**BIOLOGICAL SCIENCES**

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

**Director of Undergraduate Studies, Undergraduate Programs and Laboratories:**
Prof. Alice Heicklen, 744B Mudd; 212-854-5952; ah2289@columbia.edu

**Online Resources:**
- FAQs for first-year students
- FAQs for prospective majors
- Checklist of major requirements
- Additional course information
- FAQs for nontraditional students

The usual one-year introductory biology sequence is BIOL UN2005 INTRO BIO I: BIOCHEM, GEN, MOLEC-BIOL UN2006 INTRO BIO II: CELL BIO, DEV/PHYS, taken in the sophomore year, after one year of 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 Biology in the fall semester of their first year.

Premedical students should consult with their advising dean or the preprofessional office for relevant details of medical school requirements. Students interested in graduate school should consult the biology career adviser, Dr. Molly Przeworski

Non-science majors who wish to take a biology course to fulfill the science requirement are encouraged to take BIOL UN1130 Genes and Development. Interested students should consult listings in other departments for courses related to biology.

**Advanced Placement**

The department grants 3 credits for a score of 5 on the AP Biology exam. Placement is determined by the department. Students with a 5 on the AP are encouraged to take BIOL UN2005 INTRO BIO I: BIOCHEM, GEN, MOLEC and BIOL UN2006 INTRO BIO II: CELL BIO, DEV/PHYS, but are not required to do so. For details, visit [https://www.biology.columbia.edu/pages/first-year-students-and-prospective-students-faq](https://www.biology.columbia.edu/pages/first-year-students-and-prospective-students-faq)

**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**

Biology Major and Concentration Advisers (CC):

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-G: Prof. Carol Prives, 816 Fairchild; clp3@columbia.edu
- H-N: Prof. Mary Ann Price, 744A Mudd; map2293@columbia.edu
- O-Z: Prof. Tulle Hazelrigg, 753A Mudd, tih1@columbia.edu

**Biology Major and Concentration Adviser (GS):**

Prof. Deborah Mowshowitz, 744D Mudd; dbm2@columbia.edu

**Biochemistry Advisers (CC & GS):**

Biology: Prof. John Hunt, 702A Fairchild; jfh21@columbia.edu (for course planning questions)

- Prof. James Manley, 1117A Fairchild; jlm2@columbia.edu (for research, graduate school questions)

Chemistry: Prof. Vesna Gasperov, 355 Chandler Hall; vg2231@columbia.edu

**Biophysics Adviser (CC & GS):**

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

**Neuroscience and Behavior Advisers (CC):**

Biology:

- A-P: Prof. Stuart Firestein, 1011B Fairchild; sjf24@columbia.edu
- Q-Z: Prof. Jian Yang, 917A Fairchild; jy160@columbia.edu

Psychology: Prof. Caroline Marvin, 317 Schermerhorn; cbm2118@columbia.edu

**Neuroscience and Behavior Advisers (GS):**

Biology: Prof. Deborah Mowshowitz; 744D Mudd; dbm2@columbia.edu

Psychology: Prof. Caroline Marvin, 317 Schermerhorn; cbm2118@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.

Current detailed descriptions of the SURF program and the application procedure are available at SURF’s website, [https://www.biology.columbia.edu/programs/surf](https://www.biology.columbia.edu/programs/surf). For more information...
on the Amgen Scholarship Program, please visit https://www.biology.columbia.edu/programs/amgen-scholars-program. 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 before spring break of their senior year. For details, please visit the departmental website at http://biology.columbia.edu/programs/honors-biological-sciences.

**Professors**
- Peter Andolfatto
- Harmen Bussemaker
- Martin Chalfie
- Lawrence Chasin
- Stuart Firestein
- Joachim Frank
- Iva Greenwald
- Tulle Hazelrigg
- Oliver Hobert
- John Hunt
- Songtao Jia
- Daniel Kalderon
- Darcy Kelley
- Laura Landweber
- James Manley
- Robert Pollack
- Carol Prives
- Ronald Prywes
- Molly Przeworski
- Michael Sheetz
- Brent Stockwell
- Simon Tavare

**Associate Professors**
- Saeed Tavazoie
- Liang Tong
- Jian Yang
- Rafael Yuste

**Associate Professors**
- Lars Dietrich
- 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
Presbyterian Medical Center are open to advanced undergraduates. In addition, selected courses at the Columbia-

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

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.

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 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

Developmental Biology

GENETICS

Cell Biology

Biochemistry: Structure and Metabolism

Biochemistry

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:

Project Laboratory in Microbiology

PROJECT LAB-MOLECULAR GENETICS

Contemporary Biology Laboratory

Option 2:

BIOL UN2501
Select an additional 3-point lab such as BIOL UN3040, a 5-point project lab, or a Barnard lab. Barnard labs must be approved by a Biology Major Advisor.

**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, except BIOL UN3500 Independent Biological Research and SURF.

### 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. A list of 3000- or 4000-level approved electives can be found on the biology website: https://www.biology.columbia.edu/pages/biology-major-requirements

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

**Option 1:**
<table>
<thead>
<tr>
<th>COURSE</th>
<th>COURSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM UN1403</td>
<td>GENERAL CHEMISTRY I-LECTU</td>
</tr>
<tr>
<td>CHEM UN1404</td>
<td>and GENERAL CHEMISTRY II-LECTURES</td>
</tr>
<tr>
<td>CHEM UN1500</td>
<td>GENERAL CHEMISTRY LABORATORY</td>
</tr>
<tr>
<td>CHEM UN1501</td>
<td>and GENERAL CHEMISTRY LAB-LECTURE</td>
</tr>
<tr>
<td>CHEM UN2443</td>
<td>Organic Chemistry I (Lecture)</td>
</tr>
<tr>
<td>CHEM UN2444</td>
<td>and ORGANIC CHEMISTRY II-LECTURES</td>
</tr>
<tr>
<td>CHEM UN2493</td>
<td>Organic Chemistry Laboratory I (Techniques)</td>
</tr>
<tr>
<td>CHEM UN2494</td>
<td>and ORGANIC CHEM. LAB II SYNTHESIS</td>
</tr>
</tbody>
</table>

**Option 2:**
For students who qualify for intensive chemistry

<table>
<thead>
<tr>
<th>COURSE</th>
<th>COURSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM UN1604</td>
<td>2ND TERM GEN CHEM (INTENSIVE)</td>
</tr>
<tr>
<td>CHEM UN1507</td>
<td>Intensive General Chemistry Laboratory</td>
</tr>
<tr>
<td>CHEM UN2444</td>
<td>ORGANIC CHEMISTRY II-LECTURES</td>
</tr>
<tr>
<td>CHEM UN2443</td>
<td>and Organic Chemistry I (Lecture)</td>
</tr>
<tr>
<td>CHEM UN2495</td>
<td>Organic Chem. Laboratory I</td>
</tr>
<tr>
<td>CHEM UN2496</td>
<td>and Organic Chem. Laboratory II</td>
</tr>
</tbody>
</table>

