechanics, motility and adhesion; biomembranes; biomolecular mechanics and molecular motors. Experimental methods for probing structures at the tissue, cellular, and molecular levels.

M. Bathe, K. Van Vliet, M. Jonas

20.315 Physical Biology

Subject meets with 8.241, 20.415

Prereq: 20.110[J], 5.60, or permission of instructor

U (Spring)

3-0-9 units

Focuses on current major research topics in quantitative, physical biology. Covers synthetic structural biology, synthetic cell biology, microbial systems biology and evolution, cellular decision making, neuronal circuits, and development and morphogenesis. Emphasizes current motivation and historical background, state-of-the-art measurement methodologies and techniques, and quantitative physical modeling frameworks. Experimental techniques include structural biology, next-generation sequencing, fluorescence imaging and spectroscopy, and quantitative biochemistry. Modeling approaches include stochastic rate equations, statistical thermodynamics, and statistical inference. Students taking graduate version complete additional assignments.

M. Bathe, J. Gore

20.320 Analysis of Biomolecular and Cellular Systems

Prereq: 20.110[J], 18.03, 6.0002; *Coreq: 5.07[J] or 7.05*

U (Fall)

4-0-8 units

Analysis of molecular and cellular processes across a hierarchy of scales, including genetic, molecular, cellular, and cell population levels. Topics include gene sequence analysis, molecular modeling, metabolic and gene regulation networks, signal transduction pathways and cell populations in tissues. Emphasis on experimental methods, quantitative analysis, and computational modeling.

F. White, K. D. Wittrup

20.330[J] Fields, Forces and Flows in Biological Systems

Same subject as 2.793[J], 6.023[J]

Prereq: Physics II (GIR); 2.005, 6.021[J], or permission of instructor,

Coreq: 20.309[J]

U (Spring)

4-0-8 units

Introduction to electric fields, fluid flows, transport phenomena and their application to biological systems. Flux and continuity laws, Maxwell's equations, electro-quasistatics, electro-chemical-mechanical driving forces, conservation of mass and momentum, Navier-Stokes flows, and electrokinetics. Applications include biomolecular transport in tissues, electrophoresis, and microfluidics.

J. Han, S. Manalis

20.334 Biological Systems Modeling (New)

Prereq: 20.330[J] or permission of instructor

U (Fall; first half of term)

1-0-5 units

Practices the use of modern numerical analysis tools (e.g., COMSOL) for biological systems with multi-physics behavior. Covers modeling of diffusion, reaction, convection and other transport mechanisms. Analysis of microfluidic devices as examples. Discusses practical issues and challenges in numerical modeling. No prior knowledge of modeling software required. Includes weekly modeling homework and one final modeling project.

J. Han

20.345[J] Bioinstrumentation Project Lab

Same subject as 6.123[J]

Prereq: Biology (GIR), and 2.004 or 6.003; or 20.309[J]; or

permission of instructor

U (Spring)

2-7-3 units

In-depth examination of instrumentation design, principles and techniques for studying biological systems, from single molecules to entire organisms. Lectures cover optics, advanced microscopy techniques, electronics for biological measurement, magnetic resonance imaging, computed tomography, MEMs, microfluidic devices, and limits of detection. Students select two lab exercises during the first half of the semester and complete a final design project in the second half. Lab emphasizes design process and skillful realization of a robust system. Enrollment limited; preference to Course 20 majors and minors.

E. Boyden, M. Jonas, S. F. Nagle, P. So, S. Wasserman, M. F. Yanik

20.352 Principles of Neuroengineering

Subject meets with 9.422[J], 20.452[J], MAS.881[J]

Prereq: Permission of instructor

U (Fall)

3-0-9 units

Covers how to innovate technologies for brain analysis and engineering, for accelerating the basic understanding of the brain, and leading to new therapeutic insight and inventions. Focuses on using physical, chemical and biological principles to understand technology design criteria governing ability to observe and alter brain structure and function. Topics include optogenetics, noninvasive brain imaging and stimulation, nanotechnologies, stem cells and tissue engineering, and advanced molecular and structural imaging technologies. Includes design projects. Students taking graduate version complete additional assignments. Designed for students with engineering maturity who are ready for design.

