BIOPHYSICS

Departmental Office: 600 Fairchild, 212-854-4581; mes2314@columbia.edu; biology@columbia.edu

Director of Undergraduate Studies, Undergraduate Programs and Laboratories:
Prof. Deborah Mowshowitz, 744D Mudd; 212-854-4497; dbm2@columbia.edu

Biology Major and Concentration Advisers:
For a list of current biology, biochemistry, biophysics, and neuroscience and behavior advisers, please visit http://biology.columbia.edu/programs/advisors (http://biology.columbia.edu/programs/advisors/)

A-H: Prof. Daniel Kalderon, 1013 Fairchild; ddk1@columbia.edu
I-P. Prof. Alice Heicklen, 744B Mudd; ah2289@columbia.edu
Q-Z: Prof. Harmen Bussemaker, 607E Fairchild; hjb2004@columbia.edu
Backup Advisor. Prof. Deborah Mowshowitz, 744D Mudd; 212-854-4497; dbm2@columbia.edu

Biochemistry Advisers:
Biology: Prof. Brent Stockwell, 1208 Northwest Corner Building; 212-854-2948; stockwell@biology.columbia.edu
Chemistry: Prof. Virginia Cornish, 1209 Northwest Corner Building; 212-854-5209; vc114@columbia.edu

Biophysics Adviser: Prof. Ozgur Sahin, 908 Northwest Corner Building; os2246@columbia.edu

Neuroscience and Behavior Advisers:
Biology: Prof. Jian Yang, 917A Fairchild; 212-854-6161; jy160@columbia.edu
or Prof. Deborah Mowshowitz, 744D Mudd; 212-854-4497; dbm2@columbia.edu
Psychology:

Professor Caroline Marvin, 317 Schermerhorn Ext, 854-0166, cbm2118@columbia.edu

On-Line Resources:
FAQs for prospective majors: http://www.columbia.edu/cu/biology/ug/advice/faqs/major.html
Checklist of major requirements: http://biology.columbia.edu/programs/major-requirements (http://biology.columbia.edu/programs/major-requirements/)
Additional course information: http://biology.columbia.edu/courses (http://biology.columbia.edu/courses/)
FAQs for prospective traditional students: http://www.columbia.edu/cu/biology/ug/advice/faqs/firstyr.html
FAQs for nontraditional students: http://www.columbia.edu/cu/biology/ug/advice/faqs/gs.html

For the first term of their introductory biology sequence, students may take either BIOL UN2005 Introductory Biology I: Biochemistry, Genetics & Molecular Biology, which has a prerequisite of chemistry, or EEEB UN2001 Environmental Biology I: Elements to Organisms, which does not require chemistry. EEEB UN2001 Environmental Biology I: Elements to Organisms may be taken in the first year.

BIOL UN2005 Introductory Biology I: Biochemistry, Genetics & Molecular Biology should be taken later, after general chemistry. For more details, see *Introductory Courses* under *Requirements*—Major in Biology. All students interested in biology are encouraged to take BIOL UN1908 First-Year Seminar in Modern Biology in the fall semester of their first year.

Nonscience majors who wish to take a biology course to fulfill the science requirement are encouraged to take BIOL UN1130 Genes and Development. They may also take, with the instructor's permission, BIOL UN3208 Introduction to Evolutionary Biology or EEEB UN2001 Environmental Biology I: Elements to Organisms.

Interested students should consult listings in other departments for courses related to biology. For courses in environmental studies, see listings for Earth and environmental sciences or for ecology, evolution, and environmental biology. For courses in human evolution, see listings for anthropology or for ecology, evolution, and environmental biology. For courses in the history of evolution, see listings for history and for philosophy of science. For a list of courses in computational biology and genomics, visit http://systemsbiology.columbia.edu/courses (http://systemsbiology.columbia.edu/courses/).

Advanced Placement Transfer Credit

Transfer credits granted toward the degree are not automatically counted toward the major. The department determines which transfer credits can be counted toward the major. For most majors, at least four biology or biochemistry courses and at least 18 credits of the total (biology, biochemistry, math, physics, and chemistry) must be taken at Columbia. Barnard courses may not be substituted for the required Columbia courses without advance permission from the adviser. For neuroscience and behavior, one of the five biology course and one of the psychology courses may be transferred. Students who wish to count a course from outside Columbia toward their major must receive written approval from their adviser or the director of undergraduate studies. Students must supply a syllabus and/or course description to receive approval.

Advising

Neuroscience and Behavior Advisers:
Biology: Prof. Jian Yang, 917A Fairchild; 854-6161; jy160@columbia.edu
or Prof. Deborah Mowshowitz, 744D Mudd; 854-4497; dbm2@columbia.edu
Psychology:

A-E: Professor Carl Hart, 401D Schermerhorn Hall; 212-854-5313; chair@psych.columbia.edu

F-Q: Professor Caroline Marvin, 355B Schermerhorn Ext; 212-854-3608; cbm2118@columbia.edu\

R-Z: Professor Don Hood, 415 Schermerhorn; 212-854-4587; dch3@columbia.edu

Summer Undergraduate Research Fellowship (SURF) Program

First-year students, sophomores, and juniors are eligible for the department's paid internship program (SURF). This program is competitive; the department cannot assure every eligible student a place in any given summer.

Students apply to the program early in the spring term. A faculty committee headed by Dr. Alice Heicklen then matches selected students

to appropriate labs. The deadline for SURF applications is at the beginning of the spring semester.

SURF students must submit a report on their work at the end of the summer session and participate in the following year's annual Undergraduate Research Symposium. Although it does not carry any academic credit, SURF can be used toward the lab requirement for majors and toward graduation with honors. For detailed information on all summer research programs and how to apply, please visit the SURF website (http://www.columbia.edu/cu/biology/ug/surf/).

Current detailed descriptions of the SURF program and the application procedure are available at SURF's website, http://www.columbia.edu/cu/biology/ug/surf/. For more information on the Amgen Scholarship Program, please visit http://www.columbia.edu/cu/biology/ug/amgen/. Applications to all of these programs are through SURF.

Departmental Honors

Students must apply for departmental honors. Applications are due no later than one day after spring break of their senior year. For details, please visit the departmental website at http://biology.columbia.edu/programs/honors-biological-sciences (http://biology.columbia.edu/programs/honors-biological-sciences/). (http://biology.columbia.edu/programs/honors-biological-sciences/)

Professors

Peter Andolfatto

J. Chloë Bulinski

Harmen Bussemaker

Martin Chalfie

Lawrence Chasin

Julio Fernandez

Stuart Firestein

Joachim Frank

Iva Greenwald

Tulle Hazelrigg

Oliver Hobert

John Hunt

Daniel Kalderon

Darcy Kelley

Laura Landweber

James Manley

Robert Pollack

Carol Prives

Ronald Prywes

Molly Przeworski

Michael Sheetz

Brent Stockwell

Simon Tavare

Saeed Tavazoie

Liang Tong

Alexander Tzagoloff

Jian Yang

Rafael Yuste

Associate Professors

Lars Dietrich

Songtao Jia

Ozgur Sahin

Guy Sella

Assistant Professors

Erin Barnhart
Laura Duvall

Jellert Gaublomme

Marko Jovanovic

Raju Tomer
Maria Tosches

Lecturers

Claire Elise Hazen

Alice Heicklen

Mary Ann Price

Lili Yamasaki

Adjunct Faculty

Lewis Brown
Ronald Guido
Jay Hammel

Danny Nam Ho

John Loike

Alan Morrison

Deborah Mowshowitz

Solomon Mowshowitz

Dana Pe'er

Vincent Racaniello

David Sable

Guidelines for all Biological Sciences Majors, Concentrators, and Interdepartmental Majors

Returning students should check the departmental website for any last-minute changes and/or additional information. See especially undergraduate updates and list of department courses. All major and concentration requirements are detailed on the website and links provided below.

Exceptions to Requirements

Students must get written permission in advance for any exceptions to the requirements listed below. For the exceptions to be applied toward graduation, the student must notify the biology department in one of the following two ways:

1. The student can file a completed paper planning form, signed by a faculty adviser, in the biology department office at 600 Fairchild;
2. The faculty member approving the exception can send an e-mail explaining the exceptions to mes2314@columbia.edu.

Grade Requirements for the Major

A grade of C- or higher must be earned and revealed on your transcript for any course – including the first – to be counted toward the major or concentration requirements. The grade of P is not acceptable. A course that was taken Pass/D/Fail may be counted if and only if the P is uncovered by the Registrar's deadline.

Courses

Courses with the subject code *HPSC* or *SCNC* do not count toward the majors or concentrations.

Major in Biology

General Information

The requirements for the biology major include courses in biology, chemistry, physics, and mathematics.

The required biology courses are one year of introductory biology, two core courses in biology or biochemistry, two 3-point electives in biology or biochemistry, and an appropriate lab experience. See below for details.

The required courses outside the biology department are chemistry through organic (plus labs), one year of college-level physics (plus lab), and the completion of one year of college-level mathematics (usually calculus).

Alternative sequences to the above may be arranged in special circumstances, but only with the permission of the director of undergraduate studies or a departmental adviser obtained in advance; for example, certain courses listed in the *Summer Term Bulletin,* the *School of General Studies Bulletin,* and the *Barnard College Bulletin* may be applied toward the major. In addition, selected courses at the Columbia-Presbyterian Medical Center are open to advanced undergraduates. Credit toward the major for courses not listed in the *Columbia College Bulletin* must be discussed in advance with the director of undergraduate studies or a departmental adviser. Students are responsible for notifying the department of all exceptions either in writing or by e-mail as explained above.

Alternative programs must be arranged in advance with the director of undergraduate studies. Students planning graduate work in biology should keep in mind that physical chemistry and statistics are important for many graduate programs.

Introductory Courses

The usual one-year introductory biology sequence is BIOL UN2005 Introductory Biology I: Biochemistry, Genetics & Molecular Biology-BIOL UN2006 Introductory Biology II: Cell Biology, Development & Physiology, taken in the sophomore year, or EEEB UN2001 Environmental Biology I: Elements to Organisms-BIOL UN2006 Introductory Biology II: Cell Biology, Development & Physiology, which may be taken in the first year.