**Option 3:**
For students who qualify for first year organic chemistry

<table>
<thead>
<tr>
<th>COURSE</th>
<th>COURSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM UN1507</td>
<td>Intensive General Chemistry Laboratory</td>
</tr>
<tr>
<td>CHEM UN2045</td>
<td>INTENSIVE ORGANIC CHEMISTRY</td>
</tr>
<tr>
<td>CHEM UN2046</td>
<td>and INTENSIVE ORG CHEM-FOR 1ST YEAR</td>
</tr>
<tr>
<td>CHEM UN2495</td>
<td>Organic Chem. Laboratory I</td>
</tr>
<tr>
<td>CHEM UN2496</td>
<td>and Organic Chem. Laboratory II</td>
</tr>
<tr>
<td>CHEM UN2545</td>
<td>or CHEM UN2545</td>
</tr>
</tbody>
</table>

### Physics
Students must take two terms of physics including the accompanying labs. The usual choices are PHYS UN1201-PHYS UN1202 General Physics I 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.


### 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.

For more details, see the Chemistry section in this Bulletin. For additional information visit the Department of Biological Sciences website: [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:

<table>
<thead>
<tr>
<th>COURSE</th>
<th>COURSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL UN2005</td>
<td>INTRO BIO I: BIOCHEM,GEN,MOLEC</td>
</tr>
<tr>
<td>BIOL UN2006</td>
<td>and INTRO BIO II:CELL BIO/DEV/PHYS</td>
</tr>
</tbody>
</table>

Select at least one of the following laboratory courses:

<table>
<thead>
<tr>
<th>COURSE</th>
<th>COURSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL UN3050</td>
<td>Project Laboratory In Protein Biochemistry</td>
</tr>
<tr>
<td>BIOL UN3052</td>
<td>PROJECT LAB-MOLECULAR GENETICS</td>
</tr>
<tr>
<td>BIOL UN3058</td>
<td>Project Laboratory in Molecular Biology</td>
</tr>
<tr>
<td>BIOL UN3500</td>
<td>Independent Biological Research</td>
</tr>
</tbody>
</table>

One course in biochemistry or molecular biology:

<table>
<thead>
<tr>
<th>COURSE</th>
<th>COURSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCHM GU4501</td>
<td>BIOCHEM I-STRUCTURE/METABOLISM</td>
</tr>
<tr>
<td>or BIOL UN3512</td>
<td>Molecular Biology</td>
</tr>
<tr>
<td>or BIOL UN3500</td>
<td>Biochemistry</td>
</tr>
</tbody>
</table>

Select one of the following options:

**Option 1 - Genetics:**

<table>
<thead>
<tr>
<th>COURSE</th>
<th>COURSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL UN3031</td>
<td>GENETICS</td>
</tr>
</tbody>
</table>

**Option 2 - Neurobiology:**

<table>
<thead>
<tr>
<th>COURSE</th>
<th>COURSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL UN3004</td>
<td>Neurobiology I: Cellular and Molecular Neurobiology</td>
</tr>
<tr>
<td>or BIOL UN3005</td>
<td>Neurobiology II: Development &amp; Systems</td>
</tr>
</tbody>
</table>

**Option 3 - Developmental Biology:**

<table>
<thead>
<tr>
<th>COURSE</th>
<th>COURSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL UN3022</td>
<td>Developmental Biology</td>
</tr>
</tbody>
</table>

Select one of the following sequences to be completed at the end of sophomore year:
Major in Neuroscience and Behavior

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

For more details, see the Psychology section in this Bulletin or visit http://biology.columbia.edu/pages/neuroscience-and-behavior-major-requirements.

CHEMISTRY COURSES

One year of college chemistry is required prior to taking Introductory Biology.

BIOLOGY COURSES

One year of introductory biology.

Biology

One of the following courses:
- BIOL UN3006 PHYSIOLOGY
- BIOL UN3019 Brain Evolution
- 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

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 COURSES

One year of college chemistry is required prior to taking Introductory Biology.

BIOLOGY COURSES

One year of introductory biology.

Biology

One of the following courses:
- BIOL UN2005 INTRO BIO I: BIOCHEM,GEN,MOLEC
- BIOL UN2006 INTRO BIO II:CELL BIO,DEV/PHYS

One year of Neurobiology

Biology

One of the following courses:
- BIOL UN3004 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 UN3019 Brain Evolution
- 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

For more details, see the Physics section in this Bulletin or visit the Department of Biological Sciences website: http://biology.columbia.edu/pages/biophysics-major-requirements.

BIOL UN3193 Stem Cell Biology and Applications
BIOL UN3300 Biochemistry
BIOL UN3404 The Global Threat of Antimicrobial Resistance
BIOL GU4034 Biotechnology (or BIOL UN3404)
BIOL GU4035 Seminar in Epigenetics
BIOL GU4075 Biology at Physical Extremes
BIOL GU4080 ANCIENT AND MODERN RNA WORLDS
BIOL GU4082 Theoretical Foundations and Applications of Biophysical Methods
BIOL GU4260 Proteomics Laboratory
BIOL GU4290 Biological Microscopy
BIOL GU4300 Drugs and Disease
BIOL GU4305 Seminar in Biotechnology
BIOL GU4323 Biophysical Chemistry I
BIOL GU4324 Biophysical Chemistry II
BCHM GU4501 BIOCHEM I-STRUCTURE/METABOLISM (or BIOL UN3501)
BIOL GU4512 Molecular Biology (or BIOL UN3512)
BIOL GU4510 Genomics of Gene Regulation
BIOL GU4560 Evolution in the age of genomics

PSYCHOLOGY COURSES

Each of the following courses:

- PSYC UN1001 or PSYC UN1021 The Science of Psychology
- PSYC UN2430 COGNITIVE NEUROSCIENCE (Students who have previously taken PSYC UN1010 Mind, Brain and Behavior (no longer offered) may use that course to fulfill this requirement.)
- PSYC UN2450 or PSYC UN2450 Behavioral Neuroscience
- PSYC UN2470 or PSYC UN2470 Fundamentals of Human Neuropsychology

One statistics or research methods course from the following:

- PSYC UN1420 RESEARCH METHODS - HUMAN BEHAVIOR
- PSYC UN1450 RESEARCH METHODS - SOCIAL COGNITION # EMOTION
- PSYC UN1455 RESEARCH METHODS: SOCIAL/PERSONALITY
- PSYC UN1490 RESEARCH METHODS - COGNITION/DECISION MAKING
- PSYC UN1610 Introductory Statistics for Behavioral Scientists
- PSYC UN1660 Advanced Statistical Inference
- STAT UN1101 Introduction to Statistics
- STAT UN1201 Calculus-Based Introduction to Statistics (Note, STAT UN1001 does not count towards the N&B major.)
- STAT UN1420 RESEARCH METHODS - HUMAN BEHAVIOR
- STAT UN1450 RESEARCH METHODS - SOCIAL COGNITION # EMOTION
- STAT UN1455 RESEARCH METHODS: SOCIAL/PERSONALITY
- STAT UN1490 RESEARCH METHODS - COGNITION/DECISION MAKING
- STAT UN1610 Introductory Statistics for Behavioral Scientists
- STAT UN1660 Advanced Statistical Inference
- STAT UN1101 Introduction to Statistics
- STAT UN1201 Calculus-Based Introduction to Statistics (Note, STAT UN1001 does not count towards the N&B major.)

One additional 2000- or 3000-level psychology lecture course from a list approved by the psychology advisor:

- PSYC S2210Q Cognition: Basic Processes
- PSYC UN2215 or PSYC S2215D Cognition and the Brain
- PSYC UN2220 or PSYC UN2220 Cognition: Memory and Stress
- PSYC W2225 Attention and Perception
- PSYC W2230 Perception and Sensory Processes
- PSYC UN2235 or PSYC S2235Q THINKING AND DECISION MAKING
- PSYC UN2235 or PSYC S2235Q Thinking and Decision Making
<table>
<thead>
<tr>
<th>Course Code/Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSYC UN2250 Evolution of Cognition</td>
</tr>
<tr>
<td>PSYC UN2280 Developmental Psychology</td>
</tr>
<tr>
<td>PSYC UN2420 Animal Behavior</td>
</tr>
<tr>
<td>PSYC UN2440 Language and the Brain</td>
</tr>
<tr>
<td>PSYC UN2450 Behavioral Neuroscience</td>
</tr>
<tr>
<td>PSYC S2450Q Behavioral Neuroscience</td>
</tr>
<tr>
<td>PSYC UN2460 Drugs and Behavior</td>
</tr>
<tr>
<td>PSYC UN2470 Fundamentals of Human Neuropsychology</td>
</tr>
<tr>
<td>PSYC UN2480 The Developing Brain</td>
</tr>
<tr>
<td>PSYC UN2481 Developmental Cognitive Neuroscience</td>
</tr>
<tr>
<td>PSYC S2490Q Evolutionary Psychology</td>
</tr>
<tr>
<td>PSYC UN2620 Abnormal Behavior</td>
</tr>
<tr>
<td>PSYC S2620Q Abnormal Behavior</td>
</tr>
<tr>
<td>PSYC UN2690 Frontiers of Justice</td>
</tr>
<tr>
<td>PSYC W3265 Auditory Perception (Seminar)</td>
</tr>
<tr>
<td>PSYC UN3270 Computational Approaches to Human Vision(Seminar)</td>
</tr>
<tr>
<td>PSYC UN3280 Seminar In Infant Development</td>
</tr>
<tr>
<td>PSYC S3280D Seminar in Infant Development</td>
</tr>
<tr>
<td>PSYC S3285D The Psychology of Disaster Preparedness</td>
</tr>
<tr>
<td>PSYC UN3290 Self: A Cognitive Exploration (Seminar)</td>
</tr>
<tr>
<td>PSYC GU4202 Theories of Change in Human Development</td>
</tr>
<tr>
<td>PSYC GU4222 The Cognitive Neuroscience of Aging</td>
</tr>
<tr>
<td>PSYC GU4223 Memory and Executive Function Thru the Lifespan</td>
</tr>
<tr>
<td>PSYC GU4224 Consciousness and Cognitive Science</td>
</tr>
<tr>
<td>PSYC GU4225 CONSCIOUSNESS # ATTENTION</td>
</tr>
<tr>
<td>PSYC GU4229 Attention and Perception</td>
</tr>
<tr>
<td>PSYC GU4232 Production and Perception of Language</td>
</tr>
<tr>
<td>PSYC GU4235 Special Topics in Vision (Seminar)</td>
</tr>
<tr>
<td>PSYC GU4236 Machine Intelligence</td>
</tr>
<tr>
<td>PSYC GU4239 Cognitive neuroscience of narrative and film</td>
</tr>
<tr>
<td>PSYC GU4242 Evolution of Language (Seminar)</td>
</tr>
<tr>
<td>PSYC GU4244 Language and Mind</td>
</tr>
<tr>
<td>PSYC GU4250 Evolution of Intelligence, Cognition, and Language (Seminar)</td>
</tr>
<tr>
<td>PSYC GU4265 Auditory Perception</td>
</tr>
<tr>
<td>PSYC GU4270 COGNITIVE PROCESSES</td>
</tr>
<tr>
<td>PSYC G4272 Advanced Seminar in Language Development</td>
</tr>
<tr>
<td>PSYC GU4280 Core Knowledge (Seminar)</td>
</tr>
<tr>
<td>PSYC GU4281 The Psychology of Curiosity</td>
</tr>
<tr>
<td>PSYC GU4282 The Neurobiology and Psychology of Play</td>
</tr>
<tr>
<td>PSYC G4285 Multidisciplinary Approaches to Human Decision Making (Seminar)</td>
</tr>
<tr>
<td>PSYC GU4287 Decision Architecture</td>
</tr>
<tr>
<td>PSYC GU4289 THE GAMES PEOPLE PLAY/PSYCH OF STRAT DEC</td>
</tr>
<tr>
<td>PSYC S3410Q Seminar in Emotion</td>
</tr>
<tr>
<td>PSYC W3435 Neurobiology of Reproductive Behavior (Seminar)</td>
</tr>
<tr>
<td>PSYC UN3345 The Brain &amp; Memory</td>
</tr>
<tr>
<td>PSYC UN3450 Evolution of Intelligence, Animal Communication, # Language (Seminar)</td>
</tr>
<tr>
<td>PSYC S3450Q Evolution of Intelligence, Animal Communication, # Language (Seminar)</td>
</tr>
<tr>
<td>PSYC UN3481 Critical Periods in Brain Development and Behavior</td>
</tr>
<tr>
<td>PSYC W3484 Life Span Development: Theory and Methods</td>
</tr>
<tr>
<td>PSYC UN3496 Neuroscience and Society</td>
</tr>
<tr>
<td>PSYC S3490Q Neuroscience and Society</td>
</tr>
<tr>
<td>PSYC W4415 Methods and Issues in Cognitive Neuroscience (Seminar)</td>
</tr>
<tr>
<td>PSYC GU4420 Animal Cognition (Seminar)</td>
</tr>
<tr>
<td>PSYC GU4430 Learning and the Brain (Seminar)</td>
</tr>
<tr>
<td>PSYC GU4435 Non-Mnemonic Functions of Memory Systems</td>
</tr>
<tr>
<td>PSYC GU4440 TOPICS-NEUROBIOLOGY &amp; BEH</td>
</tr>
<tr>
<td>PSYC S4440Q Topics in Neurobiology and Behavior</td>
</tr>
<tr>
<td>PSYC G4460 Cognitive Neuroscience and the Media (Seminar)</td>
</tr>
<tr>
<td>PSYC GU4470 Psychology &amp; Neuropsychology of Language(Seminar)</td>
</tr>
<tr>
<td>PSYC GU4480 Psychobiology of Infant Development</td>
</tr>
<tr>
<td>PSYC GU4482 Neural Plasticity</td>
</tr>
<tr>
<td>PSYC G4485 Affective Neuroscience (Seminar)</td>
</tr>
<tr>
<td>PSYC GU4486 Developmental and Affective Neuroscience(Seminar)</td>
</tr>
<tr>
<td>PSYC GU4490 Inheritance (Seminar)</td>
</tr>
<tr>
<td>PSYC G4492 Psychobiology of Stress</td>
</tr>
<tr>
<td>PSYC GU4493 Stress and the Brain</td>
</tr>
<tr>
<td>PSYC G4495 Ethics, Genetics, and the Brain</td>
</tr>
<tr>
<td>PSYC GU4496 Behavioral Neuroimmunology</td>
</tr>
<tr>
<td>PSYC GU4498 Behavioral Epigenetics</td>
</tr>
<tr>
<td>PSYC S3610D The Psychology of Stereotyping &amp; Prejudice</td>
</tr>
<tr>
<td>PSYC UN3615 Children at Risk (Lecture)</td>
</tr>
<tr>
<td>PSYC UN3620 Seminar in Developmental Psychopathology</td>
</tr>
<tr>
<td>PSYC UN3623 Topics in Clinical Psychology</td>
</tr>
<tr>
<td>PSYC UN3624 Adolescent Mental Health: Causes, Correlates, Consequences</td>
</tr>
<tr>
<td>PSYC UN3625 Clinical Neuropsychology (Seminar)</td>
</tr>
<tr>
<td>PSYC S3625Q Clinical Neuropsychology Seminar</td>
</tr>
<tr>
<td>PSYC UN3655 Field Experimentation Methods for Social Psychology</td>
</tr>
<tr>
<td>PSYC UN3661 Happiness Studies Seminar</td>
</tr>
<tr>
<td>PSYC UN3671 Motivation Science</td>
</tr>
<tr>
<td>PSYC UN3680 Social Cognitive Neuroscience (Seminar)</td>
</tr>
<tr>
<td>PSYC GU4685</td>
</tr>
<tr>
<td>PSYC UN3691 Interpersonal Cognition Seminar: Close Relationships, Identity and Memory</td>
</tr>
<tr>
<td>PSYC UN3693 Stress in an Interpersonal Context</td>
</tr>
<tr>
<td>PSYC GU4612 Frontiers of Justice</td>
</tr>
<tr>
<td>PSYC GU4615 PSYCH OF CULTURE &amp; DIVERS</td>
</tr>
<tr>
<td>PSYC GU4627 Seminar in Anxiety, Obsessive-Compulsive, and Related Disorders</td>
</tr>
<tr>
<td>PSYC GU4630 Advanced Seminar in Current Personality Theory and Research (Seminar)</td>
</tr>
</tbody>
</table>
The requirements for the concentration in biology are as follows:

**A project laboratory and physics, chemistry, and mathematics are required as detailed below.**

In the Biological Sciences section of the Bulletin. Additional courses in biochemistry, with at least five courses chosen from the courses listed here. The requirement for the concentration is 22 points in biology or biology major-requirements

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

Students requesting permission to use a course not on this list must ensure that their substantive coursework in the seminar (generally their final paper) is on a neuroscience-focused topic.

For additional information visit the Department of Biological Sciences website: [http://biology.columbia.edu/pages/biology-concentration-requirements](http://biology.columbia.edu/pages/biology-concentration-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** INTRO BID I: BIOCHEM,GEN,MOLEC
**BIOL UN2006** INTRO BID II:CELL BIO,DEV/PHYS

Select at least one of the following core courses:

BIOL UN3022 Developmental Biology
BIOL UN3031 GENETICS
BIOL UN3041 Cell Biology
or BIOLGU4041

BIOC GU4501 Biochemistry: Structure and Metabolism
or BIOL UN3300 Biochemistry
BIOL GU4512 Molecular Biology

Plus additional biology elective courses (see electives listed under biology major) to reach a total of 22 points in biology courses.

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


**Fall 2022**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL UN1360</td>
<td>Science and Society</td>
</tr>
<tr>
<td>BIOL UN1908</td>
<td>First Year Seminar in Biology</td>
</tr>
<tr>
<td>BIOL UN2005</td>
<td>INTRO BID I: BIOCHEM,GEN,MOLEC</td>
</tr>
<tr>
<td>BIOL UN2401</td>
<td>CONTEMPORARY BIOLOGY I</td>
</tr>
<tr>
<td>BIOL UN2501</td>
<td>Contemporary Biology Laboratory</td>
</tr>
<tr>
<td>BIOL UN3004</td>
<td>Neurobiology I: Cellular and Molecular Neurobiology</td>
</tr>
<tr>
<td>BIOL UN3006</td>
<td>PHYSIOLOGY</td>
</tr>
<tr>
<td>BIOL UN3022</td>
<td>Developmental Biology</td>
</tr>
<tr>
<td>BIOL UN3025</td>
<td>Neurogenetics</td>
</tr>
<tr>
<td>BIOL UN3041</td>
<td>Cell Biology</td>
</tr>
<tr>
<td>BIOL UN3073</td>
<td>Cellular and Molecular Immunology</td>
</tr>
<tr>
<td>BIOL UN3300</td>
<td>Biochemistry</td>
</tr>
<tr>
<td>BIOL UN3320</td>
<td>Regulation of Behaviors for Survival</td>
</tr>
<tr>
<td>BIOL UN3404</td>
<td>The Global Threat of Antimicrobial Resistance</td>
</tr>
<tr>
<td>BIOL UN3500</td>
<td>Independent Biological Research</td>
</tr>
<tr>
<td>BIOL GU4036</td>
<td>Transformative Concepts in Systems Biology</td>
</tr>
<tr>
<td>BIOL GU4260</td>
<td>Proteomics Laboratory</td>
</tr>
<tr>
<td>BIOL GU4300</td>
<td>Drugs and Disease</td>
</tr>
<tr>
<td>BIOL GU4323</td>
<td>Biophysical Chemistry I</td>
</tr>
<tr>
<td>BCHM GU4501</td>
<td>BIOCHEM I-STRUCTURE/METABOLISM</td>
</tr>
<tr>
<td>BIOL GU4600</td>
<td>Cell Signaling</td>
</tr>
</tbody>
</table>

