An interdepartmental program

Linguistics

Courses of Study:
Minor
Major (B.A.)

Objectives

The major in linguistics is designed to give students a foundation in the theory of language and its relation to allied fields of inquiry. The major emphasizes the approach of generative grammar, which attempts to describe formally the nature of a speaker's knowledge of his or her native language and to place this knowledge in a psychological and biological framework. In the last 40 years, this approach to the study of language has had a profound influence on fields as diverse as philosophy, psychology, anthropology, neuroscience, and computer science, as well as the linguist's traditional concerns with modern and classical languages and with linguistic universals.

How to Become a Major or Minor

In order to get the flavor of the field of linguistics, the best way to start is to take LING 100a (Introduction to Linguistics), which deals with the major concepts of the field and the technical tools used to articulate these concepts. The course also introduces students to the feel of doing research on language, through the use of numerous problem sets concerning the organization of a variety of languages.

Students wishing to major or minor in linguistics should arrange to meet with the undergraduate advising head to discuss the planning of a program that meets their interests.

Faculty

Ray Jackendoff, Chair and Undergraduate Advising Head
Conceptual structure. Consciousness. Spatial cognition. Social cognition.

Joan Maling
Syntactic theory. Icelandic syntax. Korean syntax.

The following members of other departments are affiliated with linguistics:

Joan Chevalier (RUS), Janet McIntosh (ANTH), James Pustejovsky (COSI), Jerry Samet (PHIL).

Requirements for the Major

A. Ten semester courses are required of all candidates:

1. LING 100a, LING 110a, LING 120b, and LING 130a.

2. Two additional courses selected from LING 125b, 128a, 197a, and PSYC 173a.

3. Three additional courses to be chosen from the LING courses and the cross-listed and electives below. This selection must be approved by the undergraduate advisor for the major.

4. One advanced course in a natural language to be chosen from the following list: CHIN 105a, CHIN 105b, FREN 105a, FREN 106b, GER 103a, GER 104a, HBRW 141a, HBRW 161b, ITAL 105a, JAPN 105a, RUS 105a, RUS 106b, SPAN 105a, or SPAN 106b.

B. Honors will be awarded on successful completion of a senior thesis (LING 99d) in addition to the above course requirements. A grade point average of 3.50 or above in linguistics and cognitive science courses is normally required.

C. A grade of C or better is necessary for all courses offered toward a major in linguistics. No course offered toward the fulfillment requirements for the major may be taken on a pass/fail basis.

D. Students may petition the linguistics major committee for changes in the above program.

Requirements for the Minor

A. Five semester courses are required:

1. LING 100a and 120b.

2. LING 110a or 130a.

3. Any other two LING or cross-listed courses numbered 98 and above. Courses from the list of electives may be substituted with approval of the advisor.

B. At most, one course will be accepted as simultaneously satisfying a student's major requirements and the requirements of the minor in linguistics.

C. No course offered toward the fulfillment of the requirements for the minor may be taken on a pass/fail basis.

D. Students may petition the linguistics major committee for changes in the above program.

Courses of Instruction

(1-99) Primarily for Undergraduate Students

LING 8b Structure of the English Language
[ss hum]
Open to first-year students.
A nontechnical introduction to the structure of English words and sentences. Classical roots of English vocabulary: word analysis, base forms, and rules of allomorphy. Basic concepts of grammar: categories (noun, adjective, adverb, etc.), functions (subject, object, modifier, etc.), phrases and clauses of various types. Consists of three class hours and one one-hour recitation per week. Usually offered every year.
Staff

LING 98a Readings in Linguistics
Independent reading and research under the direction of a faculty supervisor. When appropriate, a faculty member may organize a small group of students into a senior seminar. Usually offered every year.
Staff

LING 98b Readings in Linguistics
See LING 98a for course description. Usually offered every year.
Staff

LING 99d Senior Research
Involves the student in an independent research project under the supervision of a staff member. A student whose grade point average in linguistics is 3.50 or better may petition at the end of junior year for permission to enter this course. The student's findings are to be presented in writing and defended orally before a committee of staff members. Usually offered every year.
Staff

(100-199) For Both Undergraduate and Graduate Students

LING 100a Introduction to Linguistics
[ss]
Open to first year students.
A general introduction to linguistic theory and the principles of linguistic analysis. Students will construct detailed analyses of data from English and other languages in the areas of syntax, semantics, phonetics, and phonology and examine their implications for a theory of language as it is encoded in the human mind. Usually offered every year.
Staff

LING 110a Phonological Theory
[ss]
Prerequisite: LING 100a.
An introduction to generative phonology, the theory of natural language sound systems. Includes discussion of articulatory phonetics, distinctive feature theory, the concept of a "natural class," morphology and the nature of morphophonemics, and universal properties of the rules that relate morphophonemic and phonetic representations. Usually offered every second year.
Staff

LING 112b Historical Linguistics
[ss]
Prerequisite: LING 100a or permission of the instructor.
Explores how and why language changes. Methods of linguistic reconstruction and the "comparative method" are introduced and explored. Features a hands-on approach, challenging students to apply principles to examples from a wide variety of languages. Usually offered every third year.
Ms. Chevalier

LING 120b Syntactic Theory
[ss]
Prerequisite: LING 100a. LING 8b recommended.
Extends the syntactic framework developed in the introductory course through the study of such problems as the complement system, the lexicon, and constraints, with emphasis on their relevance to universal grammar. Usually offered every year.
Staff

LING 125b Universal Grammar
[ss]
Prerequisite: LING 100a or permission of the instructor.
Advanced topics in the theory of language typology and universal grammar. May be repeated for credit with permission of instructor. Usually offered every second year.
Staff

LING 128a Investigations in an Unfamiliar Language
[ss]
Prerequisite: ANTH 61b or LING 100a. May not be repeated for credit by students who have taken ANTH 125b in previous semesters.
Using a native speaker of an unfamiliar language (such as Turkish or Amharic) as a source of data, the class will investigate the structure of the language and compare it with the structure of English and other familiar languages. May be repeated for credit. Usually offered every second year.
Staff

LING 130a Semantics: The Structure of Concepts
[ss hum]
Prerequisite: LING 100a or permission of the instructor. LING 8b or LING 120b recommended.
Explores the semantic structure of language in terms of current linguistic theory. Its goal is to use the structure of language to help discover the characteristics of human concepts. Topics include the nature of word meanings, categorization, and the semantics of spatial and possessional expressions. Usually offered every year.
Staff

LING 190b Topics in Cognitive Science: Evolution of the Language Faculty
[ss]
Prerequisite: LING 120b and/or LING 130a or permission of the instructor. May be repeated for credit with instructor's permission. Intended primarily for upperclass majors, but open to other qualified students.
This year's topic is the evolution of the human language capacity, with discussion of evolutionary antecedents in animal communication, hypotheses about stages in the evolution of language, and archaeological and contemporary evidence for the course of evolution. Usually offered every fourth year.
Staff

LING 197a Language Acquisition and Development
[ss]
Prerequisite: LING 100a or permission of the instructor.
The central problem of language acquisition is to explain what makes this formidable task possible. Theories of language acquisition are studied, and conclusions are based on recent research in the development of syntax, semantics, and phonology. The overall goal is to arrive at a coherent picture of the language learning process. Usually offered every third year.
Staff

LING 199a Directed Research in Linguistics
[ss]
Usually offered every year.
Staff

LING 199b Directed Research in Linguistics
[ss]
Usually offered every year.
Staff

Cross-Listed Courses

ANTH 172b
Cognition of Society and Culture

COSI 114b
Topics in Computational Linguistics

ENG 142b
Introduction to Old Norse

HBRW 167b
The Revival of Modern Hebrew

PSYC 153a
Consciousness

PSYC 173a
Psycholinguistics

PSYC 183a
Social Cognition from a Cognitive Science Perspective

Elective Courses

ANTH 61b
Language in American Life

ANTH 126b
Symbol, Meaning, and Reality: Explorations in Cultural Semiotics

ANTH 139b
Language, Ethnicity, and Nationalism

ANTH 161b
Culture and Cognition

ANTH 186b
Linguistic Anthropology

COSI 35a
Fundamentals of Artificial Intelligence

NEJS 104b
Ezra, Daniel, and Early Aramaic Texts

NPSY 22b
Introduction to Cognitive Neuroscience

NPSY 199a
Human Neuropsychology

PHIL 6a
Introduction to Symbolic Logic

PHIL 37a
Philosophy of Language

PHIL 39b
Philosophy of Mind

PHIL 137a
Innateness

PHIL 139b
Topics in Logic

PHIL 141b
Topics in Philosophy and Cognitive Science

PSYC 13b
Perception

PSYC 103a
Seminar in the Neuropsychology of Language

Department of

Mathematics

Courses of Study:
Minor
Major (B.A.)
Combined B.A./M.A
Master of Arts
Doctor of Philosophy

Objectives

Undergraduate Major
As our society becomes more technological, it is more affected by mathematics. Quite sophisticated mathematics is now central to the natural sciences, to ecological issues, to economics, and to our commercial and technical life. A student who takes such general level courses as Math 5, 8, 10, 15, or 20 will better understand the world and be prepared to act in it.