Other sequences require permission in advance from the director of undergraduate studies or departmental advisers. Students with a strong background in chemistry or molecular biology may take BIOL UN2005 Introductory Biology I: Biochemistry, Genetics & Molecular Biology-BIOL UN2006 Introductory Biology II: Cell Biology, Development & Physiology in their first year; the permission of one of the instructors is required.

Premedical students usually take BIOL UN2005 Introductory Biology I: Biochemistry, Genetics & Molecular Biology-BIOL UN2006 Introductory Biology II: Cell Biology, Development & Physiology after a year of general chemistry; premedical students interested in the environmental sciences may take *EEEB UN2001 Environmental Biology I: Elements to Organisms* followed by BIOL UN2006 Introductory Biology II: Cell Biology, Development & Physiology.

Students with advanced placement in biology are expected but not required to take EEEB UN2001 Environmental Biology I: Elements to Organisms or BIOL UN2005 Introductory Biology I: Biochemistry, Genetics & Molecular Biology as their initial biology course, because

BIOL UN2005 Introductory Biology I: Biochemistry, Genetics & Molecular Biology-BIOL UN2006 Introductory Biology II: Cell Biology, Development & Physiology is taught at a level of detail and depth not found in most advanced placement courses.

Students who wish to skip BIOL UN2005 Introductory Biology I: Biochemistry, Genetics & Molecular Biology and start with a higher-level biology course may do so, but they must obtain permission in advance from the director of undergraduate studies. For additional information, see FAQs for first-year students at http://www.columbia.edu/cu/biology/ug/advice/faqs/firstyr.html.

Core Courses

Two out of the following five departmental core courses are required:

BIOL UN3022	Developmental Biology
BIOL UN3031	Genetics
BIOL UN3041	Cell Biology
BIOC GU4501	Biochemistry: Structure and Metabolism
or BIOC UN3300	Biochemistry
BIOC UN3512	Molecular Biology

Laboratory Courses

A laboratory experience in biology is required. It may be fulfilled by completing any one of the following options:

Option 1:	
Select one of the following 5-point laboratory courses:	
BIOL UN3050	Project Laboratory In Protein Biochemistry
BIOL UN3052	Project Laboratory in Molecular Genetics
BIOL UN3058	Project Laboratory in Microbiology
Option 2:	
BIOL UN2501	Contemporary Biology Laboratory
Select an additional 3-point lab such as BIOL UN3040 or a Barnard lab.	
Option 3:	
Two terms of BIOL UN3500 taken for a letter grade, including the submission of a satisfactory research report at the end of each semester	
Option 4:	
Completion of all the requirements for one session of the Summer Undergraduate Research Fellowship (SURF). An additional semester of BIOL UN3500 in the same research lab is recommended but not required. Summer lab work under other auspices may not be substituted for the SURF Program.	

The laboratory fee ($150) partially covers the cost of nonreturnable items. This fee is charged for all lab courses, including BIOL UN3500 Independent Biological Research.

Upper-Level Elective Courses

Select two additional courses, carrying at least 3 points each, from any of the *3000-* or *4000-* level lecture courses. BIOL UN3500 Independent Biological Research cannot be used as one of the courses to satisfy the upper-level elective course requirement.

Chemistry

All majors must take chemistry through organic including labs. One of the following three groups of chemistry courses is required:

Option 1:	
CHEM UN1403 - CHEM UN1404	GENERAL CHEMISTRY I-LECTURES and General Chemistry II (Lecture)
CHEM UN1500 - CHEM UN1501	General Chemistry Laboratory and General Chemistry Laboratory Lecture
CHEM UN2443 - CHEM UN2444	Organic Chemistry I (Lecture) and ORGANIC CHEMSTRY II-LECTURES
CHEM UN2493 - CHEM UN2494	Organic Chemistry Laboratory I (Techniques) and Organic Chemistry Laboratory II (Synthesis)
Option 2:	
For students who qualify for intensive chemistry	
CHEM UN1604	2ND TERM GEN CHEM (INTENSIVE)
CHEM UN1507	Intensive General Chemistry Laboratory
CHEM UN2444 - CHEM UN2443	ORGANIC CHEMSTRY II-LECTURES and Organic Chemistry I (Lecture)
CHEM UN2495 - CHEM UN2496	Organic Chem. Laboratory I and Organic Chem. Laboratory II
Option 3:	
For students who qualify for first year organic chemistry	
CHEM UN1507	Intensive General Chemistry Laboratory
CHEM UN2045 - CHEM UN2046	Intensive Organic Chemistry I (Lecture) and Intensive Organic Chemistry II (Lecture)
CHEM UN2495 - CHEM UN2496	Organic Chem. Laboratory I and Organic Chem. Laboratory II
or CHEM UN2545	Intensive Organic Chemistry Laboratory

Physics

Students must take two terms of physics including the accompanying labs. The usual choices are PHYS UN1201-PHYS UN1202 General Physics II and PHYS UN1291-PHYS UN1292 General Physics Laboratory II. Higher-level physics sequences are also acceptable. The *1400*-level sequence is recommended for students who plan to take three terms of physics.

Mathematics

Two semesters of calculus or honors mathematics are required. Students may substitute one semester of statistics for one semester of calculus with an adviser's permission. For students with AP credit, completion of MATH UN1102 Calculus II, MATH UN1201 Calculus III, or MATH UN1207 Honors Mathematics A is sufficient. However, students with AP credit are encouraged to take additional courses in mathematics or statistics at Columbia.

For more details on the biology major requirements, visit http://biology.columbia.edu/pages/biology-major-requirements (http://biology.columbia.edu/pages/biology-major-requirements/).

Major in Biochemistry

The required basic courses for the biochemistry major are chemistry through organic, including laboratory, and one year each of physical chemistry, physics, calculus, biology, and biochemistry/molecular biology.

The required additional courses are three lecture courses chosen from mathematics, chemistry, and biology, and two upper-level laboratory courses.

http://biology.columbia.edu/pages/biochemistry-major-requirements (http://biology.columbia.edu/pages/biochemistry-major-requirements/)

Major in Biophysics

The requirements for the biophysics major are as follows:

One year of introductory biology:	
BIOL UN2005 - BIOL UN2006	Introductory Biology I: Biochemistry, Genetics & Molecular Biology and Introductory Biology II: Cell Biology, Development & Physiology
Select at least one of the following laboratory courses:	
BIOL UN3050	Project Laboratory In Protein Biochemistry
BIOL UN3052	Project Laboratory in Molecular Genetics
BIOL UN3058	Project Laboratory in Microbiology
BIOL UN3500	Independent Biological Research
One course in biochemistry or molecular biology:	
BCHM GU4501	BIOCHEM I-STRUCTURE/METABOLISM
or BIOC UN3512	Molecular Biology
or BIOC UN3300	Biochemistry
Select one of the following options:	
Option 1 - Genetics:	
BIOL UN3031	Genetics
Option 2 - Neurobiology:	
BIOL UN3004	Neurobiology I: Cellular and Molecular Neurobiology
or BIOL UN3005	Neurobiology II: Development & Systems
Option 3 - Developmental Biology:	
BIOL UN3022	Developmental Biology
Select one of the following sequences to be completed at the end of sophomore year:	
PHYS UN1401 - PHYS UN1402 - PHYS UN1403 - PHYS UN1494	Introduction To Mechanics and Thermodynamics and Introduction To Electricity, Magnetism, and Optics and Introduction to Classical and Quantum Waves and Introduction to Experimental Physics
PHYS UN1601 - PHYS UN1602 - PHYS UN2601 - PHYS UN2699	Physics, I: Mechanics and Relativity and Physics, II: Thermodynamics, Electricity, and Magnetism and Physics, III: Classical and Quantum Waves and Experiments in Classical and Modern Physics
PHYS UN2801 - PHYS UN2802 - PHYS UN3081	Accelerated Physics I and Accelerated Physics II and Intermediate Laboratory Work
Select any two physics courses at the 3000-level or above, chosen in consultation with the adviser.	
Calculus through MATH UN1202 or MATH UN1208	
MATH UN3027	Ordinary Differential Equations
Chemistry through organic including labs; see biology major for options	
Select one additional course at the 3000- or 4000-level, including BIOL GU4002, BIOC GU4323, and BIOC GU4324, in either physics or biology.	

Major in Neuroscience and Behavior

In addition to one year of general chemistry, ten courses are required to complete the major in neuroscience and behavior—five in biology and five in psychology.

BIOLOGY COURSES	
One year of introductory biology.	
BIOL UN2005 - BIOL UN2006	Introductory Biology I: Biochemistry, Genetics & Molecular Biology and Introductory Biology II: Cell Biology, Development & Physiology
One year of Neurobiology	
BIOL UN3004 - BIOL UN3005	Neurobiology I: Cellular and Molecular Neurobiology and Neurobiology II: Development & Systems
One additional 3000 or 4000 level biology lecture course from the following:	
BIOL UN3006	Physiology
BIOL UN3022	Developmental Biology
BIOL UN3025	Neurogenetics
BIOL UN3031	Genetics
BIOL UN3799	Molecular Biology of Cancer
BIOL UN3041	Cell Biology
BIOL UN3073	Cellular and Molecular Immunology
BIOL UN3193	Stem Cell Biology and Applications
BIOC UN3300	Biochemistry
BIOC UN3501	Biochemistry: Structure and Metabolism
BIOL UN3310	Virology
BIOL UN3404	Seminar on the Global Threat of Antimicrobial Resistance
BIOC UN3512	Molecular Biology
BIOL GU4008	The Cellular Physiology of Disease
BIOL GU4034	Biotechnology
BIOL GU4082	Theoretical Foundations and Applications of Biophysical Methods
BIOL GU4300	Drugs and Disease
BIOL GU4510	Genomics of Gene Regulation
BIOL GU4560	Evolution in the age of genomics
BIOL GU4035	Seminar in Epigenetics
BIOL GU4070	The Biology and Physics of Single Molecules
BIOL GU4075	Biology at Physical Extremes
BIOL GU4080	The Ancient and Modern RNA Worlds
BIOL GU4260	Proteomics Laboratory
BIOL GU4290	Biological Microscopy
BIOL GU4305	Seminar in Biotechnology
BCHM GU4501	BIOCHEM I-STRUCTURE/METABOLISM
PSYCHOLOGY COURSES	
PSYC UN1001	The Science of Psychology
PSYC UN2430	Cognitive Neuroscience (Students who have previously taken PSYC UN1010 Mind, Brain and Behavior may use that course to fulfill this requirement.)
or PSYC UN2450	Behavioral Neuroscience
One lab or statistics course from the following:	