**Spring 2022**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL UN1130</td>
<td>Genes and Development</td>
</tr>
<tr>
<td>BIOL UN2006</td>
<td>INTRO BID II:CELL BIO,DEV/PHYS</td>
</tr>
<tr>
<td>BIOL UN2402</td>
<td>Contemporary Biology II: Cell Biology, Development &amp; Physiology</td>
</tr>
<tr>
<td>BIOL UN2501</td>
<td>Contemporary Biology Laboratory</td>
</tr>
<tr>
<td>HIST UN2978</td>
<td>Science and Pseudoscience: Alchemy to AI</td>
</tr>
<tr>
<td>BIOL UN3005</td>
<td>Neurobiology II: Development &amp; Systems</td>
</tr>
<tr>
<td>BIOL UN3031</td>
<td>GENETICS</td>
</tr>
<tr>
<td>BIOL UN3052</td>
<td>PROJECT LAB-MOLECULAR GENETICS</td>
</tr>
<tr>
<td>BIOL UN3058</td>
<td>Project Laboratory in Microbiology</td>
</tr>
<tr>
<td>BIOL UN3300</td>
<td>Biochemistry</td>
</tr>
<tr>
<td>BIOL UN3500</td>
<td>Independent Biological Research</td>
</tr>
<tr>
<td>BIOL UN3799</td>
<td>Molecular Biology of Cancer</td>
</tr>
<tr>
<td>BIOL UN3995</td>
<td>Topics in Biology</td>
</tr>
<tr>
<td>BIOL GU4001</td>
<td>Advanced Genetic Analysis</td>
</tr>
<tr>
<td>BIOL GU4002</td>
<td>Macromolecular Structure &amp; Interactions</td>
</tr>
<tr>
<td>BIOL GU4080</td>
<td>ANCIENT AND MODERN RNA WORLDS</td>
</tr>
</tbody>
</table>
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.

Spring 2023: BIOC UN3300

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOC 3300</td>
<td>001/14163</td>
<td>T 7:00pm - 9:30pm</td>
<td>Danny Ho</td>
<td>3</td>
<td>60/60</td>
</tr>
</tbody>
</table>

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/req-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.
BIOL GU4501 Biochemistry: Structure and Metabolism. 4 points.
Undergraduates should register for BIOL 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 BIOL 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.

Fall 2022: BIOL GU4501

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 4501</td>
<td>001/10360</td>
<td>T Th 2:40pm - 3:55pm</td>
<td>Brent Stockwell, Hengrui Liu</td>
<td>4</td>
<td>63/64</td>
</tr>
</tbody>
</table>

BIOC GU4512 Molecular Biology. 3 points.
Prerequisites: one year of biology. Recommended but not required: BIOL UN3501
This is a lecture course designed for advanced undergraduates and graduate students. The focus is on understanding 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

Spring 2023: BIOL GU4512

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 4512</td>
<td>001/14195</td>
<td>M W 2:40pm - 3:55pm</td>
<td>James Manley, Alice Heicklen</td>
<td>3</td>
<td>65/60</td>
</tr>
</tbody>
</table>

BIOL UN1004 Foundations of Biology. 1.50 point.
In this course, we will introduce basic terminology, important concepts, and basic problem-solving skills in order to prepare biology and pre-health students for the challenging Biology courses they will take at Columbia. We will do a deep dive into a small number of topics and use these as access points to teaching skills that will aid them in future STEM courses. Classes will include time for problem solving, and there will be an optional recitation

Spring 2023: BIOL UN1004

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 1004</td>
<td>001/14136</td>
<td>M W 4:10pm - 5:25pm</td>
<td>Mary Ann Price</td>
<td>1.50</td>
<td>12/60</td>
</tr>
</tbody>
</table>

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

Spring 2023: BIOL UN1130

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 1130</td>
<td>001/14137</td>
<td>T Th 2:40pm - 3:55pm</td>
<td>Tulle Hazelrigg</td>
<td>3</td>
<td>25/25</td>
</tr>
</tbody>
</table>

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 UN1360 Science and Society. 3.00 points.
This course, which has been given at another institution for the past five years, uses a seminar discussion format to examine the relationship between science and society from numerous perspectives, using examples from many fields of science, mostly biology and medicine, including the Covid-19 pandemic. We welcome undergraduates from all classes who are concentrating in any field of sciences, humanities, or the arts; there are no prerequisites, other than an interest in how the scientific enterprise works. The course addresses a wide array of topics: why do people choose a scientific career; why do governments and other funders support scientific work; how does science fail; why is there widespread skepticism about science; how is it represented in the arts; how are results disseminated, evaluated, and legally protected; and many other subjects. Assignments—mainly short articles (from newspapers and journals) and book chapters, but also a few films and novels—will be provided for each class, and every student will undertake a term project of their own choosing, after consultations with the instructor.

BIOL UN1908 First Year Seminar in Biology. 1.00 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 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

BIOL UN2005 INTRO BIO I: BIOCHEM, GEN, MOLEC. 4.00 points.
Prerequisites: one year of college chemistry, or a strong high school chemistry background.
Prerequisites: one year of college chemistry is required. 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. 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

BIOL UN2006 INTRO BIO II: CELL BIO, DEV/PHYS. 4.00 points.
Prerequisites: EEB UN2001 or BIOL UN2005, or the instructor’s permission.
Prerequisites: EEB 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
**BIOL UN2015 INTRO BIO I: BIOCHEM, GEN, MOLEC. 0.00 points.**
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. 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](http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf)