Mathematics is, at the same time, a subject of the greatest depth and beauty with a history extending from antiquity. The department attempts to make this depth and beauty manifest. The undergraduate major introduces students to some fundamental fields—algebra, real and complex analysis, geometry, and topology—and to the habit of mathematical thought. Mathematics majors may go on to graduate school, scientific research, or mathematics teaching, but many choose the major for its inherent interest with unrelated career intentions.

Graduate Program in Mathematics
The Graduate Program in Mathematics is designed primarily to lead to the doctor of philosophy degree. The formal coursework gives the student a broad foundation for work in modern pure mathematics. An essential part of the program consists of seminars on a variety of topics of current interest in which mathematicians from greater Boston often participate. In addition, the Brandeis-Harvard-MIT-Northeastern Mathematics Colloquium gives the student an opportunity to hear the current work of eminent mathematicians from all over the world.

How to Become an Undergraduate Major

Students who enjoy mathematics are urged to consider majoring in it; Brandeis offers a wide variety of mathematics courses, and majors will have the benefits of small classes and individual faculty attention. To become a major a student should have completed either MATH 15 and 20, MATH 21a, 21b, or MATH 22a, 22b by the end of the sophomore year—these courses are prerequisites to the higher-level offerings. Therefore, it is important for students to start calculus and linear algebra (MATH 10, 15, 20, 21, or 22) in the first year. Note that MATH 21a, 21b will no longer be offered starting in Fall 2006.

How to Be Admitted to the Graduate Program

The general requirements for admission to graduate work in mathematics are the same as those for the Graduate School as a whole. The department has available a variety of fellowships and scholarships for well-qualified students. To be considered for such financial support the student should submit an application by January 15.

Faculty

Kiyoshi Igusa, Chair
Differential topology. Homological algebra.

Mark Adler
Analysis. Differential equations. Completely integrable systems.

Ruth Charney, Undergraduate Advising Head
Geometric group theory. Topology.

Fred Diamond
Number theory.

Ira Gessel, Graduate Advising Head
Combinatorics. Computer science.

Edward Goldstein
Differential geometry. Special structures on manifolds.

Dmitry Kleinbock
Dynamical systems. Ergodic theory. Number theory.

Jerome Levine, Undergraduate Administrator
Differential topology. Knot theory and related algebra.

Bong Lian (On leave Fall 2005)
Representation theory. Calabi-Yau geometry. String theory.

Alan Mayer
Classical algebraic geometry and related topics in mathematical physics.

Susan Parker, Elementary Mathematics Coordinator
Combinatorics. Elementary mathematics instruction.

Daniel Ruberman
Geometric topology and gauge theory.

Gerald Schwarz
Algebraic groups. Transformation groups.

Harry Tamvakis
Arithmetic algebraic geometry. Arakelov theory.

Pierre Van Moerbeke (On leave 2005-06)
Stochastic processes. Korteweg-deVries equation. Toda lattices.

Requirements for the Undergraduate Major

A. MATH 21a, 22a, or 15a; MATH 21b, 22b, or 20a.

B. MATH 23b or exemption. See item E in Special Notes Relating to Undergraduates.

C. MATH 35a, 40a, or 45a.

D. MATH 28a, 28b, or 30a.

E. Four additional semester courses, either MATH courses numbered 27 or higher or cross-listed courses. A course used to satisfy the requirements for the major must be passed with a grade of C- or higher.

Honors
A degree with honors requires items A, B, C, and D above as well as:
E. Six additional semester courses, either MATH courses numbered 27 or higher or cross-listed courses, passed with at least a grade of B. At least four of the courses used to satisfy the major requirement must be honors courses. The honors courses are MATH 30a, 30b, 32a, 34a, 38b, 40a, 40b, 45a, and all MATH courses numbered 100 or higher.

Teacher Preparation Track
Students who complete the Brandeis program for Massachusetts High School Teacher Licensure (see section on Education Program in this *Bulletin*) may earn a bachelor's degree in mathematics by satisfying major requirements A, B, C, and D above and the following:

E. MATH 8a (Introduction to Probability and Statistics) or 36a (Probability).

F. Two additional courses, either MATH courses numbered 27 or higher or cross-listed courses.

G. A computer science course numbered 10 or higher.

H. Completion of the High School Teacher Licensure Program.

Combined B.A./M.A. Program

Undergraduate students are eligible for the B.A./M.A. program in mathematics if they have completed MATH 101a,b; 110a; 111a,b; and 121 a,b with a grade of B- or better, and demonstrated a reading knowledge of mathematical French, German, or Russian. No more than three of these courses, however, may be counted towards the major. In addition, students must fulfill a minimum of three years' residence on campus. A student must make formal written application for admission to this program on forms available at the Graduate School office. This must be done no later than May 1 preceding his/her final year of study on campus.

Requirements for the Undergraduate Minor

A. MATH 21a, 22a, or 15a; MATH 21b, 22b, or 20a.

B. Three additional semester courses, either MATH courses numbered 27 or higher or cross-listed courses. Most MATH courses numbered 27 or higher require MATH 23b as a prerequisite.

Students interested in analysis, physics, or applied mathematics are advised to choose additional courses from among MATH 35a, 36a, 36b, 37a, and 45a. Students interested in algebra or computer science are advised to consider MATH 28a, 28b, 30a, 30b, and 38b. With permission of the undergraduate advising head, courses taken in other Brandeis departments or taken at other universities may be substituted for mathematics courses required for the minor. A course used to satisfy the requirements for the minor must be passed with a grade of C- or higher.

Special Notes Relating to Undergraduates

A. With permission of the undergraduate advising head, courses taken in other Brandeis departments or taken at other universities may be substituted for required mathematics courses. A grade of C or better is required in courses satisfying the major requirements.

B. Students who intend to take mathematics courses numbered 10 or higher should take the departmental placement exam. On the basis of the exam, recommendations are made placing students out of the first year of calculus or into MATH 5a, 10a, or 10b. Students receiving a score of 5 on the advanced placement MATH AB Exam or a score of 4

or more on the MATH BC Exam place out of the first-year calculus sequence. Students receiving a score of 4 on the MATH AB Exam or a score of 3 on the MATH BC Exam place out of first-semester calculus. Such students must take the departmental placement exam if they wish to place out of second semester calculus. Questions about placement should be directed to the elementary mathematics coordinator, or the undergraduate advising head.

C. The usual calculus sequence is MATH 10a, 10b, and 20a. Students may precede this with MATH 5a. Many students also take MATH 15a (Applied Linear Algebra), which has MATH 5a (or placement out of MATH 5a) as a prerequisite. Students with a strong interest in mathematics and science are encouraged to take MATH 21a,b or 22a,b in place of MATH 15a and 20a. Note that MATH 21a, 21b will no longer be offered starting in Fall 2006.

D. A student may not receive credit for more than one of MATH 15a, 21a, and 22a; or MATH 20a, 21b, and 22b. Similarly, a student may not receive credit for all three of MATH 28a, 28b, and 30a.

E. Students should normally take MATH 23b before taking upper-level courses (i.e., those numbered above 23). For many students this means taking MATH 23b concurrently with MATH 15a, or MATH 20a, MATH 21a or b, MATH 22a or b. Students may also take MATH 23b concurrently with MATH 35a and MATH 36a since these do not have MATH 23b as a prerequisite. A student may be exempted from the requirement of taking MATH 23b by satisfactory performance on a placement exam. The placement exam will be given at the beginning of the fall semester and the end of the spring semester.

F. Students interested in graduate school or a more intensive study of mathematics are urged to include all of the following courses in their program:

1. MATH 21a and b or 22a and b

2. MATH 30a and b

3. MATH 35a or 40a and b

4. MATH 45a

5. A course numbered 100 or higher.

G. The following schedule determines course offerings in mathematics:

1. Offered every semester are MATH 5a, 10a and b, 15a, and 20a.

2. Offered once each year are MATH 8a, 21a and b, 23b, 28a and b, 30a and b, 35a, 36a and b, 37a, 40a and b, 45a.

3. In addition, the following semester courses are usually offered according to the following schedule:

a. MATH 32a (Differential Geometry) spring term odd-even years (e.g., 2005-06)

b. MATH 34a (Introduction to Topology) fall term odd-even years (e.g., 2005-06)

c. MATH 38b (Number Theory) spring term even-odd years (e.g., 2006-07)

d. MATH 39a (Introduction to Combinatorics) fall term even-odd years (e.g., 2006-07)

H. The number of cross-listed courses used to satisfy the requirements for the major, the honors or teacher preparation track must not exceed two; for the minor, the limit is one.