PSYC S2210Q	Cognition: Basic Processes STAT UN1001 does not count towards the Neuroscience & Behavior Major.
or PSYC UN1420	RESEARCH METHODS - HUMAN BEHAVIOR
or PSYC UN1450	RESEARCH METHODS - SOCIAL COGNITION # EMOTION
or PSYC UN1490	RESEARCH METHODS - COGNITION/DECISION MAKING
or PSYC UN1610	Introductory Statistics for Behavioral Scientists
or PSYC UN1660	Advanced Statistical Inference
or STAT UN1101	Introduction to Statistics
or STAT UN1201	Calculus-Based Introduction to Statistics
One additional 2000 or 3000 level psychology course from a list approved by the Psychology Departmental adviser to the program.	
PSYC S2215D	Cognition and the Brain
or PSYC S2215D	Cognition and the Brain
PSYC UN2220	Cognition: Memory and Stress
PSYC W2225	Attention and Perception
PSYC W2230	Perception and Sensory Processes
PSYC UN2235	Thinking and Decision Making
or PSYC S2235Q	Thinking and Decision Making
PSYC UN2250	Evolution of Cognition
PSYC UN2280	Introduction to Developmental Psychology
PSYC UN2420	Animal Behavior
or PSYC UN2430	Cognitive Neuroscience
PSYC W2440	Language and the Brain
PSYC S2450Q	Behavioral Neuroscience
or PSYC UN2450	Behavioral Neuroscience
PSYC UN2460	Drugs and Behavior
PSYC W2480	The Developing Brain
PSYC UN2620	Abnormal Behavior
or PSYC S2620Q	Abnormal Behavior
One advanced psychology seminar from a list approved by the Psychology Department adviser to the program	
PSYC W3225	The Wandering Mind: Psychological Approaches to Distraction
PSYC W3250	Seminar in Space Perception (Seminar)
or PSYC G4230	Sensation and Perception (Seminar)
PSYC W3255	Modern Classics in Visual Perception, Visual Science and Visual Neuroscience (Seminar)
or PSYC G4255	Modern Classics in Visual Perception, Visual Science and Visual Neuroscience (Seminar)
PSYC W3265	Auditory Perception (Seminar)
PSYC UN3270	Computational Approaches to Human Vision (Seminar)
PSYC W3280	Seminar In Infant Development
or PSYC S3280D	Seminar in Infant Development
PSYC S3285D	The Psychology of Disaster Preparedness
PSYC UN3290	Self: A Cognitive Exploration (Seminar)
PSYC G4220	Cognition and Psychopathology (Seminar)
PSYC GU4222	The Cognitive Neuroscience of Aging (Seminar)
PSYC GU4223	Memory and Executive Function Thru the Lifespan
PSYC GU4225	Consciousness and Attention (Seminar)
PSYC GU4229	Attention and Perception
PSYC G4230	Sensation and Perception (Seminar)
PSYC GU4232	Production and Perception of Language
PSYC GU4235	Special Topics in Vision (Seminar)
PSYC GU4239	Cognitive neuroscience of narrative and film
PSYC GU4250	Evolution of Intelligence, Cognition, and Language (Seminar)
PSYC GU4270	Cognitive Processes (Seminar)
PSYC G4272	Advanced Seminar in Language Development
PSYC G4275	Contemporary Topics in Language and Communication (Seminar)
PSYC GU4280	Core Knowledge (Seminar)
PSYC G4285	Multidisciplinary Approaches to Human Decision Making (Seminar)
PSYC GU4287	Decision Architecture
PSYC S3410Q	Seminar in Emotion
PSYC S3425D	Animals in Our Own Backyard: The Science of Observing Behavior
PSYC W3435	Neurobiology of Reproductive Behavior (Seminar)
PSYC W3440	Issues In Brain and Behavior (Seminar)
or PSYC UN3445	The Brain & Memory
PSYC UN3450	EVOL-INTELLIGENC/CONSCIOUSNESS
or PSYC G4450	The Evolution of Intelligence & Consciousness (Seminar)
PSYC UN3460	Evolution of Behavior (Seminar)
PSYC UN3470	Brain Evolution: Becoming Human (Seminar)
PSYC UN3481	Critical Periods in Brain Development and Behavior
PSYC S3483D	The Dynamic Brain: Plasticity from Birth to Old Age
PSYC W3484	Life Span Development: Theory and Methods
PSYC UN3496	Neuroscience and Society
or PSYC S3496Q	Neuroscience and Society
PSYC GU4420	Animal Cognition (Seminar)
PSYC GU4430	Learning and the Brain (Seminar)
PSYC GU4435	Non-Mnemonic Functions of Memory Systems
PSYC GU4440	TOPICS-NEUROBIOLOGY & BEH
or PSYC S4440Q	Topics in Neurobiology and Behavior
PSYC G4460	Cognitive Neuroscience and the Media (Seminar)
PSYC G4475	Neurobiology of Social Behavior
PSYC GU4480	Psychobiology of Infant Development (Seminar)
PSYC G4485	Affective Neuroscience (Seminar)
PSYC GU4486	Developmental and Affective Neuroscience (Seminar)
PSYC GU4490	Inheritance (Seminar)
PSYC G4492	Psychobiology of Stress
PSYC G4495	Ethics, Genetics, and the Brain
PSYC GU4498	Behavioral Epigenetics
PSYC G4499	Behavioral Psychopharmacology (Seminar)
PSYC UN3615	Children at Risk (Lecture)

PSYC UN3620	Seminar in Developmental Psychopathology
PSYC UN3625	Clinical Neuropsychology (Seminar)
or PSYC S3625D	Clinical Neuropsychology Seminar
PSYC UN3680	Social Cognitive Neuroscience (Seminar)
or PSYC GU4685	Social Cognitive Neuroscience (Seminar)
PSYC G4635	The Unconscious Mind (Seminar)
PSYC GU4690	Social Factors and Psychopathology (Seminar)

For more details, see the *Psychology* section in this Bulletin, and for additional information visit the Department of Biological Sciences website: http://biology.columbia.edu/pages/neuroscience-and-behavior-major-requirements (http://biology.columbia.edu/pages/neuroscience-and-behavior-major-requirements/).

Concentration in Biology

Students who wish to concentrate in biology must design their programs in advance with the director of undergraduate studies or a departmental adviser.

The requirement for the concentration is 22 points in biology or biochemistry, with at least five courses chosen from the courses listed in the Biological Sciences section of the Bulletin. Additional courses in physics, chemistry, and mathematics are required as detailed below.

A project laboratory and BIOL UN2501 Contemporary Biology Laboratory may **not** both be counted toward the 22-point total. See the biology major requirements for additional information.

The requirements for the concentration in biology are as follows:

BIOL UN2005	Introductory Biology I: Biochemistry, Genetics & Molecular Biology
or EEEB UN2001	Environmental Biology I: Elements to Organisms
BIOL UN2006	Introductory Biology II: Cell Biology, Development & Physiology
Select at least one of the following core courses:	
BIOL UN3022	Developmental Biology
BIOL UN3031	Genetics
BIOL UN3041	Cell Biology
BIOC UN3501	Biochemistry: Structure and Metabolism
or BIOC UN3300	Biochemistry
BIOC UN3512	Molecular Biology
Beginning Fall 2018, no biology lab is required for the concentration. All other requirements remain the same, including enough electives to reach at least 22 points. Either UN2501 or a five-point lab course, but not both, may count towards the 22 point total.	
Chemistry through organic including labs; see biology major for options	
One year of physics, including laboratory; see biology major for options	
One year of college-level mathematics (ordinarily this should be calculus); see biology major for options	

For more details, visit http://biology.columbia.edu/pages/biology-concentration-requirements (http://biology.columbia.edu/pages/biology-concentration-requirements/).

Major in Environmental Biology

Fall 2020

BIOL UN1908	First-Year Seminar in Modern Biology
BIOL UN2005	Introductory Biology I: Biochemistry, Genetics & Molecular Biology
BIOL UN2401	Contemporary Biology I: Biochemistry, Genetics & Molecular Biology
BIOL UN2501	Contemporary Biology Laboratory
BIOL UN3004	Neurobiology I: Cellular and Molecular Neurobiology
BIOL UN3006	Physiology
BIOL UN3022	Developmental Biology
BIOL UN3041	Cell Biology
BIOL UN3073	Cellular and Molecular Immunology
BIOC UN3300	Biochemistry
BIOL UN3404	Seminar on the Global Threat of Antimicrobial Resistance
BIOL UN3500	Independent Biological Research
BIOL UN3700	Independent Clinical Research
BIOL GU4034	Biotechnology
BIOL GU4260	Proteomics Laboratory
BIOL GU4300	Drugs and Disease
BIOC GU4323	Biophysical Chemistry I
BCHM GU4501	BIOCHEM I-STRUCTURE/METABOLISM (Previously listed under BCHM UN3501)
BIOL GU4600	Cell Signaling

Spring 2020

BIOL UN1130	Genes and Development
BIOL UN2006	Introductory Biology II: Cell Biology, Development & Physiology
BIOL UN2402	Contemporary Biology II: Cell Biology, Development & Physiology
BIOL UN2501	Contemporary Biology Laboratory
BIOL UN3005	Neurobiology II: Development & Systems
BIOL UN3025	Neurogenetics
BIOL UN3031	Genetics
BIOL UN3040	Lab in Molecular Biology
BIOC UN3300	Biochemistry
BIOL UN3500	Independent Biological Research
BIOL UN3700	Independent Clinical Research
BIOL UN3799	Molecular Biology of Cancer
BIOL UN3995	Topics in Biology
BIOL GU4075	Biology at Physical Extremes
BIOL GU4290	Biological Microscopy
BIOL GU4305	Seminar in Biotechnology
BIOL GU4310	Virology
BIOC GU4324	Biophysical Chemistry II
BIOC GU4512	Molecular Biology

All Courses

BIOC UN3300 Biochemistry. *3 points*.
Prerequisites: one year each of Introductory Biology and General Chemistry. Corequisites: Organic Chemistry. Primarily aimed at nontraditional students and undergraduates who have course conflicts with BIOC UN3501.
Biochemistry is the study of the chemical processes within organisms that give rise to the immense complexity of life. This complexity emerges from a highly regulated and coordinated flow of chemical energy from one biomolecule to another. This course serves to familiarize students with the spectrum of biomolecules (carbohydrates, lipids, amino acids, nucleic acids, etc.) as well as the fundamental chemical processes (glycolysis, citric acid cycle, fatty acid metabolism, etc.) that allow life to happen. In particular, this course will employ active learning techniques and critical thinking problem-solving to engage students in answering the question: how is the complexity of life possible? NOTE: While Organic Chemistry is listed as a corequisite, it is highly recommended that you take Organic Chemistry beforehand.