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 2015</td>
<td>001/10771</td>
<td>M 6:10pm - 8:00pm 601b Fairchild Life Sciences Bldg</td>
<td>Michelle Attner 0.00</td>
<td>19/30</td>
<td></td>
</tr>
<tr>
<td>BIOL 2015</td>
<td>002/10772</td>
<td>M 6:10pm - 8:00pm 103 Knox Hall</td>
<td>Michelle Attner 0.00</td>
<td>13/30</td>
<td></td>
</tr>
<tr>
<td>BIOL 2015</td>
<td>003/10769</td>
<td>T 8:10am - 10:00am 405 Kent Hall</td>
<td>Michelle Attner 0.00</td>
<td>21/30</td>
<td></td>
</tr>
<tr>
<td>BIOL 2015</td>
<td>004/10770</td>
<td>T 12:10pm - 2:00pm 425 Pupin Laboratories</td>
<td>Michelle Attner 0.00</td>
<td>27/30</td>
<td></td>
</tr>
<tr>
<td>BIOL 2015</td>
<td>005/10774</td>
<td>T 12:10pm - 2:00pm 800 Fairchild Life Sciences Bldg</td>
<td>Michelle Attner 0.00</td>
<td>26/30</td>
<td></td>
</tr>
<tr>
<td>BIOL 2015</td>
<td>006/10775</td>
<td>T 6:10pm - 8:00pm 1000 Fairchild Life Sciences Bldg</td>
<td>Michelle Attner 0.00</td>
<td>19/30</td>
<td></td>
</tr>
<tr>
<td>BIOL 2015</td>
<td>007/10777</td>
<td>W 12:10pm - 2:00pm 607 Hamilton Hall</td>
<td>Michelle Attner 0.00</td>
<td>20/30</td>
<td></td>
</tr>
<tr>
<td>BIOL 2015</td>
<td>008/10779</td>
<td>W 12:10pm - 2:00pm 507 Philosophy Hall</td>
<td>Michelle Attner 0.00</td>
<td>8/30</td>
<td></td>
</tr>
<tr>
<td>BIOL 2015</td>
<td>009/10781</td>
<td>W 2:10pm - 4:00pm 307 Uris Hall</td>
<td>Michelle Attner 0.00</td>
<td>30/30</td>
<td></td>
</tr>
<tr>
<td>BIOL 2015</td>
<td>010/10782</td>
<td>W 2:10pm - 4:00pm 703 Hamilton Hall</td>
<td>Michelle Attner 0.00</td>
<td>23/30</td>
<td></td>
</tr>
<tr>
<td>BIOL 2015</td>
<td>011/10783</td>
<td>W 4:10pm - 6:00pm 293 Engineering Terrace</td>
<td>Michelle Attner 0.00</td>
<td>28/30</td>
<td></td>
</tr>
<tr>
<td>BIOL 2015</td>
<td>013/10785</td>
<td>W 8:10pm - 10:00pm 900 Fairchild Life Sciences Bldg</td>
<td>Michelle Attner 0.00</td>
<td>8/30</td>
<td></td>
</tr>
<tr>
<td>BIOL 2015</td>
<td>014/10786</td>
<td>Th 12:10pm - 2:00pm 601c Fairchild Life Sciences Bldg</td>
<td>Michelle Attner 0.00</td>
<td>28/30</td>
<td></td>
</tr>
</tbody>
</table>

**BIOL UN2016 INTRO BIO II: CELL BIO, DEV/PHYS. 0 points.**
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.

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 2016</td>
<td>001/14138</td>
<td>M 6:10pm - 8:00pm 607 Hamilton Hall</td>
<td>0</td>
<td>16/24</td>
<td></td>
</tr>
<tr>
<td>BIOL 2016</td>
<td>002/14139</td>
<td>M 6:10pm - 8:00pm 412 Pupin Laboratories</td>
<td>0</td>
<td>5/24</td>
<td></td>
</tr>
<tr>
<td>BIOL 2016</td>
<td>004/14141</td>
<td>T 12:10pm - 2:00pm 2124 Lewisohn Hall</td>
<td>0</td>
<td>20/24</td>
<td></td>
</tr>
<tr>
<td>BIOL 2016</td>
<td>005/14142</td>
<td>T 12:10pm - 2:00pm 602 Lewisohn Hall</td>
<td>0</td>
<td>5/27</td>
<td></td>
</tr>
<tr>
<td>BIOL 2016</td>
<td>006/14143</td>
<td>T 6:10pm - 8:00pm 607 Hamilton Hall</td>
<td>0</td>
<td>12/24</td>
<td></td>
</tr>
<tr>
<td>BIOL 2016</td>
<td>007/14144</td>
<td>W 12:10pm - 2:00pm 311 Fayerweather</td>
<td>0</td>
<td>16/24</td>
<td></td>
</tr>
<tr>
<td>BIOL 2016</td>
<td>008/14145</td>
<td>W 12:10pm - 2:00pm 329 Uris Hall</td>
<td>0</td>
<td>9/24</td>
<td></td>
</tr>
<tr>
<td>BIOL 2016</td>
<td>009/14146</td>
<td>W 2:10pm - 4:00pm Room TBA</td>
<td>0</td>
<td>14/24</td>
<td></td>
</tr>
<tr>
<td>BIOL 2016</td>
<td>010/14148</td>
<td>W 2:10pm - 4:00pm Room TBA</td>
<td>0</td>
<td>5/24</td>
<td></td>
</tr>
<tr>
<td>BIOL 2016</td>
<td>011/14149</td>
<td>W 4:10pm - 6:00pm 511 Hamilton Hall</td>
<td>0</td>
<td>12/24</td>
<td></td>
</tr>
<tr>
<td>BIOL 2016</td>
<td>012/14150</td>
<td>W 4:10pm - 6:00pm 424 Pupin Laboratories</td>
<td>0</td>
<td>9/24</td>
<td></td>
</tr>
<tr>
<td>BIOL 2016</td>
<td>013/14151</td>
<td>W 8:10pm - 10:00pm 425 Pupin Laboratories</td>
<td>0</td>
<td>0/24</td>
<td></td>
</tr>
<tr>
<td>BIOL 2016</td>
<td>014/14152</td>
<td>Th 12:10pm - 2:00pm 2124 Lewisohn Hall</td>
<td>0</td>
<td>8/24</td>
<td></td>
</tr>
</tbody>
</table>
BIOL UN2401 CONTEMPORARY BIOLOGY I. 3.00 points.
Prerequisites: a course in college chemistry or the written permission of either the instructor or the premedical adviser.
Prerequisites: one year of college chemistry or the written permission of either the instructor or the premedical adviser is required. 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/c2006/index.html. 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.columbia.edu/sites/default/files/content/reg-adjustment.pdf

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/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. 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. registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf

BIOL UN2502 Foundations for Lab Biology. 3.00 points.
Due to COVID-19 related restrictions on in-person laboratory work, this course acts as a replacement for BIOL UN2501. This course will act as a virtual introduction to the practice of contemporary biology, with an emphasis on common laboratory methods, online tools, statistical analysis, styles of scientific reasoning, and science communication. Students will be expected to watch a weekly lecture, either in-person or via recording. Lab activities are designed to be highly interactive and collaborative to reflect the realities of biological research. Small groups of students will work together on in-class activities, as well as on a long-term student-designed biological research project.
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.