Requirements for the Degree of Master of Arts

A. One year's residence as a full-time student.

B. Successful completion of an approved schedule of courses: MATH 101a and b, MATH 110a, MATH 111a and b, and MATH 121a and b.

C. Proficiency in reading French, German, or Russian.

Requirements for the Degree of Doctor of Philosophy

Program of Study
The normal first year of study consists of MATH 101a and b, 111a and b, and 121a and b. With the permission of the graduate advisor, a student with superior preparation may omit one or more of these courses and elect higher level courses instead. In this case the student must take an examination in the equivalent material during the first two weeks of the course. The second year's work will normally consist of MATH 110a and higher level courses in addition to preparation for the qualifying examinations described below and participation in the second-year seminar. Upon completion of the qualifying examinations, the student will choose a dissertation advisor and begin work on a thesis. This should be accompanied by advanced courses and seminars.

Teaching Requirements
An important part of the doctoral program is participation, as a teaching fellow, in a structured program of undergraduate teaching. During the spring semester of their first year, every student takes part in our teaching apprenticeship program to learn basic classroom teaching skills. All graduate students are then expected to teach a section of calculus or precalculus for at least four semesters, usually beginning in their second year of study. Teaching fellows must also enroll every fall semester in the Teaching Practicum, in which their teaching is evaluated and discussed.

Residence Requirement
The minimum residence requirement is three years.

Language Requirement
Proficiency in reading one of French, German, or Russian, and one other language (besides English) determined with the consent of the advisor.

Qualifying Examination
The qualifying examination consists of two parts: a major examination and a minor examination. Both are normally taken in the latter part of the second year but may occasionally be postponed until early in the third year. For the major examination, the student will choose a limited area of mathematics (e.g., differential topology, several complex variables, or ring theory) and a major examiner from among the faculty. Together they will plan a program of study and a subsequent examination in that material. The aim of this study is to prepare the student for research towards the Ph.D. The minor examination will be more limited in scope and less advanced in content. The procedures are similar to those for the major examination, but its subject matter should be significantly different from that of the major examination.

Dissertation and Defense
The doctoral degree will be awarded only after the submission and acceptance of an approved dissertation and the successful defense of that dissertation.

Courses of Instruction

(1-99) Primarily for Undergraduate Students

MATH 1a Introduction to Mathematical Concepts
[sn]
Mathematical reasoning; where it would be expected, and elsewhere. A variety of short topics involving games and puzzles, number theory, combinatorics, and topology.
Usually offered every third year.
Staff

MATH 5a Precalculus Mathematics
Does not satisfy the School of Science requirement.
Brief review of algebra followed by the study of functions. Emphasis on exponential, logarithmic, and trigonometric functions. The course's goal is to prepare students for MATH 10a. The decision to take this course should be guided by the results of the mathematics placement exam. Usually offered every semester in multiple sections.
Ms. Parker and Staff

MATH 8a Introduction to Probability and Statistics
[sn qr]
Discrete probability spaces, random variables, expectation, variance, approximation by the normal curve, sample mean and variance, and confidence intervals. Does not require calculus, only high school algebra and graphing of functions. Usually offered every year.
Staff (Spring)

MATH 10a Techniques of Calculus (a)
[sn]
Prerequisite: a satisfactory grade of C- or higher in MATH 5a or placement by examination.
Introduction to differential (and some integral) calculus of one variable, with emphasis on techniques and applications. Usually offered every semester in multiple sections.
Ms. Parker and Staff (fall), Mr. Diamond and Staff (spring)

MATH 10b Techniques of Calculus (b)
[sn]
Prerequisite: a satisfactory grade of C- or higher in MATH 10a or placement by examination. Continuation of 10a. Students may not take MATH 10a and MATH 10b simultaneously.
Introduction to integral calculus of one variable with emphasis on techniques and applications. Usually offered every semester in multiple sections.
Ms. Charney and Staff (fall), Ms. Parker and Staff (spring)

MATH 13a Theory of Graphs and Tilings
[sn]
This course provides an introduction to the theory of graphs and tilings, followed by an exploration of applications of the theory to other sciences, such as biology, chemistry, physics, computer science, and sociology. Non-math majors are encouraged to enroll. Special one-time offering, fall 2005.
Mr. Petersen

MATH 15a Applied Linear Algebra
[sn]
Prerequisites: MATH 5a and permission of the instructor, placement by examination, or any mathematics course numbered 10 or above. Students may not take more than one of MATH 15a, 21a, and 22a for credit.
Matrices, determinants, linear equations, vector spaces, eigenvalues, quadratic forms, linear programming. Emphasis on techniques and applications. Usually offered every semester.
Mr. Goldstein

MATH 20a Techniques of Calculus: Calculus of Several Variables
[sn]
Prerequisite: MATH 10a,b. Students may not take more than one of MATH 20a, 21b, and 22b for credit.
Among the topics treated are vectors and vector-valued functions, partial derivatives and multiple integrals, extremum problems, line and surface integrals, Green's and Stokes's theorems. Emphasis on techniques and applications. Usually offered every semester.
Mr. Mayer (fall) and Mr. Lian (spring)

MATH 21a Intermediate Calculus: Linear Algebra and Calculus of Several Variables, Part I
[sn]
Prerequisite: MATH 10a,b or placement by examination. Students intending to take the course should consult the instructor or the undergraduate administrator. Students may not take more than one of MATH 15a, 21a, and 22a for credit.
MATH 21a and 21b cover calculus of several variables for those with a serious interest in mathematics. The course starts with an introduction to linear algebra and then discusses various important topics in vector calculus, including directional derivatives, Jacobian matrices, multiple integrals, line integrals and surface integrals, and differential equations. Usually offered every year.
Mr. Schwarz (Fall)

MATH 21b Intermediate Calculus: Linear Algebra and Calculus of Several Variables, Part II
[sn]
Prerequisite: MATH 21a or permission of the instructor. Students may not take more than one of MATH 20a, 21b, and 22b for credit.
See MATH 21a for special notes and course description. Usually offered every year.
Mr. Kleinbock (Spring)

MATH 22a Linear Algebra and Intermediate Calculus, Part I
[sn]
Prerequisite: MATH 10a,b or placement by examination. Students intending to take the course should consult with the instructor or the undergraduate administrator. Students may not take more than one of MATH 15a, 21a, or 22a for credit.
MATH 22a and 22b cover linear algebra and calculus of several variables. The material is similar to that of MATH 21a and MATH 21b, but with a more theoretical emphasis and with more attention to proofs. Usually offered every year.
Staff (Fall)

MATH 22b Linear Algebra and Intermediate Calculus, Part II
[sn]
Prerequisite: MATH 22a or permission of the instructor. Students may not take more than one of MATH 20a, 21b, or 22b for credit.
See MATH 22a for course description. Usually offered every year.
Mr. Levine (Spring)

MATH 23b Introduction to Proofs
[wi sn]
Prerequisites: MATH 15a, 20a, 21a, 22a, or permission of the instructor.
Emphasizes the analysis and writing of proofs. Various techniques of proof are introduced and illustrated with topics chosen from set theory, calculus, algebra, and geometry. Usually offered every semester.
Mr. Gessel (fall), Staff (spring)

MATH 28a Introduction to Groups
[sn]
Prerequisites: MATH 23b and either MATH 15a, 21a, 22a, or permission of the instructor.
Groups. Lagrange's theorem. Modulo n addition and multiplication. Matrix groups and permutation groups. Homomorphisms, normal subgroups, cosets, and factor groups. Usually offered every year.
Mr. Goldstein

MATH 28b Introduction to Rings and Fields
[sn]
Prerequisites: MATH 23b and either MATH 15a, 21a, 22a, or permission of the instructor.
Fields. Z/p and other finite fields. Commutative rings. Polynomial rings and subrings of C. Euclidean rings. The quotient ring A/(f). Polynomials over Z. Usually offered every year.
Staff

MATH 30a Introduction to Algebra, Part I
[sn]
Prerequisite: MATH 23b and either MATH 21a, 22a, or permission of the instructor.
An introduction to the basic notions of modern algebra—rings, fields, and linear algebra. Usually offered every year.
Mr. Levine (Fall)