BIOC UN3501 Biochemistry: Structure and Metabolism. *4 points*.
Prerequisites: one year of BIOL UN2005 and BIOL UN2006 and one year of organic chemistry.
Lecture and recitation. Students wishing to cover the full range of modern biochemistry should take both *BIOC UN3501* and *BIOC UN3512*. *UN3501* covers subject matters in modern biochemistry, including chemical biology and structural biology, discussing the structure and function of both proteins and small molecules in biological systems. Proteins are the primary class of biological macromolecules and serve to carry out most cellular functions. Small organic molecules function in energy production and creating building blocks for the components of cells and can also be used to perturb the functions of proteins directly. The first half of the course covers protein structure, enzyme kinetics and enzyme mechanism. The second half of the course explores how small molecules are used endogenously by living systems in metabolic and catabolic pathways; this part of the course focuses on mechanistic organic chemistry involved in metabolic pathways.

BIOC UN3512 Molecular Biology. *3 points*.
Prerequisites: one year of biology. Recommended but not required: BIOC UN3501.
This is a lecture course designed for advanced undergraduates and graduate students. The focus is on understanding at the molecular level how genetic information is stored within the cell and how it is regulated. Topics covered include genome organization, DNA replication, transcription, RNA processing, and translation. This course will also emphasize the critical analysis of the scientific literature and help students understand how to identify important biological problems and how to address them experimentally. SPS and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar. http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf

BIOC GU4323 Biophysical Chemistry I. *4 points*.
This course provides a rigorous introduction to the theory underlying widely used biophysical methods, which will be illustrated by practical applications to contemporary biomedical research problems. The course has two equally important goals. The first goal is to explicate the fundamental approaches used by physical chemists to understand the behavior of molecules and to develop related analytical tools. The second goal is to prepare students to apply these methods themselves to their own research projects. The course will be divided into seven modules: (i) solution thermodynamics; (ii) hydrodynamic methods; (iii) statistical analysis of experimental data; (iv) basic quantum mechanics; (v) optical spectroscopy with an emphasis on fluorescence; (vi) nuclear magnetic resonance spectroscopy; and (vii) light-scattering and diffraction methods. The first three modules will be covered during the fall term. In each module, the underlying physical theories and models with be presented and used to derive the mathematical equations applied to the analysis of experimental data. Weekly recitations will emphasize the analysis of real experimental data and understanding the applications of biophysical experimentation in published research papers.

BIOC GU4324 Biophysical Chemistry II. *4 points*.
This course provides a rigorous introduction to the theory underlying widely used biophysical methods, which will be illustrated by practical applications to contemporary biomedical research problems. The course has two equally important goals. The first goal is to explicate the fundamental approaches used by physical chemists to understand the behavior of molecules and to develop related analytical tools. The second goal is to prepare students to apply these methods themselves to their own research projects. The course will be divided into seven modules: (i) solution thermodynamics; (ii) hydrodynamic methods; (iii) statistical analysis of experimental data; (iv) basic quantum mechanics; (v) optical spectroscopy with an emphasis on fluorescence; (vi) nuclear magnetic resonance spectroscopy; and (vii) light-scattering and diffraction methods. In each module, the underlying physical theories and models with be presented and used to derive the mathematical equations applied to the analysis of experimental data. Weekly recitations will emphasize the analysis of real experimental data and understanding the applications of biophysical experimentation in published research papers.

BIOC GU4501 Biochemistry: Structure and Metabolism. *4 points*.
Undergraduates should register for *BIOC C3501*.

Prerequisites: one year of *BIOL C2005* and *BIOL C2006* and one year of organic chemistry.
Lecture and recitation. Students wishing to cover the full range of modern biochemistry should take both *BIOC C3501* and *C3512*. *C3501* covers subject matters in modern biochemistry, including chemical biology and structural biology, discussing the structure and function of both proteins and small molecules in biological systems. Proteins are the primary class of biological macromolecules and serve to carry out most cellular functions. Small organic molecules function in energy production and creating building blocks for the components of cells and can also be used to perturb the functions of proteins directly. The first half of the course covers protein structure, enzyme kinetics and enzyme mechanism.
The second half of the course explores how small molecules are used endogenously by living systems in metabolic and catabolic pathways; this part of the course focuses on mechanistic organic chemistry involved in metabolic pathways.

BIOC GU4512 Molecular Biology. *3 points*.
Prerequisites: one year of biology. Recommended but not required: BIOC UN3501
This is a lecture course designed for advanced undergraduates and graduate students. The focus is on understanding at the molecular level how genetic information is stored within the cell and how it is regulated. Topics covered include genome organization, DNA replication, transcription, RNA processing, and translation. This course will also emphasize the critical analysis of the scientific literature and help students understand how to identify important biological problems and how to address them experimentally. SCE and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar. http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf

BIOL UN1002 Theory and Practice of Science: Biology. *4 points*.
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: either BIOL UN1015 or AP biology, or the instructor's permission.
Lecture and recitation. By analysis and example from the primary literature of evolution and genetics, examines how scientific theories are invented and how they come to be accepted, verified, and in some cases rejected. Papers begin with Darwin and Mendel and end with Watson. Ordinarily does not fulfill biology major or concentration requirements. Normally may not be taken for credit by any student who has previously completed any biology course numbered 2000 or above. BIOL UN1015 should be taken first then BIOL UN1002 for nonscience majors.

BIOL UN1130 Genes and Development. *3 points*.
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: one year of high school or college biology.
This course covers selected topics in genetics and developmental biology, with special emphasis on issues that are relevant to contemporary society. Lectures and readings will cover the basic principles of genetics, how genes are expressed and regulated, the role of genes in normal development, and how alterations in genes lead to abnormal development and disease. We will also examine how genes can be manipulated in the laboratory, and look at the contributions of these manipulations to basic science and medicine, as well as some practical applications of these technologies. Interspersed student-run workshops will allow students to research and discuss the ethical and societal impacts of specific topics (e.g. *in vitro* fertilization, uses and misuses of genetic information, genetically modified organisms, steroid use, and cloning). SCE and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar. http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf

BIOL UN1908 First-Year Seminar in Modern Biology. *1 point*.
If you are interested in doing biology-related research at Columbia University this is the course for you. Each week a different Columbia University professor's discusses their biology-related research giving you an idea of what kind of research is happening at Columbia. Come ask questions and find out how the body works, the latest therapies for disease and maybe even find a lab to do research in. http://www.columbia.edu/cu/biology/courses/UN1908/index.html (http://www.columbia.edu/cu/biology/courses/UN1908/)

Fall 2020: BIOL UN1908

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 1908	001/12184	W 2:40pm - 3:40pm Online Only	Alice Heicklen	1	70/70

BIOL UN2005 Introductory Biology I: Biochemistry, Genetics & Molecular Biology. *4 points*.
Prerequisites: one year of college chemistry, or a strong high school chemistry background.
Lecture and recitation. Recommended as the introductory biology course for biology and related majors, and for premedical students. Fundamental principles of biochemistry, molecular biology, and genetics. Website: http://www.columbia.edu/cu/biology/courses/c2005/index.html. (http://www.columbia.edu/cu/biology/courses/c2005/) SPS, Barnard, and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar. registrar. http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf

Fall 2020: BIOL UN2005

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 2005	001/11824	T Th 10:10am - 11:25am Online Only	Deborah Mowshowitz, Mary Ann Price, Marko Jovanovic	4	205/400
BIOL 2005	002/11825	T Th 4:10pm - 5:25pm Online Only	Deborah Mowshowitz, Mary Ann Price, Marko Jovanovic	4	97/200

BIOL UN2006 Introductory Biology II: Cell Biology, Development & Physiology. *4 points*.
Prerequisites: EEEB UN2001 or BIOL UN2005, or the instructor's permission.
Lecture and recitation. Recommended second term of biology for majors in biology and related majors, and for premedical students. Cellular biology and development; physiology of cells and organisms. Website: http://www.columbia.edu/cu/biology/courses/c2006/ SPS, Barnard, and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar. http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf Students must register for a recitation section BIOL UN2016. (http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf)

BIOL UN2016 INTRO BIO II:CELL BIO,DEV/PHYS. *0 points*.
Prerequisites: Prerequisites: Course does not fulfill Biology major requirements or premedical requirements. ,Enrollment in laboratory limited to 16 students per section.
Corequisites: BIOL UN2006
Prerequisites: Course does not fulfill Biology major requirements or premedical requirements. Enrollment in laboratory limited to 16 students per section. Exploration of the major discoveries and ideas that have revolutionized the way we view organisms and understand life. The basic concepts of cell biology, anatomy and physiology, genetics, evolution, and ecology will be traced from seminal discoveries to the modern era. The laboratory will develop these concepts and analyze biological diversity through a combined experimental and observational approach.