E. S. Boyden, III

20.361[] Molecular and Engineering Aspects of Biotechnology

Same subject as 7.37[], 10.441[]

Prereq: 2.005, 3.012, 5.60, or 20.110[]; 7.06; or permission of instructor

U (Spring)

4-0-8 units

Credit cannot also be received for 7.371

See description under subject 7.37[].

H. Lodish, L. Griffith

20.363[] Biomaterials Science and Engineering

Same subject as 3.055[]

Subject meets with 3.963[], 20.463[]

Prereq: 3.034, 20.110[], or permission of instructor

U (Fall)

3-0-9 units

Covers, at a molecular scale, the analysis and design of materials used in contact with biological systems, and biomimetic strategies aimed at creating new materials based on principles found in biology. Topics include molecular interaction between bio- and synthetic molecules and surfaces; design, synthesis, and processing approaches for materials that control cell functions; and application of materials science to problems in tissue engineering, drug delivery, vaccines, and cell-guiding surfaces. Students taking graduate version complete additional assignments.

D. Irvine, K. Ribbeck

20.365 Engineering the Immune System in Cancer and Beyond

Subject meets with 20.465

Prereq: 20.110[], 5.60, or 7.10; permission of instructor

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: U (Spring)

3-0-9 units

Examines strategies in clinical and preclinical development for manipulating the immune system to treat and protect against disease. Begins with brief review of immune system. Discusses interaction of tumors with the immune system, followed by approaches by which the immune system can be modulated to attack cancer. Also covers strategies based in biotechnology, chemistry, materials science, and molecular biology to induce immune responses to treat infection, transplantation, and autoimmunity. Students taking graduate version complete additional assignments.

D. Irvine, M. Birnbaum

20.370[] Cellular Neurophysiology and Computing

Same subject as 2.791[], 6.021[], 9.21[]

Subject meets with 2.794[], 6.521[], 9.021[], 20.470[], HST.541[]

Prereq: Physics II (GIR); 18.03; 2.005, 6.002, 6.003, 6.071, 10.301, 20.110[], or permission of instructor

U (Fall)

5-2-5 units

See description under subject 6.021[] Preference to juniors and seniors.

J. Han, T. Heldt

20.375 Applied Developmental Biology and Tissue Engineering (New)

Subject meets with 20.475

Prereq: 7.06, 20.320, and 7.02[] or 20.109; or permission of instructor

U (Spring)

3-0-9 units

Addresses the integration of engineering and biology design principles to create human tissues and organs for regenerative medicine to drug development. Provides an overview of embryogenesis, how morphogenic phenomena are governed by biochemical and biophysical cues. Analyzes *in vitro* generation of human brain, gut, and other organoids from stem cells. Studies the roles of biomaterials and microreactors in improving organoid formation and function; organoid use in modeling disease and physiology *in vitro*; and engineering and biological principles of reconstructing tissues and organs from postnatal donor cells using biomaterials scaffolds and bioreactors. Includes select applications, such as liver disease, brain disorders, and others. Students taking graduate version complete additional assignments.

L. Boyer, L. Griffith

20.380 Biological Engineering Design

Prereq: 7.06, 20.320, 20.330[]; *Coreq: 20.309[]*

U (Fall, Spring)

5-0-7 units

Illustrates how knowledge and principles of biology, biochemistry, and engineering are integrated to create new products for societal benefit. Uses case study format to examine recently developed products of pharmaceutical and biotechnology industries: how a product evolves from initial idea, through patents, testing, evaluation, production, and marketing. Emphasizes scientific and engineering principles, as well as the responsibility scientists, engineers, and business executives have for the consequences of their technology. Instruction and practice in written and oral communication provided. Enrollment limited; preference to Course 20 undergraduates.