MATH 30b Introduction to Algebra, Part II
[sn]
Prerequisite: MATH 30a or permission of the instructor.
A continuation of MATH 30a, culminating in Galois theory. Usually offered every year.
Mr. Tamvakis (Spring)

MATH 32a Differential Geometry
[sn]
Prerequisite: MATH 23b and either MATH 21b, 22b, or permission of the instructor.
Results in the classical differential geometry of curves and surfaces is studied theoretically and also implemented as computer algorithms. Static images and animations of geometrical objects are illustrated using the mathematical visualization program 3D-XplorMath. Computer projects involving MathLab and Mathematica are important components of the course, and for those without prior experience in using these programming systems, appropriate training is provided. Usually offered every second year. Not offered for 2005-06.
Staff

MATH 34a Introduction to Topology
[sn]
Prerequisite: MATH 23b and either MATH 21a and b, 22a and b, or permission of the instructor.
An introduction to point set topology, covering spaces, and the fundamental group. Usually offered every second year.
Mr. Igusa (Fall)

MATH 35a Advanced Calculus
[sn]
Prerequisites: MATH 15a, 21a, or 22a and MATH 20a, 21b or 22b.
Infinite series: convergence tests, power series, and Fourier series. Improper integrals: convergence tests, the gamma function, Fourier and Laplace transforms. Complex numbers. Usually offered every year.
Mr. Mayer (Spring)

MATH 36a Probability
[sn qr]
Prerequisite: MATH 20a, 21b, or 22b.
Sample spaces and probability measures, elementary combinatorial examples. Random variables, expectations, variance, characteristic, and distribution functions. Independence and correlation. Chebychev's inequality and the weak law of large numbers. Central limit theorem. Markov and Poisson processes. Usually offered every year.
Mr. Mayer (Fall)

MATH 36b Mathematical Statistics
[sn qr]
Prerequisite: MATH 36a or permission of the instructor.
Probability distributions, estimators, hypothesis testing, data analysis. Theorems will be proved and applied to real data. Topics include maximum likelihood estimators, the information inequality, chi-square test, and analysis of variance. Usually offered every year.
Mr. Adler (Spring)

MATH 37a Differential Equations
[sn]
Prerequisite: MATH 15a, 21a, or 22a and MATH 20a, 21b, or 22b.
A first course in ordinary differential equations. Study of general techniques, with a view to solving specific problems such as the brachistochrone problem, the hanging chain problem, the motion of the planets, the vibrating string, Gauss's hypergeometric equation, the Volterra predator-prey model, isoperimetric problems, and the Abel mechanical problem. Usually offered every year.
Mr. Adler (Fall)

MATH 38b Number Theory
[sn]
Prerequisite: MATH 23b and either MATH 21a, 22a, or permission of the instructor.
Congruences, finite fields, the Gaussian integers, and other rings of numbers. Quadratic reciprocity. Such topics as quadratic forms or elliptic curves will be covered as time permits. Usually offered every second year. Not offered for 2005-06.
Staff

MATH 39a Introduction to Combinatorics
[sn]
Prerequisites: COSI 29a or MATH 23b
Topics include graph theory (trees, planarity, coloring, Eulerian and Hamiltonian cycles), combinatorial optimization (network flows, matching theory), enumeration (permutations and combinations, generating functions, inclusion-exclusion), and extremal combinatorics (pigeonhole principle, Ramsey's theorem). Usually offered every second year. Not offered for 2005-06.
Staff

MATH 40a Introduction to Real Analysis, Part I
[sn]
Prerequisites: MATH 23b and either MATH 21a and b, 22a and b, or permission of the instructor.
MATH 40a and 40b give a rigorous introduction to metric space topology, continuity, derivatives, and Riemann and Lebesgue integrals. Usually offered every year.
Mr. Tamvakis (Fall)

MATH 40b Introduction to Real Analysis, Part II
[sn]
Prerequisite: MATH 40a or permission of the instructor.
See MATH 40a for course description. Usually offered every year.
Mr. Levine (Spring)

MATH 45a Introduction to Complex Analysis
[sn]
Prerequisites: MATH 15a, 21a, or 22a and MATH 20a, 21b, or 22b, and MATH 23b or permission of the instructor.
An introduction to functions of a complex variable. Topics include analytic functions, line integrals, power series, residues, conformal mappings. Usually offered every year.
Mr. Goldstein (Spring)

MATH 47a Introduction to Mathematical Research
[sn]
Prerequisite: MATH 23b or permission of the instructor.
Students work on research projects that involve generating data, making conjectures, and proving theorems, and present their results orally and in writing. Introduces applications of computers in mathematical research: symbolic computation, typesetting, and literature search. Usually offered every third year.
Mr. Kleinbock (Fall)

MATH 98a Independent Research
Usually offered every year.
Staff

MATH 98b Independent Research
Usually offered every year.
Staff

(100-199) For Both Undergraduate and Graduate Students

Undergraduate students should consult with the instructor regarding the required background for each course.

MATH 101a Algebra I
[sn]
Groups, rings, modules, Galois theory, affine rings, and rings of algebraic numbers. Multilinear algebra. The Wedderburn theorems. Other topics as time permits. Usually offered every year.
Mr. Diamond

MATH 101b Algebra II
[sn]
Continuation of MATH 101a. Usually offered every year.
Mr. Diamond

MATH 110a Geometric Analysis
[sn]
Manifolds, tensor bundles, vector fields, and differential forms. Frobenius theorem. Integration, Stokes's theorem, and deRham's theorem. Usually offered every year.
Mr. Ruberman

MATH 110b Differential Geometry
[sn]
Riemannian metrics, parallel transport, geodesics, curvature. Introduction to Lie groups and Lie algebras, vector bundles and principal bundles. Usually offered every second year.
Mr. Mayer

MATH 111a Real Analysis
[sn]
Measure and integration. Lp spaces, Banach spaces, Hilbert spaces. Radon-Nikodym, Riesz representation, and Fubini theorems. Fourier transforms. Usually offered every year.
Mr. Kleinbock

MATH 111b Complex Analysis
[sn]
The Cauchy integral theorem, calculus of residues, and maximum modulus principle. Harmonic functions. The Riemann mapping theorem and conformal mappings. Other topics as time permits. Usually offered every year.
Mr. Adler

MATH 121a Topology I
[sn]
Fundamental group, covering spaces. Cell complexes, homology and cohomology theory, with applications. Usually offered every year.
Mr. Ruberman

MATH 121b Topology II
[sn]
Continuation of MATH 121a. Manifolds and orientation, cup and cap products, Poincare duality. Other topics as time permits. Usually offered every year.
Mr. Igusa

MATH 150a Combinatorics
[sn]
Emphasis on enumerative combinatorics. Generating functions and their applications to counting graphs, paths, permutations, and partitions. Bijective counting, combinatorial identities, Lagrange inversion and Mobius inversion. Usually offered every second year.
Mr. Gessel

MATH 150b Topics in Combinatorics
[sn]
Possible topics include symmetric functions, graph theory, extremal combinatorics, combinatorial optimization, coding theory. Usually offered every second year.
Staff

(200 and above) Primarily for Graduate Students

All graduate level courses will have organizational meetings the first week of classes.

MATH 200a Second-Year Seminar
A course for second-year students in the Ph.D. program designed to provide exposure to current research and practice in giving seminar talks. Students read recent journal articles and preprints and present the material. Usually offered every year.
Mr. Gessel

MATH 201a Topics in Algebra
Introduction to a field of algebra. Possible topics include representation theory, vertex algebras, algebraic groups. Usually offered every year.
Mr. Lian

MATH 202a Algebraic Geometry I
Varieties and schemes. Cohomology theory. Curves and surfaces. Usually offered every second year.
Staff

MATH 202b Algebraic Geometry II
Continuation of MATH 202a. Usually offered every second year.
Staff

MATH 203a Number Theory
Basic algebraic number theory (number fields, ramification theory, class groups, Dirichlet unit theorem), zeta and L-functions (Riemann zeta function, Dirichlet L-functions, primes in arithmetic progressions, prime number theorem). Usually offered every second year.
Mr. Diamond

MATH 203b Topics in Number Theory
Possible topics include class field theory, cyclotomic fields, modular forms, analytic number theory, ergodic number theory. Usually offered every year.
Staff

MATH 204a T.A. Practicum
Teaching elementary mathematics courses is a subtle and difficult art, involving many skills besides those that make mathematicians good at proving theorems. This course focuses on the development and support of teaching skills. The main feature is individual observation of the graduate student by the practicum teacher, who provides written criticism of, and consultation on, classroom teaching practices. Usually offered every year.
Ms. Charney