BIOL UN2401 Contemporary Biology I: Biochemistry, Genetics & Molecular Biology. *3 points*.
Prerequisites: a course in college chemistry or the written permission of either the instructor or the premedical adviser.
Recommended as the introductory biology course for science majors who have completed a year of college chemistry and premedical students. The fundamental principles of biochemistry, molecular biology, and genetics. Website: http://www.columbia.edu/cu/biology/courses/c2005/index.html. (http://www.columbia.edu/cu/biology/courses/c2005/) SPS and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar. registrar. http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf

Fall 2020: BIOL UN2401

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 2401	001/11826	T Th 4:10pm - 5:25pm Online Only	Deborah Mowshowitz, Mary Ann Price, Marko Jovanovic	3	40/400
BIOL 2401	002/21822	T Th 10:10am - 11:25am Online Only	Deborah Mowshowitz, Mary Ann Price, Marko Jovanovic	3	70/200

BIOL UN2402 Contemporary Biology II: Cell Biology, Development & Physiology. *3 points*.
Prerequisites: a course in college chemistry and BIOL UN2005 or BIOL UN2401, or the written permission of either the instructor or the premedical adviser.
Cellular biology and development; physiology of cells and organisms. Same lectures as *BIOL UN2006*, but recitation is optional. For a detailed description of the differences between the two courses, see the course web site or http://www.columbia.edu/cu/biology/ug/advice/faqs/gs.html. Website: http://www.columbia.edu/cu/biology/courses/c2006/

SPS, Barnard, and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar. http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf

BIOL UN2501 Contemporary Biology Laboratory. *3 points*.
Enrollment per section limited to 28. Lab Fee: $150.
Fee: Lab Fee - 150.00

Prerequisites: Strongly recommended prerequisite or corequisite: BIOL UN2005 or BIOL UN2401.
Experiments focus on genetics and molecular biology, with an emphasis on data analysis and experimental techniques. The class also includes a study of mammalian anatomy and histology. SPS and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar. http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf

Fall 2020: BIOL UN2501

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 2501	001/12816	M 1:10pm - 5:00pm Online Only	Claire Hazen	3	16/70
BIOL 2501	002/12817	T 1:10pm - 5:00pm Online Only	Claire Hazen	3	40/70
BIOL 2501	003/12818	W 1:10pm - 5:00pm Online Only	Claire Hazen	3	35/70
BIOL 2501	004/12819	Th 6:40pm - 10:30pm Online Only	Claire Hazen	3	39/70
BIOL 2501	005/12820	F 1:10pm - 5:00pm Online Only	Claire Hazen	3	23/70

BIOL UN2700 Past and future of the human genome. *3 points*.
CC/GS: Partial Fulfillment of Science Requirement

We can now determine the genetic makeup of any person in a matter of days and at a cost already within reach for many millions of people. For the past few years a movement has emerged to provide detailed genetic information directly to ordinary people, in some cases with the explicit aim of helping prospective parents to “eliminate preventable genetic disease” or, as one newspaper put it, to promote “genetically flawless babies.”

But our technical capacity to both interrogate and manipulate the human genome has raced far ahead of serious consideration of the societal implications of doing so. This course will provide students with the background necessary to understand what has and will be done with the human genome and ultimately to help society formulate appropriate policies for wise stewardship of the human genome.

To help illustrate the information available in the human genome and how it may influence individuals' lives, the instructors' will share and discuss their own and other public genomes in ways both molecular and personal.

BIOL UN3004 Neurobiology I: Cellular and Molecular Neurobiology. *4 points*.
Discussion Section Required

Prerequisites: one year of biology; a course in physics is highly recommended.
Lecture and recitation. This is an advanced course intended for majors providing an in depth survey of the cellular and molecular aspects of nerve cell function. Topics include: the cell biology and biochemistry of neurons, ionic and molecular basis of electrical signals, synaptic transmission and its modulation, function of sensory receptors. Although not required, it is intended to be followed by Neurobiology II (see below). The recitation meets once per week in smaller groups and emphasizes readings from the primary literature.

Fall 2020: BIOL UN3004

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 3004	001/11560	T Th 10:10am - 11:25am Online Only	Stuart Firestein	4	109/120

BIOL UN3005 Neurobiology II: Development & Systems. *4 points*.
Prerequisites: BIOL UN3004, one year of biology, or the instructor's permission.
This course is the "capstone" course for the Neurobiology and Behavior undergraduate major at Columbia University and will be taught by the faculty of the Kavli Institute of Brain Science: http://www.kavli.columbia.edu/ Science: http://www.kavli.columbia.edu/. It is designed for advanced undergraduate and graduate students. Knowledge of Cellular Neuroscience (how an action potential is generated and how a synapse works) will be assumed. It is strongly recommended that students take *BIOL UN3004* Neurobiology I: Molecular and Cellular Neuroscience, or a similar course, before enrolling in *BIOL UN3005*. Students unsure about their backgrounds should check a representative syllabus of *BIOL UN3004* on the *BIOL UN3004* website (http://www.columbia.edu/cu/biology/courses/w3004/). Website for *BIOL UN3005*: http://www.columbia.edu/cu/biology/courses/w3005/index.html

BIOL UN3006 Physiology. *3 points*.
Prerequisites: (BIOL UN2005 and BIOL UN2006) or (BIOL UN2401 and BIOL UN2402) or the instructor's permission.
Major physiological systems of vertebrates (circulatory, digestive, hormonal, etc.) with emphasis on cellular and molecular mechanisms and regulation. Readings include research articles from the scientific literature. SCE and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar. http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf

Fall 2020: BIOL UN3006

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 3006	001/11934	T Th 4:10pm - 5:25pm Online Only	Mary Ann Price	3	24/72

BIOL UN3008 The Cellular Physiology of Disease. *3 points*.
Prerequisites: one 3000-level course in Cell Biology or Biochemistry, or the instructor's permission.
This course will present a quantitative description of the cellular physiology of excitable cells (mostly nerve and muscle). While the course will focus on examining basic mechanisms in cell physiology, there will be a thread of discussion of disease mechanisms throughout. The end of each lecture will include a discussion of the molecular mechanisms of selected diseases that relate to the topics covered in the lecture. The course will consist of two lectures per week. This course will be of interest to advanced (3000-4000 level) undergraduates that aim to pursue careers in medicine as well as those that will pursue careers in biomedical research. This course will also be of interest to graduate students desiring an introduction to the cellular physiology of nerve and muscle.

BIOL UN3022 Developmental Biology. *3 points*.
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: BIOL UN2005 and BIOL UN2006 or equivalent.
Come discover how the union of egg and sperm triggers the complex cellular interactions that specify the diverse variety of cells present in multicellular organisms. Cellular and molecular aspects of sex determination, gametogenesis, genomic imprinting, X-chromosome inactivation, telomerase as the biological clock, stem cells, cloning, the pill and cell interactions will be explored, with an emphasis on humans. Original research articles will be discussed to further examine current research in developmental biology. SPS and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar. http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf

Fall 2020: BIOL UN3022

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 3022	001/12182	T Th 1:10pm - 2:25pm Online Only	Alice Heicklen	3	43/70

BIOL UN3025 Neurogenetics. *3 points*.
Prerequisites: (BIOL UN2005 and BIOL UN2006)
This course provides an introduction to Neurogenetics, which studies the role of genetics in the development and function of the nervous system (https://en.wikipedia.org/wiki/Neurogenetics). The course will be focused on teaching classic and contemporary concepts in genetics and neuroscience, rather than cataloguing mere facts. The course will emphasize the discovery processes, historical figures involved in these processes and methodologies of discovery. Primary research papers will be discussed in detail. A central organizational theme of the course is the presence of a common thread and narrative throughout the course. The common thread is an invertebrate model system, the roundworm Caenorhabditis elegans, which serves as a paradigm to show how simple genetic model systems have informed our view on the genetics of nervous system development and function. The ultimate goal of this course is to gain an understanding of the underlying principles of how the nervous system of one specific animal species forms, from beginning to end. The course is intended for neuroscience-inclined students (e.g. neuroscience majors) who want to learn about how genetic approaches have informed our understanding of brain development and function and, vice versa, for students with an interest in molecular biology and genetics, who want to learn about key problems in neuroscience and how genetic approaches can address them.

BIOL UN3031 Genetics. *3 points*.
Students may receive credit for *BIOL W3031* or *BIOL C3032*, but not both due to overlap in course content.

Prerequisites: BIOL UN2005 and BIOL UN2006 or the equivalent.
General genetics course focused on basic principles of transmission genetics and the application of genetic approaches to the study of biological function. Principles will be illustrated using classical and contemporary examples from prokaryote and eukaryote organisms, and the experimental discoveries at their foundation will be featured. Applications will include genetic approaches to studying animal development and human diseases. SCE and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar.http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pd (http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf)

BIOL UN3034 Biotechnology. *3 points*.
CC/GS: Partial Fulfillment of Science Requirement
For upper-level undergraduates.

Prerequisites: genetics or molecular biology.
The course covers techniques currently used to explore and manipulate gene function and their applications in medicine and the environment. Part I covers key laboratory manipulations, including DNA cloning, gene characterization, association of genes with disease, and methods for studying gene regulation and activities of gene products. Part II also covers commercial applications, and includes animal cell culture, production of recombinant proteins, novel diagnostics, high throughput screening, and environmental biosensors. SCE and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar. http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf

BIOL UN3040 Lab in Molecular Biology. *3 points*.
Enrollment limited to 12. Lab fee: $150.

Prerequisites: one year of biology (BIOL UN2005 and BIOL UN2006) and Contemporary Biology Laboratory (BIOL UN2501).
Prerequisites: one year of biology (*UN2005*-UN*2006*) and Contemporary Biology Laboratory (*UN2501*). This lab will explore various molecular biology techniques frequently utilized in modern molecular biology laboratories. The lab will consist of four modules: 1) Molecular verification of genetically modified organisms (GMOs); 2) Site-directed mutagenesis; 3) gDNA extraction, PCR amplification, sequencing and GenBank analysis of the COI genes from diverse fish species and 4) protein gel analysis of fish muscle components. SPS and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at: http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf

Spring 2021: BIOL UN3040

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 3040	001/11269	Th 1:10pm - 4:00pm Online Only	Alice Heicklen	3	0/16

BIOL UN3041 Cell Biology. *3 points*.
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: one year of biology, normally BIOL UN2005-BIOL UN2006, or the equivalent.
Cell Biology 3041/4041 is an upper-division course that covers in depth all organelles of cells, how they make up tissues, secrete substances important for the organism, generate and adapt to their working environment in the body, move throughout development, and signal to each other. Because these topics were introduced in the Intro Course (taught by Mowshowitz and Chasin), this course or its equivalent is a pre-requisite for W3041/4041. Students for whom this course is useful include biology, biochem or biomedical engineering majors, those preparing to apply for medical school or graduate school, and those doing or planning to start doing research in a biology or biomedical lab. SCE and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar. http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf

BIOL UN3050 Project Laboratory In Protein Biochemistry. *5 points*.
Prerequisites: one year of biology (UN2005- UN2006) plus one upper-level course recommended. Enrollment is not restricted as long as total is no more than 14. Seniors will be given preference in the unlikely event that restriction is necessary. Students with specific questions should e-mail the instructor (jfh21@columbia.edu).
This course provides an intensive introduction to professional biomedical laboratory research. Students conduct a portion of an ongoing biochemical research project and write-up their results in a format suitable for publication in a peer-reviewed scientific research journal. Techniques in molecular biology and protein biochemistry are used to address a problem in mechanistic biochemistry or molecular pharmacology. Students are exposed to the full spectrum of techniques used in contemporary protein biochemistry, including molecular sequence analysis of genomic databases, molecular cloning and manipulation of recombinant DNA, protein expression in E. coli, protein purification, and biophysical characterization (typically including crystallization for x-ray structure determination). The couse emphasizes the use of critical thinking skills in scientific research while giving students the opportunity to apply the basic knowlegde learned in a wide variety of biology and chemistry lecture courses to a real research project. Examples of past projects can be found on the course website: https://www1.columbia.edu/sec/cu/biology/courses/w3050/class/index.html (https://www1.columbia.edu/sec/cu/biology/courses/w3050/class/) (cunix account required to login).