Fall: J. Collins, A. Koehler

Spring: J. Essigmann, K. Ribbeck

20.385 Understanding Current Research in Synthetic Biology

Subject meets with 20.020

Prereq: 20.109, 20.320; or permission of instructor

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: U (Spring)

3-3-3 units

Provides an in-depth understanding of the state of research in synthetic biology. Critical evaluation of primary research literature covering a range of approaches to the design, modeling and programming of cellular behaviors. Focuses on developing the skills needed to read, present and discuss primary research literature, and to manage and lead small teams. Students mentor a small undergraduate team of 20.020 students. Open to advanced students with appropriate background in biology.

N. Kuldell

20.390[] Foundations of Computational and Systems Biology

Same subject as 6.802[]

Subject meets with 6.874[], 20.490, HST.506[]

Prereq: Biology (GIR), 6.0002 or 6.01; 7.05; or permission of instructor

U (Spring)

3-0-9 units

Provides an introduction to computational and systems biology. Includes units on the analysis of protein and nucleic acid sequences, protein structures, and biological networks. Presents principles and methods used for sequence alignment, motif finding, expression array analysis, structural modeling, structure design and prediction, and network analysis and modeling. Techniques include dynamic programming, Markov and hidden Markov models, Bayesian networks, clustering methods, and energy minimization approaches. Exposes students to emerging research areas. Designed for students with strong backgrounds in either molecular biology or computer science. Some foundational material covering basic programming skills, probability and statistics is provided for students with less quantitative backgrounds. Students taking graduate version complete additional assignments.

D. K. Gifford, T. S. Jaakkola

20.405[] Principles of Synthetic Biology

Same subject as 6.589[]

Subject meets with 6.580[], 20.305[]

Prereq: None

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: G (Fall)

3-0-9 units

Introduces the basics of synthetic biology, including quantitative cellular network characterization and modeling. Considers the discovery and genetic factoring of useful cellular activities into reusable functions for design. Emphasizes the principles of biomolecular system design and diagnosis of designed systems. Illustrates cutting-edge applications in synthetic biology and enhances skills in analysis and design of synthetic biological applications. Students taking graduate version complete additional assignments.

R. Weiss

20.409 Biological Engineering II: Instrumentation and Measurement

Subject meets with 2.673[], 20.309[]

Prereq: Permission of instructor

G (Fall, Spring)

2-7-3 units

Sensing and measurement aimed at quantitative molecular/cell/tissue analysis in terms of genetic, biochemical, and biophysical properties. Methods include light and fluorescence microscopies, electronic circuits, and electro-mechanical probes (atomic force microscopy, optical traps, MEMS devices). Application of statistics, probability, signal and noise analysis, and Fourier techniques to experimental data. Limited to 5 graduate students.

*Fall: P. Blainey, S. Manalis, S. Wasserman, J. Bagnall, E. Frank
Spring: E. Boyden, P. So, S. Wasserman, J. Bagnall, E. Frank*

20.410[] Molecular, Cellular, and Tissue Biomechanics

Same subject as 2.798[], 3.971[], 6.524[], 10.537[]

Prereq: Biology (GIR); 2.002, 2.006, 6.013, 10.301, or 10.302

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: G (Fall)

3-0-9 units

Develops and applies scaling laws and the methods of continuum mechanics to biomechanical phenomena over a range of length scales. Topics include structure of tissues and the molecular basis for macroscopic properties; chemical and electrical effects on mechanical behavior; cell mechanics, motility and adhesion; biomembranes; biomolecular mechanics and molecular motors. Experimental methods for probing structures at the tissue, cellular, and molecular levels.

R. D. Kamm, K. J. Van Vliet

20.415 Physical Biology

Subject meets with 8.241, 20.315

Prereq: Permission of instructor

G (Spring)

3-0-9 units

Focuses on current major research topics in quantitative, physical biology. Topics include synthetic structural biology, synthetic cell biology, microbial systems biology and evolution, cellular decision making, neuronal circuits, and development and morphogenesis. Emphasizes current motivation and historical background, state-of-the-art measurement methodologies and techniques, and quantitative physical modeling frameworks. Experimental techniques include structural biology, next-generation sequencing, fluorescence imaging and spectroscopy, and quantitative biochemistry. Modeling approaches include stochastic rate equations, statistical thermodynamics, and statistical inference. Students taking graduate version complete additional assignments.