MATH 205b Commutative Algebra
Associated primes, primary decomposition. Filtrations, completions, graded rings. Dimension theory, Hilbert functions. Regular sequences, depth, regular local rings. Other topics as time permits. Usually offered every second year.
Mr. Schwarz

MATH 211a Topics in Differential Geometry and Analysis I
Possible topics include complex manifolds, elliptic operators, index theory, random matrix theory, integrable systems, dynamical systems, ergodic theory. Usually offered every year.
Mr. Adler

MATH 212b Functional Analysis
Banach and Hilbert spaces, linear operators, operator topologies, Banach algebras. Convexity and fixed point theorems, integration on locally compact groups. Spectral theory. Other topics as time permits. Usually offered every second year.
Staff

MATH 221a Topology III
Vector bundles and characteristic classes. Elementary homotopy theory and obstruction theory. Cobordism and transversality; other topics as time permits. Usually offered every year.
Mr. Levine

MATH 221b Topics in Topology
Topics in topology and geometry. In recent years, topics have included knot theory, symplectic and contact topology, gauge theory, and three-dimensional topology. Usually offered every year.
Mr. Ruberman

MATH 223a Lie Algebras
Theorems of Engel and Lie. Semisimple Lie algebras, Cartan's criterion. Universal enveloping algebras, PBW theorem, Serre's construction. Representation theory. Other topics as time permits. Usually offered every second year.
Mr. Schwarz

MATH 224b Lie Groups
Basic theory of Lie groups and Lie algebras. Homogeneous spaces. Haar measure. Compact Lie groups, representation theory, Peter-Weyl theorem, differential slice theorem. Complex reductive groups. Other topics as time permits. Usually offered every second year.
Staff

MATH 250a Complex Algebraic Geometry I
Riemann surfaces, Riemann-Roch theorems, Jacobians. Complex manifolds, Hodge decomposition theorem, cohomology of sheaves, Serre duality. Vector bundles and Chern classes. Other topics as time permits. Usually offered every second year.
Mr. Tamvakis

MATH 250b Complex Algebraic Geometry II
Continuation of MATH 250a. Usually offered every second year.
Mr. Tamvakis

MATH 299a Readings in Mathematics
Staff

MATH 299b Readings in Mathematics
Staff

MATH 301a Further Topics in Algebra
Staff

MATH 302a Topics in Algebraic Geometry
Staff

MATH 302b Topics in Algebraic Geometry
Staff

MATH 311a Further Topics in Analysis
Mr. Kleinbock

MATH 321a Further Topics in Topology
Staff

MATH 326a Topics in Mathematics
Staff

MATH 399a Readings in Mathematics
Staff

MATH 399b Readings in Mathematics
Staff

MATH 401d Research
Independent research for the Ph.D. degree. Specific sections for individual faculty members as requested.
Staff

Cross-Listed Courses

BIOL 51a
Biostatistics

ECON 184b
Econometrics

PHIL 106b
Mathematical Logic

PHYS 110a
Mathematical Physics

Courses of Related Interest

PHIL 38b
Philosophy of Mathematics

An interdepartmental program

Medieval and Renaissance Studies

Courses of Study:
Minor

Objectives

The Medieval and Renaissance Studies Program provides students with a broad introduction to the development of western civilization from the end of antiquity to the 17th century. It is founded on the principle that an interdisciplinary perspective is the most profitable way to gain an understanding of the formation of early modern Europe. In order to develop a multifaceted picture of the Middle Ages and the Renaissance, all students select one of two core courses in history, and they are encouraged to explore a variety of disciplinary perspectives provided by various national literatures, fine arts, and philosophies. The exact balance of these approaches depends on a student's interest. The program offers a useful complement to many majors, and it is a good foundation to graduate study in a variety of fields.

How to Become a Minor

The most important requirement for taking part in the program is an interest in the Middle Ages and the Renaissance. Students may enter the program at any time in their undergraduate careers, but an early start maximizes a student's range of choice because a number of courses are offered at different intervals. Students should consult with their advisor and the chair of the program to map out their particular plan of study.

Faculty

Jonathan Unglaub, Chair
(Fine Arts)

Bernadette Brooten
(Near Eastern and Judaic Studies)

Mary Campbell
(English and American Literature)

Jonathan Decter
(Near Eastern and Judaic Studies)

William Flesch
(English and American Literature)

Dian Fox
(Romance and Comparative Literature)

William Kapelle
(History)

Richard Lansing
(Romance and Comparative Literature)

Avigdor Levy
(Near Eastern and Judaic Studies)

Joan Maling
(Linguistics and Psychology)

Charles McClendon
(Fine Arts)

Michael McGrade
(Music)

Sarah Mead-Ramsey
(Music)

Jessie Ann Owens
(Music)

Michael Randall
(Romance and Comparative Literature)

Benjamin Ravid
(Near Eastern and Judaic Studies)

Govind Sreenivasan
(History)

Ramie Targoff
(English and American Literature)

Cheryl Walker
(Classical Studies)

Requirements for the Minor

A. Core Course: HIST 110b (The Civilization of the High and Late Middle Ages) or HIST 123a (The Renaissance).

B. Students in the program must complete the University language requirement in one of the following: French, Italian, Spanish, German, Latin, Greek, Russian, Arabic, or Hebrew.

C. Four other courses from the program listing. In order to promote an interdisciplinary approach to the study of the Middle Ages and the Renaissance, two of these courses should be in two different fields other than history.

D. In addition, the completion of one semester of independent study (MEVL 98a or b), under the direction of one or more members of the program faculty, requiring completion of a research paper; or participation in a program seminar or colloquium, when offered; or a senior thesis in the student's major, with an emphasis on some aspect of medieval or Renaissance studies and read by at least two faculty members in the program.

Special Notes

Please note that MUS 10a and 10b yield half-course credit each, therefore two semesters of MUS 10 are required to equal one full-semester course, i.e., one elective course.

Courses of Instruction

(1-99) Primarily for Undergraduate Students

MEVL 98a Independent Study
Usually offered every year.
Staff

MEVL 98b Independent Study
Usually offered every year.
Staff

Elective Courses

The following courses are approved for the minor. Not all are given in any one year. Please refer to the *Schedule of Classes* each semester.

CLAS 115b
Topics in Greek and Roman History

CLAS 166a
Medieval Literature: A Millennium of God, Sex, and Death

COML 102a
Love in the Middle Ages

ENG 33a
Shakespeare

ENG 43a
Major English Authors, Chaucer to Milton

ENG 63a
Renaissance Poetry

ENG 132b
Chaucer I

ENG 133a
Advanced Shakespeare

ENG 142b
Introduction to Old Norse

ENG 143a
Elizabethan and Jacobean Drama

ENG 152b
Arthurian Literature

ENG 173a
Spenser and Milton

FA 40b
The Formation of Jewish, Christian, and Islamic Art

FA 41a
Art and the Origins of Europe

FA 42b
The Age of Cathedrals

FA 43a
The Art of Medieval England

FA 45a
St. Peter's and the Vatican

FA 51a
Art of the Early Renaissance in Italy

FA 54b
Renaissance Art in Northern Europe

FA 58b
High and Late Renaissance in Italy

FA 60a
Baroque in Italy and Spain

FA 63a
The Age of Rubens and Rembrandt

FA 191b
Studies in Renaissance and Baroque Art

FREN 120a
The French Middle Ages

FREN 122b
The Renaissance

HIST 110a
The Civilization of the Early Middle Ages

HIST 110b
The Civilization of the High and Late Middle Ages

HIST 112b
The Crusades and the Expansion of Medieval Europe

HIST 113a
English Medieval History

HIST 120a
Britain in the Later Middle Ages

HIST 123a
The Renaissance

HIST 123b
Reformation Europe (1400-1600)

HIST 126a
Early Modern Europe (1500-1700)

HIST 127b
Household and Family in Late Medieval and Early Modern Europe (1300-1800)

IECS 140a
Dante's Divine Comedy

IMES 104a
Islam: Civilization and Institutions

LAT 125a
Medieval Latin

MUS 10a
Early Music Ensemble

MUS 10b
Early Music Ensemble

MUS 110b
The Authenticity Question: Applying Historical Performance Practices

MUS 121a
History of Music to 1700

MUS 128b
Musical Life in the Middle Ages and Renaissance

NEJS 140a
History of the Jews from the Maccabees to 1497

NEJS 140b
The Jews in Europe to 1791

NEJS 151b
Ghettos, Gondolas, and Gelato: The Italian Jewish Experience

NEJS 152a
From Inquisition to Holocaust

NEJS 152b
Anti-Judaism, Antisemitism, and Anti-Zionism

NEJS 188a
The Rise and Decline of the Ottoman Empire, 1300-1800

SECS 150a
Golden Age Drama and Society

SPAN 110a
Introduction to Peninsular Spanish Literature

SPAN 120b
Don Quijote

SPAN 125b
Literary Women in Early Modern Spain

A graduate program

Molecular and Cell Biology

Courses of Study:
Master of Science
Doctor of Philosophy

Objectives

The Graduate Program in Molecular and Cell Biology, leading to the degree of Doctor of Philosophy, is designed to provide each student with the theoretical foundations and research experience needed to become an independent and original investigator of basic biological phenomena. Preparation is achieved through the combination of (1) a flexible curriculum of courses tailored for each student's specific needs, (2) a set of laboratory rotations that acquaints each entering student with current research techniques and permits exploration of possible research areas, and (3) a proseminar specifically for first-year students and a series of journal clubs that keep students abreast of significant research findings and develops confidence with reading research literature and giving oral presentations. First-year students participate in all three aspects of our graduate program and are thus quickly integrated into the biological research community at Brandeis. A strength of our program is frequent interactions between students and faculty, formal and informal.