BIOL UN3052 Project Laboratory in Molecular Genetics. *5 points*.
Enrollment limited to approximately 12. Fee: $150.

Prerequisites: one year of introductory biology and the instructor's permission.
Project laboratory on the manipulation of nucleic acids in prokaryotes, including DNA isolation, restriction mapping, and transformation.
The first part of the laboratory involves learning of techniques to be used subsequently in independent research projects suggested by the professor.

BIOL UN3058 Project Laboratory in Microbiology. *5 points*.
Lab fee: $150.

Prerequisites: one year of Intro Bio. An introductory biology or chemistry lab is recommended.
Bacteria are not just unicellular germs. This lab course will broaden your awareness of the amazing world of microbiology and the diverse capabilities of microbes. The focus will be on bacterial multicellularity, pigment production, and intercellular signaling. Pigment-producing bacteria will be isolated from the wild (i.e. Morningside Campus or your skin), and characterized using standard genetic tools (PCR, DNA gel electrophoresis, transformation, screen) and microbiology techniques (isolation of bacteria and growth of bacterial colonies, media preparation, enrichment techniques for pigments). These techniques will also be applied in the study of bacterial multicellularity and signaling in the standard lab strain *Pseudomonas aeruginosa*. SCE and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar. http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf

BIOL UN3073 Cellular and Molecular Immunology. *3 points*.
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: two semesters of a rigorous, molecularly-oriented introductory biology course (such as *UN2005* and *UN2006*), or the instructor's permission.
This course will cover the basic concepts underlying the mechanisms of innate and adaptive immunity, as well as key experimental methods currently used in the field. To keep it real, the course will include clinical correlates in such areas as infectious diseases, autoimmune diseases, cancer immunotherapy and transplantation. Taking this course won't turn you into an immunologist, but it may make you want to become one, as was the case for several students last year. After taking the course, you should be able to read the literature intelligently in this rapidly advancing field. SCE and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar. http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf

Fall 2020: BIOL UN3073

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 3073	001/11573	M W 2:40pm - 3:55pm Online Only	Christian Schindler	3	65/100

BIOL UN3193 Stem Cell Biology and Applications. *3 points*.
Prerequisites: three semesters of Biology or the instructor's permission.
The course examines current knowledge and potential medical applications of pluripotent stem cells (embryonic stem cells and induced pluripotent stem cells), direct conversions between cell types and adult, tissue-specific stem cells (concentrating mainly on hematopoietic and gut stem cells as leading paradigms). A basic lecture format will be supplemented by presentations and discussions of research papers. Recent reviews and research papers, together with extensive instructor notes, will be used in place of a textbook. SCE and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar. http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf

BIOL UN3208 Introduction to Evolutionary Biology. *3 points*.
Prerequisites: recommended preparation: an introductory course in college biology.
Introduction to principles of general evolutionary theory, both nomological and historical; causes and processes of evolution; phylogenetic evolution; species concept and speciation; adaptation and macroevolution; concepts of phylogeny and classification.

BIOL UN3310 Virology. *3 points*.
Prerequisites: two semesters of a rigorous, molecularly-oriented introductory biology course (such as BIOL UN2005), or the instructor's permission.
The course will emphasize the common reactions that must be completed by all viruses for successful reproduction within a host cell and survival and spread within a host population. The molecular basis of alternative reproductive cycles, the interactions of viruses with host organisms, and how these lead to disease are presented with examples drawn from a set of representative animal and human viruses.

BIOL UN3387 BIOLOGY TEST. *3 points*.
ABCDE

BIOL UN3404 Seminar on the Global Threat of Antimicrobial Resistance. *3 points*.
Prerequisites: (biol un2005 and biol un2006) or (biol un2401 and biol un2402)
The goal of this seminar is to provide an in-depth analysis of the ongoing threat of antimicrobial resistance. Discussions will include the molecular mechanisms, diverse epidemiology of transmission, the consequences of antimicrobial resistance and efforts to reduce the further emergence and spread of these pathogens both in the community and in healthcare settings. In the process, you learn a fair amount of medical microbiology.

Fall 2020: BIOL UN3404

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 3404	001/11635	T 12:10pm - 2:00pm Online Only	Franklin Lowy	3	20/20

BIOL UN3500 Independent Biological Research. *2 points*.
Fee: $150. Students must register for a recitation section, *BIOL W3510*.
Fee: Lab Fee - 150

Prerequisites: Concurrent with registering for this course, a student must register with the department and provide a written invitation from a mentor; details of this procedure are available at http://www.columbia.edu/cu/biology/courses/w3500/index.htm.,Students must register for recitations UN3510 or consult the instructor.
Corequisites: BIOL UN3510
The course involves independent study, faculty-supervised laboratory projects in contemporary biology. Concurrent with registering for this course, a student must register with the department, provide a written invitation from a mentor and submit a research proposal; details of this procedure are available at http://www.columbia.edu/cu/biology/courses/w3500/index.htm (http://www.columbia.edu/cu/biology/courses/w3500/). A paper summarizing results of the work is required by the last day of finals for a letter grade; no late papers will be accepted. See the course web site (above) for more details. Students can take anywhere from 2-4 points for this course.

Fall 2020: BIOL UN3500

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 3500	001/11650		Ron Prywes	2	22/100

BIOL UN3560 Evolution in the age of genomics. *4 points*.
Prerequisites: Introductory Biology I and II, or the instructors permission.
This course introduces basic concepts in evolutionary biology, from speciation to natural selection. While the lectures incorporate a historical perspective, the main goal of the class is to familiarize students with topics and tools of evolutionary genetics as practiced today, in the era of genomics. Thus, the focus will be on evidence from molecular evolution and genetics and exercises will assume a basic background in genetics. Examples will be drawn from across the tree of life, but with a primary focus on humans.

BIOL UN3700 Independent Clinical Research. *2-4 points*.
Prerequisites: concurrent with registering for this course, a student must register with the department, provide a written invitation from a mentor, and submit a research proposal.
BIOL 3700 will provide an opportunity for students interested in independent research work in a hospital or hospice setting. In these settings, where patients and their needs are paramount, and where IRB rules and basic medical ethics make “wet-lab biology research” inappropriate, undergraduates may well find a way nevertheless, to assist and participate in ongoing clinical research. Such students, once they have identified a mentor willing to provide support, participation, and advising, may apply to the faculty member in charge of the course for 2-4 points/semester in *BIOL W3700*. This course will closely follow procedures already in place for *BIOL 3500*, but will ask potential mentors to provide evidence that students will gain hands-on experience in a clinical setting, while participating in a hospital- or hospice-based research agenda. A paper summarizing results of the work is required by the last day of finals for a letter grade; no late papers will be accepted.

BIOL UN3799 Molecular Biology of Cancer. *3 points*.
Prerequisites: three terms of biology (genetics and cell biology recommended).
Cancer is one of the most dreaded common diseases. Yet it is also one of the great intellectual challenges in biology today. How does a cell become cancerous? What are the agents that cause this to occur? How do current findings about genes, cells, and organisms ranging from yeast cells to humans inform us about cancer? How do findings about cancer teach us new biological concepts? Over the past few years there have been great inroads into answering these questions which have led to new ways to diagnose and treat cancer. This course will discuss cancer from the point of view of basic biological research. We will cover topics in genetics, molecular and cell biology that are relevant to understanding the differences between normal and cancer cells. These will include tumor viruses, oncogenes, tumor suppressor genes, cell cycle regulation, programmed cell death and cell senescence. We will also study some current physiological concepts related to cancer including angiogenesis, tumor immunology, cancer stem cells, metastasis and new approaches to treatment that are built on recent discoveries in cancer biology. The text book for this course is "The Biology of Cancer Second Edition by Robert A Weinberg (Garland Science). Additional and complementary readings will be assigned. SCE and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar. http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf

BIOL UN3995 (Section 1) Topics in Biology: Crossroads in Bioethics. *1-2 points*.
Prerequisites: at least one introductory course in biology or chemistry.
This two credit multidisciplinary and interactive course will focus on contemporary issues in bioethics. Each topic will cover both the underlying science of new biotechnologies and the subsequent bioethical issues that emerge from these technologies. Classroom time will be devoted to student discussions, case presentations, and role playing. Topics include human trafficking, stem cell research, human reproductive cloning, neuroethics, genetic screening, human-animal chimeras, synthetic biology, bioterrorism, and neuroimaging.

BIOL UN3995 Topics in Biology. *1 point*.
Enrollment limited to 18.

Prerequisites: Introductory Biology or equivalent.
Topics in Biology: Radiographic Anatomy and Select Pathology (Section 007 Fall semester)

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Radiographic Anatomy and Selective Pathology is a survey course intended for undergraduate students. This course is not limited to science majors and would be of value to any student that may have an interest in studying the anatomy of the human body.

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The course is a systematic approach to the study of the human body utilizing medical imaging. We will be studying neuro-anatomy, anatomy of the thorax, abdomen, and pelvis. Vascular and musculoskeletal imaging will be addressed as well. Modalities will include CT, MRI, PET/CT, and Ultrasound. Cross sectional imaging will be supplemented with pathology demonstrated on appropriate cross sectional imaging.

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The class size will be limited to 15 students. The lecture will be offered Wednesday evenings from 6:10-7:00 pm. This will be a 1 credit course offered only during the fall semesters.