M. Bathe, J. Gore

20.416[] Topics in Biophysics and Physical Biology

Same subject as 7.74[], 8.590[]

Prereq: None

G (Fall)

2-0-4 units

Provides broad exposure to research in biophysics and physical biology, with emphasis on the critical evaluation of scientific literature. Weekly meetings include in-depth discussion of scientific literature led by distinct faculty on active research topics. Each session also includes brief discussion of non-research topics including effective presentation skills, writing papers and fellowship proposals, choosing scientific and technical research topics, time management, and scientific ethics.

I. Cisse, N. Fakhri, M. Guo

20.420[] Principles of Molecular Bioengineering

Same subject as 10.538[]

Prereq: 7.06, 18.03

G (Fall)

3-0-9 units

Provides an introduction to the mechanistic analysis and engineering of biomolecules and biomolecular systems. Covers methods for measuring, modeling, and manipulating systems, including biophysical experimental tools, computational modeling approaches, and molecular design. Equips students to take systematic and quantitative approaches to the investigation of a wide variety of biological phenomena.

A. Jasanoff, E. Fraenkel

20.430[] Fields, Forces, and Flows in Biological Systems

Same subject as 2.795[], 6.561[], 10.539[]

Prereq: Permission of instructor

G (Fall)

3-0-9 units

Molecular diffusion, diffusion-reaction, conduction, convection in biological systems; fields in heterogeneous media; electrical double layers; Maxwell stress tensor, electrical forces in physiological systems. Fluid and solid continua: equations of motion useful for porous, hydrated biological tissues. Case studies of membrane transport, electrode interfaces, electrical, mechanical, and chemical transduction in tissues, convective-diffusion/reaction, electrophoretic, electroosmotic flows in tissues/MEMs, and ECG. Electromechanical and physicochemical interactions in cells and biomaterials; musculoskeletal, cardiovascular, and other biological and clinical examples. Prior undergraduate coursework in transport recommended.

M. Bathe, A. J. Grodzinsky

20.440 Analysis of Biological Networks

Prereq: Permission of instructor

G (Spring)

6-0-9 units

Conceptual and experimental approaches to analyzing complex biological networks and systems, from molecules to human populations, focusing on human pathophysiology and disease. Moving from single component analysis to pathways and networks, combines didactic lectures with in-depth analysis of current literature and computational analysis. Emphasizes the chemistry and biochemistry of underlying biological processes. Topics include linking genes/SNPs to disease, defining pathways, analysis of pathways *in vivo*, systems-level analysis, and applications of network biology. First half of term focuses on fundamental biological processes and tools/analyses needed by biological engineers, and the second half elaborates on these fundamentals by covering complex biological processes. Students acquire skills in the fundamentals of grant preparation using an NIH format and make an oral presentation.

P. Blainey, M. Yaffe

20.445[] Methods and Problems in Microbiology

Same subject as 1.86[], 7.492[]

Prereq: None

G (Fall)

3-0-9 units

See description under subject 7.492[]. Preference to first-year Microbiology and Biology students.

M. Laub

20.446[] Microbial Genetics and Evolution

Same subject as 1.87[], 7.493[], 12.493[]

Prereq: 7.03, 7.05, or permission of instructor

G (Fall)

4-0-8 units

See description under subject 7.493[].

A. D. Grossman, E. Alm

20.450 Molecular and Cellular Pathophysiology

Prereq: 20.420[], 20.440; or permission of instructor

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: G (Fall)

4-0-8 units

Compares the complex molecular and cellular interactions in health and disease between commensal microbial communities, pathogens and the human or animal host. Special focus is given to current research on microbe/host interactions, infection of significant importance to public health, and chronic infectious disease.

Classwork will include lecture, but emphasize critical evaluation and class discussion of recent scientific papers, and the development of new research agendas in the fields presented.

J. C. Niles, J. Runstadler

20.452[] Principles of Neuroengineering

Same subject as 9.422[], MAS.881[]

Subject meets with 20.352

Prereq: Permission of instructor

G (Fall)

3-0-9 units

See description under subject MAS.881[].