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. 3.00 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 filing 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 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 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 UN3015 Neurobiology II Recitation. 0.00 points.
Discussion/recitation section for BIOL UN3005 Neurobiology II
BIOL UN3019 **Brain Evolution. 3.00 points.**  
If an engineer were to build “the brain”, they would not be able to reproduce any of the brains that exist on Earth. Our brains were not designed to be perfect, but are a result of millions of years of evolution and adaptation. The goal of this course is to provide an overview of brain evolution, ranging from the evolution of the first neurons to the origin of the human brain. Specifically, the course will focus on recent insights emerging from studies of development, gene expression, and neural circuit architecture. The evolutionary perspective will be common, used terms, such as “neuron” and “brain”, and general principles of brain organization and function emerging from comparative studies will be discussed.

<table>
<thead>
<tr>
<th>Course</th>
<th>Section/Call</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 3019</td>
<td>001/14159</td>
<td>F 10:10am - 12:00pm 607 Hamilton Hall</td>
<td>Maria Tosches</td>
<td>3.00</td>
<td>8/24</td>
</tr>
</tbody>
</table>

**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](http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf)

<table>
<thead>
<tr>
<th>Course</th>
<th>Section/Call</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 3022</td>
<td>001/13035</td>
<td>T Th 1:10pm - 2:25pm 601 Fairchild Life Sciences Bldg</td>
<td>Alice Heicklen</td>
<td>3</td>
<td>33/70</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Course</th>
<th>Section/Call</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 3025</td>
<td>001/10361</td>
<td>M W 8:40am - 9:55am 601 Fairchild Life Sciences Bldg</td>
<td>Oliver Hobert</td>
<td>3</td>
<td>23/40</td>
</tr>
</tbody>
</table>

**BIOL UN3031 GENETICS. 3.00 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.  
Prerequisites: BIOL UN2005 and BIOL UN2006. 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. SPS and TC students must obtain the written permission from the instructor, by filling out a Registration Adjustment Form (Add/Drop form). [https://www.registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf](https://www.registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf)

<table>
<thead>
<tr>
<th>Course</th>
<th>Section/Call</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 3031</td>
<td>001/14160</td>
<td>T Th 10:10am - 11:25am 601 Fairchild Life Sciences Bldg</td>
<td>Iva Greenwald, Michelle Attner</td>
<td>3.00</td>
<td>53/72</td>
</tr>
</tbody>
</table>
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-UN2006) 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

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 course emphasizes the use of critical thinking skills in scientific research while giving students the opportunity to apply the basic knowledge 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 (unix account required to login).
BIOL UN3052 Project Lab-Molecular Genetics. 5.00 points.  
Enrollment limited to approximately 12. Fee: $150.

Prerequisites: one year of introductory biology and the instructor’s permission.

Multicellular animals contain a diverse array of cell types, yet start from a single cell. How do cells decide what kind of cell to be? In this lab course, we will use the tools of molecular biology and genetics to explore this fascinating question. We will use the nematode Caenorhabditis elegans, a powerful model organism used in hundreds of research labs. The course will be divided into three modules: C. elegans genetics, molecular cloning, and genetic screening. Laboratory techniques will include PCR, gel electrophoresis, restriction digest, ligation, transformation, RNAi, and C. elegans maintenance. Students will pursue original projects; emphasis will be placed on scientific thinking and scientific communication. 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). Prerequisites: UN2005/UN2401 and UN2006/UN2402, or the equivalent at a different institution.

BIOL UN3052  
Spring 2023: BIOL UN3052  
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment  
BIOL 3052  001/14161  M W 1:10pm - 5:00pm  742 Seeley W. Mudd Building  Michelle Attner  5.00  9/12  

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

Spring 2023: BIOL UN3058  
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment  
BIOL 3058  001/14162  T Th 1:10pm - 5:00pm  601c Fairchild Life Sciences Bldg  Lars Dietrich  5  13/12  

BIOL UN3073 Cellular and Molecular Immunology. 3 points.  
CC/PS: 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

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 nonomological 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 UN3320 Regulation of Behaviors for Survival. 4.00 points.
To maximize their survival animals must regulate their behavior in response to external environmental cues and their own internal state. A fundamental goal of neuroscience is to understand how neural circuits in the brain function to influence behavior. The aim of this course is to highlight the neural basis of neuropeptide regulation of innate behaviors that are critical for survival and discuss modern approaches to study the neuronal control of classically studied aspects of behavior. We will explore motor control (escape responses), sensory systems (vision, taste, and olfaction), and survival behaviors (feeding, drinking, mating, and aggression). Focus will be on recent and current research, the diversity of approaches for studying it, and how this knowledge can be applied to solve scientific questions. Students will read primary scientific literature and a significant portion of the course will be presentation and discussion-based.

BIOL UN3387 BIOLOGY TEST. 3 points.

BIOL UN3404 The Global Threat of Antimicrobial Resistance. 3.00 points.
Prerequisites: (biol un2005 and biol un2006) or (biol un2401 and biol un2402)
Antimicrobial resistant bacterial infections were estimated to account for 1.27 million deaths worldwide in 2019. The goal of the seminar is to provide an in-depth analysis of this ongoing threat. Discussions will include the molecular mechanisms, epidemiology of transmission and the consequences of antimicrobial resistant infections. It will also cover current efforts to reduce the spread and emergence of these difficult to treat pathogens, both in the community and the healthcare setting.

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. 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.
**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](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)

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.

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.

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.

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

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 2023: BIOL UN3995**

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 3995</td>
<td>001/14183</td>
<td>T 1:10pm - 2:25pm, 327 Seeley W. Mudd Building</td>
<td>John Loike</td>
<td>1</td>
<td>34/40</td>
</tr>
</tbody>
</table>
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 2023: BIOL GU4001
Course Section/Call Times/Location Instructor Points Enrollment
BIOL 4001 001/14184 M T 1:10pm - 4:00pm 331 Uris Hall Martin Chalfie 3 8/25

BIOL GU4002 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 has three interrelated goals: (i) to develop an intuitive understanding of the thermodynamic forces that control the structure of biological macromolecules and the evolution of life, (ii) to learn how to apply that understanding to experimental analyses of macromolecular interactions, and (iii) to master the use of molecular graphics software for understanding and interpreting macromolecular structures and interactions. The lectures develop the essential thermodynamic theory from the ground up, starting from a review of the relevant physical forces (Newton’s and Coulomb’s Laws) and culminating with an intuitive explanation of how complex biological organisms can evolve spontaneously, in a universe in which all natural processes are driven by increasing randomness or entropy, as specified by the 2nd Law of Thermodynamics. Subsequent lectures elaborate how these thermodynamic principles govern the formation and interaction of macromolecular structures, which represent the physical foundation for the evolution of life, and how the same principles are applied to analyze related experimental data. The problem sets for the course focus on practical applications of these principles to the analysis of data from common experiments used by molecular biologists to characterize macromolecular interactions. Extensive use is made of molecular graphics software throughout the semester, including in the problem sets, based on instruction provided in both the lectures and recitation sections. The course is designed to develop a deep understanding of the physical mechanisms controlling macromolecular interactions while simultaneously empowering students to critically read related literature and rigorously design and analyze related experiments themselves.