Thesis research leading to the Ph.D. degree is carried out under the personal direction of a faculty member. A complete list of faculty research interests and recent publications can be viewed online at www.bio.brandeis.edu. Potential applicants are urged to obtain this information. As a general orientation, the following areas of research are among those represented in the program: molecular biology of the regulation of gene expression; chromosome structure and chromosomal rearrangements; mechanisms of recombination; developmental genetics; behavioral genetics and neural development; biophysics of single nerve cells; learning and memory; integration of neural function; immunogenetics; immune cell differentiation and development; molecular biology of the immune system; regulation of muscle contraction; molecular and cell architecture; organization of subcellular structures; structure and function of proteins; mammalian embryogenesis and the biotechnology of DNA diagnostics.

How to Be Admitted to the Graduate Program

The general requirements for admission to the Graduate School, given in an earlier section of this *Bulletin*, apply to candidates for admission to this area of study. The student's undergraduate record should ordinarily include courses equivalent to those required of undergraduates concentrating in biology at this institution. Applicants to the Ph.D. program who are deficient in some of these subjects, but whose records are otherwise superior, may make up their deficiencies while they are enrolled as graduate students. In exceptional cases, students may be excused from some of these requirements. Students with serious deficiencies must, however, expect to add additional time to their graduate program in order to satisfy the deficiencies.

Applicants must take the Graduate Record Examination.

Since the summer months provide an important opportunity for uninterrupted laboratory work, the Molecular and Cell Biology Program provides 12-month stipend support for all full-time Ph.D. students.

Faculty

Kalpana White, Chair of the Department of Biology (Volen National Center for Complex Systems)
Developmental neurogenetics.

Susan Birren (Volen National Center for Complex Systems)
Developmental neurobiology.

Carolyn Cohen (Rosenstiel Center)
Structural molecular biology.

Bruce Goode (Rosenstiel Center)
Biochemistry and genetics of yeast cytoskeleton.

Leslie Griffith (Volen National Center for Complex Systems)
Biochemistry of synaptic plasticity.

James Haber (Rosenstiel Center)
Genetics and molecular biology of yeast meiotic and mitotic recombination. Mating-type switching. Repair of broken chromosomes.

Jeffrey Hall (Volen National Center for Complex Systems)
Neurogenetics and molecular neurobiology of higher behaviors in *Drosophila*.

Kenneth Hayes (Director, Foster Animal Lab)
Comparative nutritional pathophysiology in man and animals. Lipoprotein metabolism and atherogenesis, cholelithiasis.

Susan Lovett (Rosenstiel Center)
Genetics and molecular biology of bacteria and yeast. DNA repair. Recombination and mutogenesis.

Melissa Moore
Molecular biology of self-splicing introns and the splicesome. Mechanisms of RNA catalysis.

Gregory Petsko (Director, Rosenstiel Center)
X-ray crystallographic analysis of protein structure and enzyme mechanisms.

Joan Press (Rosenstiel Center)
Developmental immunology and immunogenetics.

Ruibao Ren (Rosenstiel Center)
Signal transduction.

Michael Rosbash (Volen National Center for Complex Systems)
RNA processing and molecular neurobiology.

Piali Sengupta (Volen National Center for Complex Systems), Graduate Advising Head
Developmental neurobiology in *C. elegans*.

Neil Simister (Rosenstiel Center)
Molecular immunology. Antibody transport.

Lawrence Wangh
Mammalian embryogenesis, gene expression in single cells, DNA amplification and *in vitro* DNA diagnostics.

Michael Welte (Rosenstiel Center)
Regulation of motor-driven transport.

Requirements for the Degree of Master of Science

Program of Study
The program is designed to guide each student toward realizing her or his potential as an independent research biologist. Students are encouraged to become experts in the theory and practice of their chosen area of research, as well as to obtain breadth in other areas strongly represented in the program. Research areas include genetics, molecular biology, developmental biology, cell biology, structural biology, immunology, and neurobiology. Graduate courses are available in all of these areas. A total of six graduate-level courses, which must include BIOL 103b and BIOL 105b, with the balance to be agreed upon with the program advisor, are required for the degree. The research component can be met by satisfactory performance in four laboratory rotations (including submission of written rotation reports) or a two-semester research project in one laboratory (including submission of a research thesis) or submission of a research thesis based on research in the library. Research in a laboratory is predicated on the students being accepted into a laboratory or laboratories. (If no such suitable laboratory experience can be arranged, then the student's option is to use the third choice of a thesis based on library research of the literature). All students are required to take CONT 300b (Ethical Practice in Health Related Sciences), typically in the spring. The student must receive grades of B- or better in all courses and may be terminated at the end of the first semester if the student's record is unsatisfactory.

Residence Requirement
The minimum residence requirement is one year.

Requirements for the Degree of Doctor of Philosophy

Program of Study
Students are expected to obtain a knowledge of the principles and techniques of three of the areas represented in the program, i.e., genetics, developmental biology, molecular biology, neurobiology, immunology, cell biology, and structural biology. The background a student is expected to have in these areas will be covered in courses given by the program. Entering students also participate together in a proseminar, an introduction to the research literature of biology. Students take two courses each semester in the first year, with a total of six required for the degree. In the first year, students will complete four, nine-week rotations in at least four different laboratories. Throughout the graduate years, students remain involved in seminar courses, journal clubs, presentations of research, colloquia, and research courses.

Each student will choose his/her specific field of interest and will apply for a permanent advisor to be agreed upon by the program at the end of the first year. The advisor will assist the student in planning a well-balanced program in his/her specific field of interest. In addition, the advisor will ordinarily serve as the chair of the student's dissertation examining committee.

Teaching Requirement
At least one year of teaching experience (or equivalent) is required of all degree candidates.

Residence Requirement
The minimum residence requirement is three years.

Language Requirement
There is no foreign language requirement for the Ph.D. degree.

Qualifying Examination
The qualifying examination consists of two research propositions in which the student identifies an important and interesting research problem and then proposes the experiments to attack it. The propositions are written and the student gives an oral defense. The first proposition, which is taken at the end of the first year, must be in an area outside the student's area of thesis research. The second proposition constitutes a thesis proposal and is taken at the end of the second year.

Advancement in the Program
To pass into the second year of graduate studies, the student must have grades of B- or better in all courses, must have a satisfactory evaluation of the first proposition, and must have found a laboratory in which to carry out thesis research.

To pass into the third year and be admitted to candidacy, the student must have grades of B- or better in all courses, have performed satisfactorally on both propositions, and be in good standing in the thesis research laboratory.

Dissertation and Defense
Each student will conduct an original investigation. After submission of the dissertation, the candidate will be expected to present the principal results of his or her work and its significance during an examination in defense of the dissertation. The examining committee must include one faculty member from outside the University. A public seminar to the University community is also required.