E. S. Boyden, III

20.454[] Revolutionary Ventures: How to Invent and Deploy Transformative Technologies

Same subject as 9.455[], 15.128[], MAS.883[]

Prereq: Permission of instructor

G (Fall)

2-0-7 units

See description under subject MAS.883[].

E. Boyden, J. Bensen, J. Jacobson

20.463[] Biomaterials Science and Engineering

Same subject as 3.963[]

Subject meets with 3.055[], 20.363[]

Prereq: 3.034, 20.110[], or permission of instructor

G (Fall)

3-0-9 units

Covers, at a molecular scale, the analysis and design of materials used in contact with biological systems, and biomimetic strategies aimed at creating new materials based on principles found in biology. Topics include molecular interaction between bio- and synthetic molecules and surfaces; design, synthesis, and processing approaches for materials that control cell functions; and application of materials science to problems in tissue engineering, drug delivery, vaccines, and cell-guiding surfaces. Students taking graduate version complete additional assignments.

D. Irvine, K. Ribbeck

20.465 Engineering the Immune System in Cancer and Beyond

Subject meets with 20.365

Prereq: Permission of instructor

Acad Year 2017-2018: Not offered

Acad Year 2018-2019: G (Spring)

3-0-9 units

Examines strategies in clinical and preclinical development for manipulating the immune system to treat and protect against disease. Begins with brief review of immune system. Discusses interaction of tumors with the immune system, followed by approaches by which the immune system can be modulated to attack cancer. Also covers strategies based in biotechnology, chemistry, materials science, and molecular biology to induce immune responses to treat infection, transplantation, and autoimmunity. Students taking graduate version complete additional assignments.

D. Irvine, M. Birnbaum

20.470[] Cellular Neurophysiology and Computing

Same subject as 2.794[], 6.521[], 9.021[], HST.541[]

Subject meets with 2.791[], 6.021[], 9.21[], 20.370[]

Prereq: Physics II (GIR); 18.03; 2.005, 6.002, 6.003, 6.071, 10.301, 20.110[], or permission of instructor

G (Fall)

5-2-5 units

See description under subject 6.521[].

J. Han, T. Heldt

20.475 Applied Developmental Biology and Tissue Engineering (New)

Subject meets with 20.375
 Prereq: Permission of instructor
 G (Spring)
 3-0-9 units

This subject addresses the integration of engineering and biology design principles to create human tissues and organs for regenerative medicine to drug development. Overview of embryogenesis; how morphogenic phenomena are governed by biochemical and biophysical cues. Analysis of in vitro generation of human brain, gut, and other organoids from stem cells. Roles of biomaterials and microreactors in improving organoid formation and function. Organoid use in modeling disease and physiology in vitro. Engineering and biological principles of reconstructing tissues and organs from postnatal donor cells using biomaterials scaffolds and bioreactors. Select applications such as liver disease, brain disorders, and others. Graduate students will have additional assignments.

L. Boyer, L. Griffith

20.482[] Foundations of Algorithms and Computational Techniques in Systems Biology

Same subject as 6.581[]
 Subject meets with 6.503
 Prereq: 6.021[], 6.034, 6.046[], 6.336[], 18.417, or permission of instructor
 Acad Year 2017-2018: Not offered
 Acad Year 2018-2019: G (Spring)
 3-0-9 units

See description under subject 6.581[].

B. Tidor

20.486[] Case Studies and Strategies in Drug Discovery and Development

Same subject as 7.549[], 15.137[], HST.916[]
 Prereq: None
 G (Spring)
 2-0-4 units

Aims to develop appreciation for the stages of drug discovery and development, from target identification, to the submission of preclinical and clinical data to regulatory authorities for marketing approval. Following introductory lectures on the process of drug development, students working in small teams analyze how one of four new drugs or drug candidates traversed the discovery/development landscape. For each case, an outside expert from the sponsoring drug company or pivotal clinical trial principal investigator provides guidance and critiques the teams' presentations to the class.