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Topics in Biology: Crossroads in Bioethics (Section 001 Spring semester)

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This two credit multidisciplinary and interactive course will focus on contemporary issues in bioethics and medical ethics. Each topic will cover both the underlying science of new biotechnologies and the subsequent bioethical issues that emerge from these technologies. Each topic will introduce a bioethical principle that will be explored using case studies. Students are expected to prepare for each class based on the assignment so that classroom time will be devoted to discussion, case presentations, and role playing rather than merely lectures. Topics include stem cell research, human reproductive cloning, bioterrorism, neuroethics, genetic screening, medical stem cell tourism, patents and science, forensic science and the interface of science and culture/religion.

Spring 2021: BIOL UN3995

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 3995	001/10918	T 1:10pm - 2:25pm Online Only	John Loike	1	0/40

BIOL GU4001 Advanced Genetic Analysis. *3 points*.
CC/GS: Partial Fulfillment of Science Requirement
Enrollment limited to 25.

Prerequisites: for undergraduates: Introductory Genetics (*W3031*) and the instructor's permission.
This seminar course provides a detailed presentation of areas in classical and molecular genetics for advanced undergraduates and beginning graduate students. Topics include transmission genetics, gain and loss of function mutations, genetic redundancy, suppressors, enhancers, epistasis, expression patterns, using transposons, and genome analysis. The course is a mixture of lectures, student presentations, seminar discussions, and readings from the original literature.

Spring 2021: BIOL GU4001

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 4001	001/10917	M 1:10pm - 4:00pm Online Only	Martin Chalfie	3	0/25

BIOL GU4004 Neurobiology I: Cellular and Molecular Neurobiology. *4 points*.
Discussion Section Required

Prerequisites: one year of biology; a course in physics is highly recommended.
Lecture and recitation. This is an advanced course intended for majors providing an in depth survey of the cellular and molecular aspects of nerve cell function. Topics include the cell biology and biochemistry of neurons, ionic and molecular basis of electrical signals, synaptic transmission and its modulation, function of sensory receptors. Although not required, it is intended to be followed by Neurobiology II (see below). The recitation meets once per week in smaller groups and emphasizes readings from the primary literature.

Fall 2020: BIOL GU4004

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 4004	001/11563	T Th 10:10am - 11:25am Online Only	Stuart Firestein	4	6/25

BIOL GU4008 The Cellular Physiology of Disease. *3 points*.
Prerequisites: one 3000-level course in Cell Biology or Biochemistry or the instructor's permission.
Corequisites: BIOL GU4009
This course will present a quantitative description of the cellular physiology of excitable cells (mostly nerve and muscle). While the course will focus on examining basic mechanisms in cell physiology, there will be a thread of discussion of disease mechanisms throughout. The end of each lecture will include a discussion of the molecular mechanisms of selected diseases that relate to the topics covered in the lecture. The course will consist of two lectures per week. This course will be of interest to advanced (3000-4000 level) undergraduates that aim to pursue careers in medicine as well as those that will pursue careers in biomedical research. This course will also be of interest to graduate students desiring an introduction to the cellular physiology of nerve and muscle.

BIOL GU4009 Cellular Physiology of Diseases Laboratory. *1 point*.
See department for details

BIOL GU4022 Developmental Biology. *3 points*.
Prerequisites: *BIOL C2005-C2006* or equivalent.
Come discover how the union of egg and sperm triggers the complex cellular interactions that specify the diverse variety of cells present in multicellular organisms. Cellular and molecular aspects of sex determination, gametogenesis, genomic imprinting, X-chromosome inactivation, telomerase as the biological clock, stem cells, cloning, the pill and cell interactions will be explored, with an emphasis on humans. Original research articles will be discussed to further examine current research in developmental biology. SCE and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar. http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf

Fall 2020: BIOL GU4022

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 4022	001/12183	T Th 1:10pm - 2:25pm 601 Fairchild Life Sciences Bldg	Alice Heicklen	3	2/10

BIOL GU4031 Genetics. *3 points*.
Open to Biotech M.A. students and other graduate students.

Corequisites: Recommended: one term of organic chemistry.
Prerequisites: BIOL UN2005 and BIOL UN2006 or the equivalent. General genetics course focused on basic principles of transmission genetics and the application of genetic approaches to the study of biological function. Principles will be illustrated using classical and contemporary examples from prokaryote and eukaryote organisms, and the experimental discoveries at their foundation will be featured. Applications will include genetic approaches to studying animal development and human diseases. SCE and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar.http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pd (http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf)

BIOL GU4034 Biotechnology. *3 points*.
Prerequisites: genetics or molecular biology.
The course covers techniques currently used to explore and manipulate gene function and their applications in medicine and the environment. Part I covers key laboratory manipulations, including DNA cloning, gene characterization, association of genes with disease, and methods for studying gene regulation and activities of gene products. Part II also covers commercial applications, and includes animal cell culture, production of recombinant proteins, novel diagnostics, high throughput screening, and environmental biosensors.

Fall 2020: BIOL GU4034

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 4034	001/11572	M W 4:10pm - 5:25pm Online Only	Lawrence Chasin, Daniel Kalderon	3	28/50

BIOL GU4035 Seminar in Epigenetics. *3 points*.
Prerequisites: Genetics (3032/4032) or Molecular Biology (3512/4512), and the instructor's permission.
This is a combined lecture/seminar course designed for advanced undergraduates and graduate students. The focus is on understanding the mechanisms underlying epigenetic phenomena: the heritable inheritance of genetic states without change in DNA sequence. Epigenetic mechanisms play important roles during normal animal development and oncogenesis. It is an area under intensive scientific investigation and the course will focus on recent advances in understanding these phenomena. In each class, students will present and discuss in detail recent papers and background material concerning each individual topic, followed by an introductory lecture on the following week's topic. This course will emphasize critical analysis of the scientific literature and help students understand how to identify important biological problems and how to address them experimentally.

BIOL GU4065 Molecular Biology of Disease. *3 points*.
Enrollment limited to 30.

Prerequisites: open to advanced undergraduates with the instructor's permission. Completion of a 3000-level course in at least one of the following, with completion of two or more preferred: genetics, biochemistry, cell biology.
Molecular and cellular basis of infectious diseases and inherited propensities. Mechanisms of disease examined in discussions based on current research papers. Lectures, discussions, and student presentations. Essay required in lieu of final examination.

BIOL GU4070 The Biology and Physics of Single Molecules. *3 points*.
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: calculus, chemistry, physics, one year of biology, or the instructor's permission.
This course will examine the fundamental mechanisms underlying the behavior of biological molecules, at the single molecule level. The course will cover the methods used to track single molecules: optical tweezers, single molecule AFM, Magnetic tweezers, Optical techniques and Fluorescence energy transfer (FRET) probes. The course will cover the mechanism of action of mechanical motors, such as myosin dyneyin, kinesin. It will cover the action of DNA binding enzymes such as topoisomerases, helicases, etc. We will also discuss the function of large motors such as the ATP Synthase and the bacterial AAA ATPases. We will discuss the mechanical properties of DNA, RNA, and proteins. The course will consist mainly of reviewing classical experiments in each category, and developing the background physical theories to promote a deep understanding of biological mechanisms at the mesoscopic level.

BIOL GU4075 Biology at Physical Extremes. *3 points*.
Prerequisites: one year each of biology and physics, or the instructor's permission.
This is a combined lecture/seminar course designed for graduate students and advanced undergraduates. The course will cover a series of cases where biological systems take advantage of physical phenomena in counter intuitive and surprising ways to accomplish their functions. In each of these cases, we will discuss different physical mechanisms at work. We will limit our discussions to simple, qualitative arguments. We will also discuss experimental methods enabling the study of these biological systems. Overall, the course will expose students to a wide range of physical concepts involved in biological processes.

BIOL GU4080 The Ancient and Modern RNA Worlds. *3 points*.
Prerequisites: BIOC UN3512
RNA has recently taken center stage with the discovery that RNA molecules sculpt the landscape and information contained within our genomes. Furthermore, some ancient RNA molecules combine the roles of both genotype and phenotype into a single molecule. These multi-tasking RNAs offering a possible solution to the paradox of which came first: DNA or proteins. This seminar explores the link between modern RNA, metabolism, and insights into a prebiotic RNA world that existed some 3.8 billion years ago. Topics include the origin of life, replication, and the origin of the genetic code; conventional, new, and bizarre forms of RNA processing; and structure, function and evolution of key RNA molecules, including the ribosome. The format will be weekly seminar discussions with presentations. Readings will be taken from the primary literature, emphasizing seminal and recent literature. Requirements will be student presentations, class participation, and a final paper.

BIOL GU4082 Theoretical Foundations and Applications of Biophysical Methods. *4 points*.
Prerequisites: at least one year of coursework in single-variable calculus and not being freaked-out by multivariable calculus. Physics coursework through a calculus-based treatment of classical mechanics and electromagnetism. One year of general chemistry (either AP Chemistry or a college course). One year of college coursework in molecular/cellular biology and biochemistry equivalent to Biology *C2005-2006* at Columbia. Rigorous introduction to the theory underlying biophysical methods, which are illustrated by practical applications to biomedical research. Emphasizes the approach used by physical chemists to understand and analyze the behavior of molecules, while also preparing students to apply these methods in their own research. Course modules cover: (i) statistical analysis of data; (ii) solution thermodynamics; (iii) hydrodynamic methods; (iv) light-scattering methods; and (v) spectroscopic methods, especially fluorescence. Recitations focus on curve-fitting analyses of experimental data.

BIOL GU4193 Stem Cell Biology and Applications. *3 points*.
Prerequisites: Three semesters of Biology or instructor permission.
The course examines current knowledge and potential medical applications of pluripotent stem cells (embryonic stem cells and induced pluripotent stem cells), direct conversions between cell types and adult, tissue-specific stem cells (concentrating mainly on hematopoietic and gut stem cells as leading paradigms). A basic lecture format will be supplemented by presentations and discussions of research papers. Recent reviews and research papers together with extensive instructor notes will be used in place of a textbook.

BIOL GU4260 Proteomics Laboratory. *3 points*.
Lab Fee: $150.