Courses of Instruction

(100-199) For Both Undergraduate and Graduate Students

BIOL 102b Structural Molecular Biology
[sn]
Prerequisites: BIOL 22a and BIOL 22b, or permission of the instructor.
Cells are filled with machines that carry materials about the cell, that chemically transform molecules, that transduce energy, and much more. Our understanding of how these machines work depends on understanding their structures. This introduction to the structural basis of molecular biology examines the designs of proteins and nucleic acids, their assembly into macromolecular complexes, and the means whereby we visualize these structures. Considers the physical and chemical basis for specificity in molecular recognition. Usually offered every second year.
Staff

BIOL 103b Mechanisms of Cell Functions
[sn]
Prerequisite: BIOL 22b or permission of the instructor.
An advanced course focusing on a mechanistic understanding of cell biological processes and the methods by which these processes are elucidated. Papers are chosen to illustrate a variety of experimental approaches including biochemistry, genetics, and microscopy. Topics include cell cycle, signal transduction, cytoskeleton and cell movement, membrane traffic, intercellular transport, and organelle functions. Usually offered every year.
Mr. Welte

BIOL 105b Molecular Biology
[sn]
Prerequisites: BIOL 22a and BIOL 22b. Section 2 is open only to students in the Genetic Counseling Program. Class work for this section is supplemented by special readings and lectures with a clinical focus.
Examination of molecular processes in replication and expression of genetic information and techniques by which this understanding has been achieved. Topics include recombinant DNA and other molecular biological techniques, structure and organization of DNA in chromosomes, DNA replication, transcription and regulation of gene expression, RNA structure and processing, mRNA stability, and other mechanisms of post-translational control. Usually offered every year.
Mr. Haber and Mr. Rosbash

BIOL 111a Developmental Biology
[sn]
Prerequisite: BIOL 22b.
How do complex organisms build themselves starting from single cells? Examines how processes such as fertilization, embryogenesis, cell differentiation, and tissue-specific gene expression occur; what is known about the key molecules and genes that orchestrate these processes; and how genetic changes affecting these processes underlie the evolution of body form. Usually offered every second year.
Ms. Birren

BIOL 122a Molecular Genetics
[sn]
Prerequisite: BIOL 22a.
A lecture- and literature-based course emphasizing strategies of genetic analysis and the mechanisms that control genetic change and preserve genetic stability. Lectures cover the topics of mutation, recombination and repair of genetic damage, chromosome structure and transmission, analysis at the genomic level, and modern genetic and molecular biology approaches to study genes in action. Research papers of current and historical interest will be discussed. Usually offered every second year.
Mr. Haber and Ms. Lovett

BIOL 125a Immunology
[sn]
Prerequisites: BIOL 22a and BIOL 22b.
Topics include properties, functions of cells involved in immunity; genes, structure, function of immunoglobins and T cell receptors; cell interactions; antigen recognition; lymphokines; tolerance; lymphocyte differentiation; genetic regulation; viral immunity; autoimmunity; AIDS; vaccines. Usually offered every year.
Ms. Press

BIOL 126b Protein Structure and Disease
[sn]
Prerequisites: BIOL 22a and BIOL 22b, or the equivalent, or permission of the instructor.
Reviews the basic principles of protein structure, so that the functional aspects of different protein designs may be understood. Examines various protein mutations related to certain molecular diseases and the architecture of some key viruses and their infectivity. Consideration of drug design is an integral part of the course. Student presentations are essential to the course. Usually offered every second year.
Ms. Cohen

BIOL 128a Human Genetics
[sn]
Prerequisites: BIOL 22a and BIOL 22b.
Survey of mutation and polymorphism; molecular techniques; single-gene inheritance and complexities thereof; risk assessment and Bayesian analysis; cytogenetics; hemoglobinopathies; population genetics; physical and genetic mapping strategies; cancer genetics; ethical considerations; multifactorial inheritance; immunogenetics; pharmacogenetics; genetics of development; molecular and biochemical basis of genetic disease; genomics, proteomics, and bioinformatics; gene therapy; and computer databases in human genetics. Usually offered every year.
Ms. Hiller

BIOL 132a General Microbiology
[sn]
Prerequisites: BIOL 22a and BIOL 22b, CHEM 25a and 25b.
A survey of the physiology of bacteria and other microorganisms. Concentrates on those aspects of cell structure and function that are important for diverse microbial lifestyles. In addition, pays special attention to the biology of disease-causing organisms and microbiological problems facing medicine today. Usually offered every second year.
Staff

BIOL 134b Topics in Ecology
[sn]
Prerequisites: BIOL 23a or permission of the instructor.
An in-depth look at one sub-discipline in ecology. The most recent topic was tropical ecology. Consult the Schedule of Classes for current topic. Usually offered every second year.
Mr. D.L. Perlman

NBIO 136b Computational Neuroscience
[sn]
Prerequisites: MATH 10a or PHYS 10a or approved equivalents.
An introduction to concepts and methods in computer modeling of neural systems. Topics include the basic biophysics of ion conduction, single- and multi-compartment neuron models, information representation and processing in the visual system, and models of synaptic plasticity, working memory and decision making. Usually offered every second year.
Mr. Wang

NBIO 140b Principles of Neuroscience
[sn]
Prerequisite: BIOL 22b or permission of the instructor.
Basic principles of neurobiology. Topics include ion channels and their role in generating resting and action potentials; basics of synaptic physiology and pharmacology; neural circuits underlying behavior, learning, and mental illness. Usually offered every year.
Ms. Marder

NBIO 143b Developmental Neurobiology
[sn]
Prerequisite: BIOL 22b or permission of the instructor.
Discusses the mechanisms used in the development of the nervous system. Topics include determination of neuronal cell fates, neuronal differentiation and pattern formation, neuron survival and growth, and mechanisms responsible for generation of connectivity in the nervous system. Usually offered every second year.
Ms. Sengupta

NBIO 145b Systems Neuroscience
[sn]
Prerequisite: NBIO 140b.
A fundamental question regarding brain function is how we learn and remember. To understand this process, the underlying molecular, cellular, and network mechanisms have to be understood. These topics are reviewed, with emphasis on reading original papers and extensive class discussion. Usually offered every year.
Mr. Lisman

NBIO 146a The Neurobiology of Human Disease
[sn]
Prerequisite: NBIO 140b.
A lecture-and literature-based overview of the neurobiological underpinnings of neurological and psychiatric disorders including autism, mental retardation, schizophrenia, bipolar disorder, Alzheimer's Disease, Parkinson's Disease, and other neurodevelopment and neurodegenerative disorders. Usually offered every second year.
Mr. Nelson

NBIO 147a Neurogenetics
[sn]
Prerequisites: BIOL 18a and BIOL 22a.
Development and function of the nervous system and responses of excitable cells studied in neurological and behavioral mutants. Characterization and manipulation of genes, defined by these mutations and using molecular biological tools. Organisms: microbes, roundworms, fruit flies, mammals. Neurobiological areas: embryonic neural development, nerve cell differentiation and pattern formation, membrane excitability, responses to visual and chemical stimuli, biological rhythms, and reproductive behavior. Usually offered every third year.
Mr. Hall

NBIO 148b Cellular Neuroscience
[sn]
Prerequisite: NBIO 140b or permission of the instructor. May be taken concurrently with NBIO 140b. This course may not be repeated for credit by students who have taken NBCH 148b in previous years.
Focuses on cellular mechanisms of excitability and synaptic plasticity. Students examine classic experiments on action potentials and synaptic transmission and the original research literature dealing with the cellular mechanisms of developmental and learning-related plasticity. Usually offered every year.
Ms. Turrigiano

BIOL 149b Molecular Pharmacology
[sn]
Prerequisites: BIOL 22b and CHEM 25a and b. NBIO 140b strongly recommended.
Covers the essentials of pharmacology and the study of the actions of chemical agents (drugs, toxins, neurotransmitters, and hormones) that interact with living systems. Emphasizes molecular mechanisms of neuropharmacology. Topics include pharmacokinetics, hormone action, autonomic pharmacology, and the psychopharmacology of drugs of abuse and mental disorders. Usually offered every third year.
Ms. Griffith

NBIO 150a Autism and Human Developmental Disorders
[sn]
Prerequisite: BIOL 22b.
Autism and other developmental disorders are characterized by abnormal brain development resulting in cognitive and behavioral deficits. Takes an integrative approach to investigate the biological, behavioral, medical, and social aspects of human developmental disorders. Usually offered every second year.
Ms. Birren

BIOL 160b Human Reproductive and Developmental Biology
[wi sn]
Prerequisites: BIOL 22a and BIOL 22b.
Course deals with hormonal, cellular, and molecular aspects of gametogenesis, fertilization, pregnancy, and birth. Discusses pathological and abnormal variations that occur and the available medical technologies for intervention, correction, and facilitation of these processes are discussed. Usually offered every year.
Staff

BIOL 172b Growth Control and Cancer
[sn]
Prerequisites: BIOL 22a and BIOL 22b.
Covers the fundamental rules of behavior of cells in multicellular organisms. Examines cellular and molecular mechanisms that govern cell growth, differentiation and survival in normal cells, as well as how this regulation is disrupted in cancer. Usually offered every second year.
Mr. Ren