S. R. Tannenbaum, A. J. Sinskey, A. W. Wood

20.487[] Optical Microscopy and Spectroscopy for Biology and Medicine

Same subject as 2.715[]
 Prereq: Permission of instructor
 G (Spring)
 Not offered regularly; consult department
 3-0-9 units

See description under subject 2.715[].

P. T. So, C. Sheppard

20.490 Foundations of Computational and Systems Biology

Subject meets with 6.802[], 6.874[], 20.390[], HST.506[]
 Prereq: Biology (GIR), 6.0002 or 6.01; or 7.05; or permission of instructor
 G (Spring)
 3-0-9 units

Provides an introduction to computational and systems biology. Includes units on the analysis of protein and nucleic acid sequences, protein structures, and biological networks. Presents principles and methods used for sequence alignment, motif finding, expression array analysis, structural modeling, structure design and prediction, and network analysis and modeling. Techniques include dynamic programming, Markov and hidden Markov models, Bayesian networks, clustering methods, and energy minimization approaches. Exposes students to emerging research areas. Designed for students with strong backgrounds in either molecular biology or computer science. Some foundational material covering basic programming skills, probability and statistics is provided for students with less quantitative backgrounds. Students taking graduate version complete additional assignments.

D. K. Gifford, T. S. Jaakkola

20.507[] Biological Chemistry I

Same subject as 5.07[]
 Prereq: 5.12
 U (Fall)
 5-0-7 units. REST
 Credit cannot also be received for 7.05

See description under subject 5.07[].

E. Nolan, A. Klibanov

20.554[] Frontiers in Chemical Biology

Same subject as 5.54[], 7.540[]
 Prereq: 5.13, 5.07[], 7.06, permission of instructor
 G (Fall)
 2-0-4 units

See description under subject 5.54[].

L. Kiessling

20.560 Statistics for Biological Engineering

Prereq: Permission of instructor
 Acad Year 2017-2018: Not offered
 Acad Year 2018-2019: G (IAP)
 2-0-2 units

Provides basic tools for analyzing experimental data, interpreting statistical reports in the literature, and reasoning under uncertain situations. Topics include probability theory, statistical tests, data exploration, Bayesian statistics, and machine learning. Emphasizes discussion and hands-on learning. Experience with MATLAB, Python, or R recommended.

S. Olesen

20.902 Independent Study in Biological Engineering

Prereq: Permission of instructor
 U (Fall, Spring)
 Units arranged
 Can be repeated for credit.

Opportunity for independent study under regular supervision by a faculty member. Projects require prior approval, as well as a substantive paper. Minimum 12 units required.

Staff

20.903 Independent Study in Biological Engineering

Prereq: Permission of instructor
 U (Fall, Spring, Summer)
 Units arranged [P/D/F]
 Can be repeated for credit.

Opportunity for independent study under regular supervision by a faculty member. Projects require prior approval, as well as a substantive paper. Minimum 6-12 units required.

Staff

20.920 Practical Work Experience

Prereq: None
 U (Fall, IAP, Spring, Summer)
 0-1-0 units

For Course 20 students participating in off-campus work experiences in biological engineering. Before registering for this subject, students must have an employment offer from a company or organization and must identify a BE supervisor. Upon completion of the work, student must submit a letter from the employer describing the work accomplished, along with a substantive final report from the student approved by the MIT supervisor. Subject to departmental approval. Consult departmental undergraduate office.

Staff

20.930]] Research Experience in Biopharma

Same subject as 7.930]]
 Prereq: None
 G (Fall)
 2-10-0 units

Provides exposure to industrial science and develops skills necessary for success in such an environment. Under the guidance of an industrial mentor, students participate in on-site research at a local biopharmaceutical company where they observe and participate in industrial science. Serves as a real-time case study to internalize the factors that shape R&D in industry, including the purpose and scope of a project, key decision points in the past and future, and strategies for execution. Students utilize company resources and work with a scientific team to contribute to the goals of their assigned project; they then present project results to the company and class, emphasizing the logic that dictated their work and their ideas for future directions. Lecture component focuses on professional development.