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 2022: BIOL GU4004
Course Section/Call Times/Location Instructor Points Enrollment
BIOL 4004 001/10368 T Th 10:10am - 11:25am Stuart 4 7/20
106 Jerome L. Greene Hall Firestein

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 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/req-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.

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 GU4036 Transformative Concepts in Systems Biology. 3.00 points.
Systems biology approaches are rapidly transforming the technological
and conceptual foundations of research across diverse areas
of biomedicine. In this course we will discuss the fundamental
developments in systems biology with a focus on two important
dimensions: (1) the unique conceptual frameworks that have emerged
to study systems-level phenomena and (2) how these approaches are
revealing fundamentally new principles that govern the organization
and behavior of cellular systems. Although there will be much discussion of
technologies and computational approaches, the course will emphasize
the conceptual contributions of the field and the big questions that
lie ahead. Lectures and discussions of primary literature will enable
students to scrutinize research in the field and to internalize systems
biology thinking in their own research. To make this a concrete endeavor,
the students will develop mini-NIH-style grant proposals that aims
to study a fundamental problem/question using systems biology
approaches. The students will then convene an in-class NIH-style
review panel that will assess the strengths and weaknesses of these
proposals. In addition, the students will have the opportunity to defend
their proposals in a live presentation to the class. The course is open
to graduate students in Biological Sciences. Advanced undergraduates
in biological sciences, and other graduate students with background in
biology from other disciplines, including physics, chemistry, computer
science, and engineering may also attend after consulting with the
instructor.

---

**Fall 2022: BIOL GU4034**

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 4034</td>
<td>001/16692</td>
<td>M W 4:10pm - 5:25pm</td>
<td>Daniel Kalderon, Songtao Jia</td>
<td>3</td>
<td>33/50</td>
</tr>
<tr>
<td></td>
<td>601 Fairchild Life</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sciences Bldg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**BIOL GU4035 Seminar in Epigenetics. 3 points.**

**Fall 2022: BIOL GU4036**

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 4036</td>
<td>001/10363</td>
<td>W 2:10pm - 4:00pm</td>
<td>Saeed</td>
<td>3.00</td>
<td>14/16</td>
</tr>
<tr>
<td></td>
<td>602 Northwest Corner</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tavazoie</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**BIOL GU4065 Molecular Biology of Disease. 3 points.**

Enrollment limited to 30.

**BIOL GU4070 The Biology and Physics of Single Molecules. 3 points.**

CC/GS: Partial Fulfillment of Science Requirement

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.**

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
dynein, 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 ANCIENT AND MODERN RNA WORLDS. 3.00 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; structure, function and evolution of key RNA molecules, including the ribosome, and RNA therapeutics including vaccines. 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.

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.
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.

BIOL GU4410 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.

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
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](http://registrar.columbia.edu/sites/default/files/content/reg-adjustment.pdf)

<table>
<thead>
<tr>
<th>Course</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOT 4160</td>
<td>001/10362</td>
<td>Th 6:10pm - 8:00pm 224 Pupin Laboratories</td>
<td>Alan Morrison</td>
<td>3</td>
<td>15/30</td>
</tr>
<tr>
<td>BIOT 4160</td>
<td>AU1/16805</td>
<td>Th 6:10pm - 8:00pm 224 Pupin Laboratories</td>
<td>Alan Morrison</td>
<td>3</td>
<td>2/3</td>
</tr>
</tbody>
</table>

BIOT GU4161 ETHICS IN BIOPHARM PAT/REG LAW. 3.00 points.
Prerequisites: BIOT GU4160 BIOTECHNOLOGY LAW (BIOT W4160)
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. Properly exploring this branch of bioethics requires an in-depth understanding of biotech and pharmaceutical patent and regulatory law. Students can gain this understanding by first completing Biotechnology Law (BIOT GU4160), formerly the prerequisite for this course. Now, they can also gain it by reading the appropriate chapters of Biotechnology Law: A Primer for Scientists (the textbook for BIOT GU4160 published earlier this year) prior to each class. A number of students in the biotechnology fields (such as those in biotechnology, biomedical engineering, and bioethics programs) have shown a keen interest over the years in taking this course, yet were unable to do so because they hadn’t taken BIOT GU4160. Given the recent publication of Biotechnology Law and the desirability of making BIOT GU4161 accessible to more students having the appropriate science background, BIOT GU4160 has been removed as a prerequisite

<table>
<thead>
<tr>
<th>Course</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOT 4200</td>
<td>001/13227</td>
<td>Th 4:10pm - 6:00pm 402 Chandler</td>
<td>Ron Guido</td>
<td>3</td>
<td>153/126</td>
</tr>
<tr>
<td>BIOT 4200</td>
<td>AU1/17030</td>
<td>Th 4:10pm - 6:00pm 402 Chandler</td>
<td>Ron Guido</td>
<td>3</td>
<td>4/5</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Course</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOT 4201</td>
<td>001/14188</td>
<td>Th 4:10pm - 6:00pm 501 Northwest Corner</td>
<td>Ron Guido</td>
<td>3</td>
<td>1/150</td>
</tr>
</tbody>
</table>

Of Related Interest

Biomedical Engineering

- BMEN E4150 THE CELL AS A MACHINE

Chemistry

- BIOL UN3501 Biochemistry: Structure and Metabolism
- BIOL UN3512 Molecular Biology

Ecology, Evolution, and Environmental Biology

- EEB UN2001 Environmental Biology I: Elements to Organisms
- EEB GU4321 Human Nature: DNA, Race & Identity

History and Philosophy of Science

- HPSC W3201 Philosophy and History of Evolutionary Biology

Physics

- PHYS UN1201 GENERAL PHYSICS I
- PHYS UN1202 GENERAL PHYSICS II
- PHYS UN2003 GENERAL PHYSICS III
- PHYS GU2001 Advanced Laboratory Physics
- PHYS GU2002 Advanced Laboratory Physics
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS W4075</td>
<td>Biology at Physical Extremes</td>
</tr>
<tr>
<td>Psychology</td>
<td></td>
</tr>
<tr>
<td>PSYC UN1010</td>
<td>Mind, Brain and Behavior</td>
</tr>
</tbody>
</table>