This course deals with the proteome: the expressed protein complement of a cell, organelle, matrix, tissue, organ or organism. The study of the proteome (proteomics) is broadly applicable to life sciences research, and is increasingly important in academic, government and industrial research through extension of the impact of advances in genomics. These techniques are being applied to basic research, exploratory studies of cancer and other diseases, drug discovery and many other topics. Emphasis will be on mastery of practical techniques of sample preparation, liquid chromatography/ mass spectrometry (LC/MS) with electrospray ionization. Database searching and interpretation for identification of proteins will be intensively studied, and practiced supported by background tutorials and exercises covering other techniques used in proteomics. Open to students in M.A. in Biotechnology Program (points can be counted against laboratory requirement for that program), Ph.D. and advanced undergraduate students with background in genetics or molecular biology. Students should be comfortable with basic biotechnology laboratory techniques as well as being interested in doing computational work in a Windows environment.

Fall 2020: BIOL GU4260

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 4260	001/11647	T 12:30pm - 3:30pm Online Only	Lewis Brown	3	7/20

BIOL GU4290 Biological Microscopy. *3 points*.
Prerequisites: (biol un2005 or biol un2401) or BIOL UN2005 or BIOL UN2401 or equivalent
This is an advanced microscopy course aimed at graduates and advanced undergraduate students, who are interested in learning about the foundational principles of microscopy approaches and their applications in life sciences. The course will introduce the fundamentals of optics, light-matter interaction and in-depth view of most commonly used advanced microscopy methods, explore important practical imaging parameters, and also introduce digital images and their analysis.

Spring 2021: BIOL GU4290

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 4290	001/11003	T Th 11:40am - 12:55pm 601 Fairchild Life Sciences Bldg	Raju Tomer	3	0/30

BIOL GU4300 Drugs and Disease. *3 points*.
Prerequisites: four semesters of biology with a firm foundation in molecular and cellular biology.
Introduces students to the current understanding of human diseases, novel therapeutic approaches and drug development process. Selected topics will be covered in order to give students a feeling of the field of biotechnology in health science. This course also aims to strengthen students' skills in literature comprehension and critical thinking.

Fall 2020: BIOL GU4300

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 4300	001/11933	M W 2:40pm - 3:55pm 601 Fairchild Life Sciences Bldg	Lili Yamasaki	3	30/70

BIOL GU4305 Seminar in Biotechnology. *3 points*.
Prerequisites: *BIOL W4300* or the instructor's permission.
A weekly seminar and discussion course focusing on the most recent development in biotechnology. Professionals of the pharmaceutical, biotechnology, and related industries will be invited to present and lead discussions.

Spring 2021: BIOL GU4305

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 4305	001/11303	W 2:10pm - 4:00pm 601 Fairchild Life Sciences Bldg	Lili Yamasaki	3	0/40

BIOL GU4310 Virology. *3 points*.
The basic thesis of the course is that all viruses adopt a common strategy. The strategy is simple:

1. Viral genomes are contained in metastable particles.

2. Genomes encode gene products that promote an infectious cycle (mechanisms for genomes to enter cells, replicate, and exit in particles).

3. Infection patterns range from benign to lethal; infections can overcome or co-exist with host defenses.

Despite the apparent simplicity, the tactics evolved by particular virus families to survive and prosper are remarkable. This rich set of solutions to common problems in host/parasite interactions provides significant insight and powerful research tools. Virology has enabled a more detailed understanding of the structure and function of molecules, cells and organisms and has provided fundamental understanding of disease and virus evolution.

The course will emphasize the common reactions that must be completed by all viruses for successful reproduction within a host cell and survival and spread within a host population. The molecular basis of alternative reproductive cycles, the interactions of viruses with host organisms, and how these lead to disease are presented with examples drawn from a set of representative animal and human viruses, although selected bacterial viruses will be discussed.

Spring 2021: BIOL GU4310

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 4310	001/10923	M W 4:10pm - 5:25pm Online Only	Vincent Racaniello	3	0/150

BIOL GU4510 Genomics of Gene Regulation. *4 points*.
Prerequisites: one year of Biology, Chemistry, and Physics. Courses taken at CU are recommended, but AP courses may be sufficient with the instructor's permission.
This course will provide students with a quantitative understanding of the ways in which molecular interactions between nucleotides and proteins give rise to the behavior of gene regulatory networks. The key high-throughput genomics technologies for probing the cell at different levels using microarrays and next-generation sequencing will be discussed. Strategies for interpreting and integrating these data using statistics, biophysics, and genetics will be introduced. In computer exercises, student will learn the basics of the R language, and use it to perform analyses of genomics data sets. No prior computer programming experience is assumed. This highly interdisciplinary course is intended for advanced undergraduates as well as beginning graduate students in Biology, Chemistry, Physics, Engineering, and Computer Science. Offered in previous years as CHBC W4510.

BIOL GU4560 Evolution in the age of genomics. *4 points*.
Prerequisites: introductory genetics or the instructor's permission.
This course introduces basic concepts in evolutionary biology, from speciation to natural selection. While the lectures incorporate a historical perspective, the main goal of the class is to familiarize students with topics and tools of evolutionary genetics as practiced today, in the era of genomics. Thus, the focus will be on evidence from molecular evolution and genetics and exercises will assume a basic background in genetics. Examples will be drawn from across the tree of life, but with a primary focus on humans.

BIOL GU4600 Cell Signaling. *3 points*.
Prerequisites: A strong background in molecular and cellular biology. Generally students with four or more courses are accepted.
Cell Signaling is a graduate course for Ph.D. students open to advanced undergraduate and masters students. The basic molecular mechanism of signal transduction pathways will be discussed related to cell growth and stress systems. There will be an emphasis on specific categories of signaling components. Students will read the literature and give presentations. Topics include the pathways by which cells respond to extracellular signals such as growth factors and the mechanisms by which extracellular signals are translated into alterations in the cell cycle, morphology, differentiation state, and motility of the responding cells. For stress pathways we will discuss how cells respond to survive the stress or induce their own death. In many cases these pathways will be related to human diseases.

Fall 2020: BIOL GU4600

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOL 4600	001/11734	T 4:10pm - 6:00pm Online Only	Ron Prywes	3	21/25

BIOL GU4799 Readings In the Molecular Biology of Cancer. *3 points*.
Tracing the discovery of the role of DNA tumor viruses in cancerous transformation. Oncogenes and tumor suppressors are analyzed with respect to their function in normal cell cycle, growth control, and human cancers. SCE and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar. http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf

BIOL GU6002 Macromolecular Structure & Interactions. *4 points*.
Open to PhD candidates in the biomedical and chemical sciences, and to other qualified graduate, undergraduate, and continuing education students with the instructor's permission.

This course presents a rigorous introduction to solution thermodynamics and applies it to understanding the structural and functional features of proteins. After exploring the conceptual origins of thermodynamic theory, the standard equations describing solution equilibria are derived and applied to analyzing biochemical reactions, with a focus on those involved in protein folding and allosteric communication. The semester culminates with exploration of the energetic factors controlling the formation of protein secondary structures and the role of entropy-enthalpy compensation in determining the complex temperature-dependent thermodynamic properties of aqueous solutions. The course emphasizes both qualitative understanding of the thermodynamic forces controlling the evolution and function of living organisms as well as practical application of thermodynamic methods and structural insight in laboratory research. Tutorials cover the use of curve-fitting techniques to analyze biochemical equilibria as well as the use of molecular visualization software to understand protein structure and function. This is a half semester, 2-point course.

BIOT GU4160 Biotechnology Law. *3 points*.
Priority given to Biotechnology Program students.

Prerequisites: at least 4 college-level biology or biotechnology courses. This course will introduce students to the interrelated fields of patent law, regulatory law, and contract law that are vital to the biotech and biopharmaceutical sectors. The course will present core concepts in a way that permits students to use them throughout their corporate, academic, and government careers. SCE and TC students may register for this course, but they must first obtain the written permission of the instructor, by filling out a paper Registration Adjustment Form (Add/Drop form). The form can be downloaded at the URL below, but must be signed by the instructor and returned to the office of the registrar. http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf

Fall 2020: BIOT GU4160

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOT 4160	001/11548	W 6:10pm - 8:00pm Online Only	Alan Morrison	3	24/40

BIOT GU4161 Ethics in Biopharmaceutical Patent and Regulatory Law. *3 points*.
Prerequisites: BIOT GU4160 BIOTECHNOLOGY LAW (BIOT W4160)
Course Objective This course – the first of its kind at Columbia – introduces students to a vital subfield of ethics focusing on patent and regulatory law in the biotech and pharmaceutical sectors. The course combines lectures, structured debate and research to best present this fascinating and nuanced subject. Successful completion of Biotechnology Law (W4160) is a course prerequisite, since properly exploring this branch of bioethics requires an indepth understanding of biotech and pharmaceutical patent and regulatory law.

BIOT GU4200 Biopharmaceutical Development & Regulation. *3 points*.
The program aims to provide current life sciences students with an understanding of what drives the regulatory strategies that surround the development decision making process, and how the regulatory professional may best contribute to the goals of product development and approval. To effect this, we will examine operational, strategic, and commercial aspects of the regulatory approval process for new drug, biologic, and biotechnology products both in the United States and worldwide. The topics are designed to provide a chronological review of the requirements needed to obtain marketing approval. Regulatory strategic, operational, and marketing considerations will be addressed throughout the course. We will examine and analyze the regulatory process as a product candidates are advanced from Research and Development, through pre-clinical and clinical testing, to marketing approval, product launch and the post-marketing phase. The goal of this course is to introduce and familiarize students with the terminology, timelines, and actual steps followed by Regulatory Affairs professionals employed in the pharmaceutical or biotechnology industry. Worked examples will be explored to illustrate complex topics and illustrate interpretation of regulations.

Fall 2020: BIOT GU4200

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
BIOT 4200	001/11935	Th 4:10pm - 6:00pm Online Only	Ron Guido	3	115/90

Of Related Interest

Biomedical Engineering	
BMEN E4150	The cell as a machine
Chemistry	
BIOC UN3501	Biochemistry: Structure and Metabolism
BIOC UN3512	Molecular Biology
Ecology, Evolution, and Environmental Biology	
EEEB UN2001	Environmental Biology I: Elements to Organisms
EEEB GU4321	Human Nature: DNA, Race & Identity
History and Philosophy of Science	
HPSC W3201	Philosophy and History of Evolutionary Biology
Physics	
PHYS W4075	Biology at Physical Extremes
Psychology	
PSYC UN1010	Mind, Brain and Behavior