S. Clarke

20.950 Research Problems in Biological Engineering

Prereq: Permission of instructor
 G (Fall, Spring, Summer)
 Units arranged
 Can be repeated for credit.

Directed research in the fields of bioengineering and environmental health. Limited to BE students.

Staff

20.951 Thesis Proposal

Prereq: Permission of instructor
 G (Fall, Spring, Summer)
 0-24-0 units

Thesis proposal research and presentation to the thesis committee.

Staff

20.960 Teaching Experience in Biological Engineering

Prereq: Permission of instructor
 G (Fall, Spring)
 Units arranged
 Can be repeated for credit.

For qualified graduate students interested in teaching. Tutorial, laboratory, or classroom teaching under the supervision of a faculty member. Enrollment limited by availability of suitable teaching assignments.

Staff

20.BME Undergraduate Research in Biomedical Engineering

Prereq: None
U (Fall, Spring)
Units arranged [P/D/F]
Can be repeated for credit.

Individual research project with biomedical or clinical focus, arranged with appropriate faculty member or approved supervisor. Forms and instructions for the proposal and final report are available in the BE Undergraduate Office.

Consult BE Department

20.EPW UPOP Engineering Practice Workshop

Engineering School-Wide Elective Subject.
Offered under: 1.EPW, 2.EPW, 3.EPW, 6.EPW, 10.EPW, 16.EPW, 20.EPW, 22.EPW
Prereq: None
U (Fall, IAP)
1-0-0 units

See description under subject 2.EPW.Enrollment limited.
Staff

20.S900 Special Subject in Biological Engineering

Prereq: Permission of instructor
U (Fall)
Units arranged [P/D/F]
Can be repeated for credit.

Detailed discussion of selected topics of current interest. Classwork in various areas not covered by regular subjects.

Staff

20.S940 Special Subject in Biological Engineering

Prereq: Permission of instructor
U (Fall, Spring)
Units arranged
Can be repeated for credit.

Detailed discussion of selected topics of current interest. Classwork in various areas not covered by regular subjects.

Staff

20.S947 Special Subject in Biological Engineering

Prereq: Permission of instructor
G (Fall, Spring)
Units arranged
Can be repeated for credit.

Detailed discussion of selected topics of current interest. Classwork in various areas not covered by regular subjects.

Staff

20.S948 Special Subject in Biological Engineering

Prereq: Permission of instructor
G (Fall, Spring)
Units arranged
Can be repeated for credit.

Detailed discussion of selected topics of current interest. Classwork in various areas not covered by regular subjects.

Staff

20.S949 Special Subject in Biological Engineering

Prereq: Permission of instructor
G (Fall, Spring)
Units arranged
Can be repeated for credit.

Detailed discussion of selected topics of current interest. Classwork in various areas not covered by regular subjects.

Staff

20.S952 Special Subject in Biological Engineering

Prereq: Permission of instructor
G (Fall, Spring)
Units arranged [P/D/F]
Can be repeated for credit.

Detailed discussion of selected topics of current interest. Classwork in various areas not covered by regular subjects.

Staff

20.THG Graduate Thesis

Prereq: Permission of instructor
G (Fall, IAP, Spring, Summer)
Units arranged
Can be repeated for credit.

Program of research leading to the writing of an SM or PhD thesis; to be arranged by the student and the MIT faculty advisor.

Staff

20.THU Undergraduate BE Thesis

Prereq: None
U (Fall, IAP, Spring)
Units arranged
Can be repeated for credit.

Program of research leading to the writing of an SB thesis; to be arranged by the student under approved supervision.

Staff

20.UR Undergraduate Research Opportunities

Prereq: None

U (Fall, IAP, Spring, Summer)

Units arranged [P/D/F]

Can be repeated for credit.

Laboratory research in the fields of bioengineering or environmental health. May be extended over multiple terms.

S. Manalis

20.URG Undergraduate Research Opportunities

Prereq: None

U (Fall, IAP, Spring, Summer)

Units arranged

Can be repeated for credit.

Emphasizes direct and active involvement in laboratory research in bioengineering or environmental health. May be extended over multiple terms.

Consult S. Manalis