BIOL 173b Programmed Cell Death
[sn]
Prerequisites: BIOL 22a, BIOL 22b, and BCHM 100a or permission of the instructor.
Apoptosis, the programmed death of vertebrate cells, is essential for normal development and health. The topic is examined through recent research papers, lectures, and student presentations, with emphasis on the mechanism of apoptosis and its role in human diseases such as cancer and neurological disorders. Usually offered every third year.
Staff

BIOL 174b Stem Cells
[sn]
Prerequisites: BIOL 22a and BIOL 22b.
Covers stem cell biology, cell differentiation and transdifferentiation, cell lineage commitment, gene expression, signal transduction, cell identity memory and cell therapies. Provides a unique way to gain insights into developmental biology, molecular and cell biology, cancer biology, biology of aging, and regenerative medicine, as well as bioethics and health and public policies. Usually offered every second year.
Mr. Ren

BIOL 175b Advanced Immunology
[sn]
Prerequisite: BIOL 125a or permission of the instructor.
A survey of recent advances in molecular immunology. Topics include hematopoietic stem cell biology, blood lineage commitment, growth factor signal transduction, the nature and specificity of antigen receptors, the regulation and mechanism of V(D)J recombination, and B and T cell development. Usually offered every second year.
Staff

(200 and above) Primarily for Graduate Students

BIOL 200a Proseminar
For first-year Ph.D. students. Emphasizes the reading, analysis, and presentation of scientific papers. There is considerable emphasis on writing and students will be guided towards preparing research papers and grant applications. Also examines how scientists frame important questions and design appropriate experiments. Papers will be chosen for discussion, covering molecular biological, genetic, structural, and biochemical approaches. Usually offered every year.
Ms. Griffith

BIOL 202d Introduction to Genetic Counseling
A two-semester sequence that provides the historical and theoretical foundations for the practice of genetic counseling and the role of genetic services within the healthcare delivery system. Introduces students to some of the practical aspects of genetic counseling, including case preparation, pedigree construction/interpretation, and medical documentation. Usually offered every year.
Ms. McIntosh

BIOL 203a Proseminar: The Molecular Basis of Genetic Diseases
Covers the molecular basis of muscular dystrophy, fragile X syndrome, cystic fibrosis, Huntington disease, and several inherited cancer syndromes. A historical perspective is used for each topic; molecular diagnostics and genetic counseling issues are addressed as well. Usually offered every year.
Ms. Tsipis

BIOL 204b Clinical Genetics I
Introduction to basic concepts of biochemical genetics, cytogenetics, and clinical molecular genetics. Makes use of clinical cases ranging from single gene disorders to multifactorially determined conditions and includes problems in dysmorphology, inborn errors of metabolism, and cancer genetics. A problem-solving approach is emphasized. Usually offered every year.
Ms. Schneider and Ms. Stoler

BIOL 205b Counseling Theory and Technique
A comprehensive overview of counseling theory and practice. Topics include listening, observation, and interview skills and strategies; family dynamics and development; coping and adaptation processes; referral and consultation procedures; and ethical principles. Students are provided an opportunity to integrate clinical experiences with the coverage of topics. Usually offered every year.
Mr. Rintell

BIOL 206d Genetic Counseling Journal Club
Noncredit.
Informal biweekly meeting of students and faculty at which recent papers are discussed. Usually offered every year.
Staff

BIOL 207a Genetic Counseling: Case Conferences and Family Counseling
Taught by a team of health care professionals. Case studies provide the basis for discussion of a variety of genetic disorders and the application of counseling modalities. Students have an opportunity to share experiences gained during clinical internships. Discussions emphasize the interplay of medical, psychological, ethical, legal, social, and cultural factors in genetic counseling. Usually offered every year.
Ms. McIntosh and Mr. Rintell

BIOL 211a Genetic Counseling Fieldwork Placement: Part I
Students work one day per week in a community-based health service organization, school, clinic, or public health agency to develop awareness of disability-related issues and the variety of community-based services for individuals with special needs. Students also observe in a genetics clinic 20-30 hours over the course of the semester to gain exposure to concepts learned in BIOL 202d (Introduction to Genetic Counseling). Periodic course discussions supplement the fieldwork experience.
Ms. Lerner

BIOL 211b Genetic Counseling Fieldwork Placement: Part II
To begin preparing for clinical genetics internships, students participate in a variety of experiences that serve to foster and integrate the concepts introduced in courses and presentations. Students are exposed to procedures in clinical labs through lectures, site visits, and/or lab work. In addition, students continue observations in a genetics clinic and meet several times with a family with a child with a disability. Periodic course discussions supplement the fieldwork experience.
Ms. Lerner

BIOL 212a Genetic Counseling Internship I
Starting in the summer and continuing through the fall semester, students work two to three days a week under the supervision of a genetic counselor or clinical geneticist in a prenatal, pediatric, general, cancer, or specialty genetics clinic. Usually offered every year.
Ms. McIntosh

BIOL 212e Genetic Counseling Internship II
Students work two to three days a week under the supervision of a genetic counselor or clinical geneticist in a prenatal, pediatric, general, cancer, or specialty genetics clinic and meet once a week to discuss cases and develop counseling protocols for some common genetic disorders. Usually offered every year.
Ms. McIntosh

BIOL 213d Genetic Counseling Research Project
Students are introduced to the basic techniques of social science research and their grounding principles in a series of seminars. In consultation with the program's research coordinator, each student designs and carries out a project under the supervision of a research committee. Usually offered every year.
Ms. Lerner

BIOL 214c Genetic Counseling Process Group
In this small group setting, students can share and learn from their collective experiences in their field placements, courses, and individual lives and have the opportunity to process and integrate the experience of becoming a genetic counselor. Usually offered every semester.
Mr. Cunningham

BIOL 215b Readings in Molecular Biology
A combination of readings and clinical laboratory work to provide students with an in-depth understanding of the molecular biology of several human genetic diseases and the techniques used for their diagnosis. Usually offered every year.
Ms. Tsipis

BIOL 220a Clinical Genetics II
Prerequisite: Completion of BIOL 204b or permission of the instructor.
Continuation of BIOL 204b with emphasis on the genetic and developmental disorders of most major organ systems. A case-based, problem-solving approach is emphasized. Usually offered every year.
Mr. Korf or Staff

BIOL 224b The RNA World
Prerequisite: BCHM 100a, BIOL 105b (formerly BIBC 105b), or permission of the instructor.
This course employs seminars and lectures to approach a wide range of topics in RNA research. Topics include RNA enzymes, RNA structure, protein-RNA interactions, pre-MRNA splicing, and RNA localization.
Ms. Moore and Mr. Rosbash

BIOL 236b Genetics, Law, and Social Policy
Explores advances in human genetics, the clinical and economic benefits promised by new tests, problems generated by our new ability to manipulate our biological future. Analyzes the role of government in regulating technological development and the legal doctrines of privacy, informed consent, and professional liability. Usually offered every second year.
Ms. Roche

BIOL 300a Biological Research
Primarily for the first-year student with the purpose of introducing him or her to biological research and to the work in progress in the laboratories of a number of faculty members. In consultation with the graduate advisor, the student plans a sequence of such tenures, each comprising nine weeks or more, and then carries out experimental investigations under the guidance of the faculty members involved. Usually offered every year.
Staff

BIOL 300b Biological Research
Primarily for the first-year student with the purpose of introducing him or her to biological research and to the work in progress in the laboratories of a number of faculty members. In consultation with the graduate advisor, the student plans a sequence of such tenures, each comprising nine weeks or more, and then carries out experimental investigations under the guidance of the faculty members involved. Usually offered every year.
Staff

BIOL 305d Topics in Molecular Genetics and Development
Usually offered every year.
Mr. Welte

NBIO 306d Topics in Neurobiology
Usually offered every year.
Ms. Turrigiano

BIOL 307d Topics in Immunology
Usually offered every year.
Ms. Press and Mr. Simister

BIOL 316d Mechanisms of Recombination
Usually offered every year.
Mr. Haber and Ms. Lovett

NBIO 340d Systems/Computational Neuroscience Journal Club
Usually offered every year.
Mr. Wang

BIOL 350d Graduate Student Research Seminar
Usually offered every year.
Staff

BIOL 401d Dissertation Research
Independent research for the Ph.D. degree. Specific sections for individual faculty members as requested.
Staff

CONT 300b Ethical Practice in Health-Related Sciences
Required of all first-year graduate students in health-related science programs. Not for credit.
Ethics is an essential aspect of scientific research. This course, taught by University faculty from several graduate disciplines, covers major ethical issues germane to the broader scientific enterprise, including areas or applications from a number of fields of study. Lectures and relevant case studies are complemented by two public lectures during the course. Usually offered every year.
Ms. Ringe