DIVISION OF BIOLOGICAL SCIENCES

The biology major provides a unified curriculum for undergraduates enrolled in either the College of Agriculture and Life Sciences or the College of Arts and Sciences. Courses in biological sciences are integral to many disciplines and are basic requirements in many schools and colleges at Cornell.

Graduate study in the biological sciences is administered by more than a dozen specialized fields within the Graduate School, as described in the Announcement of the Graduate School.

ORGANIZATION

Many different departments participate in the biology major.

Student services are provided by the Office of Undergraduate Biology, which includes the Behrman Biology Center. Both are located in Stimson Hall, where academic advice, information on biological sciences course offerings, other important information, and counseling are available for undergraduates. The Office of Undergraduate Biology also follows the progress of biology majors and works closely with faculty advisers. Additional services and resources of the Biology Center include academic program planning, tutoring, lecture tapes, examination files, and information on undergraduate research opportunities. The center has comfortable areas for studying and relaxing.

The Shoals Marine Laboratory, a cooperative venture with the University of New Hampshire, is located on Appledore Island in the Gulf of Maine. Its base office in Stimson Hall provides advising and career counseling for students interested in the marine sciences and administers the SEA Semester program for Cornell students pursuing studies at Woods Hole or aboard the schooner *Westward* or brigantine *Corwith Cramer*.

FACULTY

E. Adkins-Regan, K. K. Adler, E. E. Alani, C. F. Aquadro, W. J. Arion, A. H. Bass, D. M. Bates, A. Bensadoun, K. W. Beyenbach, A. W. Blackler, S. E. Bloom, R. Booker, A. C. Borror, J. Bradfield, A. P. Bretscher, W. J. Brown, P. J. Bruns, J. M. Calvo, R. R. Capranica, B. F. Chabot, R. H. Chen, J. L. Cisne, J. P. Comstock, R. A. Corradino, W. L. Crepet, P. J. Davies, J. I. Davis, D. Deitcher, A. A. Dhondt, J. J. Doyle, T. Eisner, S. T. Emlen, P. P. Feeny, G. W. Feigenson, B. Finlay, J. W. Fitzpatrick, A. S. Flecker, R. H. Foote, J. E. Fortune, T. D. Fox, M. A. Geber, W. C. Ghiorse, J. Gibson, Q. H. Gibson, R. F. Gilmour, M. L. Goldberg, H. W. Greene, N. G. Hairston, Jr., B. P. Halpern, M. R. Hanson, R. G. Harrison, R. M. Harris-Warrick, C. D. Harvell, L. O. Hedin, J. D. Helmann, G. P. Hess, P. C. Hinkle, K. Hodge, S. Holmes, C. D. Hopkins, K. A. Houpt, T. R. Houpt, R. W. Howarth, S. H. Howell, H. C. Howland, R. R. Hoy, T. C. Huffaker, M. N. Kazarinoff, K. J. Kemphues, K. A. R. Kennedy, L. V. Kochian, A. S. Kondrashov, L. Kraus, R. L. Last, S. A. Levin, J. K. Liebherr, G. E. Likens, J. T. Lis, E. R. Loew, M. A. Luckow, D. McCobb, A. R. McCune, J. M. Fessenden MacDonald, R. J. MacIntyre, E. L. Madsen, P. L. Marks, H. S. Mason, G. D. May, J. G. Morin, R. P. Mortlock, J. B. Nasrallah, M. E. Nasrallah, P. W. Nathanielsz, L. Nicholson, K. J. Niklas, K. C. Nixon, T. G. Owens, D. J. Paolillo Jr., M. V. Parthasarathy, T. R. Podleski, A. G. Power, W. B. Provine, A. Quaroni, H. K. Reeve, M. E. Richmond, J. W. Roberts, D. Robertshaw, E. Rodriquez, R. B. Root, M. J. Rossman, J. B. Russell, M. M. Salpeter, T. D. Seeley, D. I. Shalloway, J. P. Shapleigh, P. W. Sherman, S. M. Snedeker, R. M. Spanswick, D. B. Stern, J. F. Thompson, R. Turgeon, B.-K. Tye, S. Vehrencamp, V. M. Vogt, C. Walcott, R. O. Wayne, W. W. Webb, N. F. Weeden, Q. D. Wheeler, K. E. Whitlock, D. B. Wilson, S. C. Winans, D. W. Winkler, M. F. Wolfner, J. F. Wootton, R. Wu, K. R. Zamudio, S. H. Zinder

Other Teaching Personnel

G. S. Albrecht, J. Barry, J. E. Blankenship, R. A. Calvo, P. W. Concannon, C. Eberhard, P. R. Ecklund, S. Ely, J. C. Glase, B. R. Johnson, B. Land, C. H. McFadden, S. Merkel, H. T. Nivison, C. M. Rehkugler, M. J. Shulman, T. Silva, C. M. Wahl-Loew

DISTRIBUTION REQUIREMENT

In the College of Agriculture and Life Sciences, the biological sciences distribution requirement (Group B) is for a minimum of 9 credits, including at least 6 credits of introductory biology satisfied by Biological Sciences 109–110, 105–106, or 101 and 103 plus 102 and 104, or 107–108 or any combination of the first term of one sequence and the second term of another. Advanced placement in biology with a score of 4 or 5 (6 or 8 credits, respectively) satisfies the requirement for introductory biology. The additional credits may be satisfied by any biological sciences courses *except BIOG 200* (unless permission is obtained), *BIOG 209, or BIOSM 367*.

For College of Arts and Sciences students matriculating before fall 1992, the biological sciences distribution requirement is for a two-semester introductory biology sequence selected from Biological Sciences 109–110, 105–106, or 101 and 103 plus 102 and 104, or 107–108 or any combination of the first term of one sequence and the second term of another. An Advanced Placement score of 4 or 5 fulfills one-half of the distribution requirement. Students must take an upper-level biology course to complete the distribution requirement in biological sciences. The remainder of the distribution requirement may be satisfied by an upper-level biology ("BIO") course (200+) *other than BIOG 200* (except by permission), *BIOG 209, or BIOSM 367*; Anthropology 101; or Chemistry 222 or any combination of the first term of one sequence and the second term of another.

For students in the College of Arts and Sciences who matriculate fall 1992 or later, all biolgy ("BIO") courses can be used toward fulfillment of the biological distribution requirement except *BIOG 200* (unless permission is obtained), *BIOG 209, or BIOSM 367*. The following courses are especially suitable for the distribution requirement because they have no prerequisites: BIO G 101–104, 105–106, 107–108, 109–110, 170, 202, 207; BIOBM 132; BIOES 154, 264, 275; BIOGD 184; BIOMI 192; BIOAP 212; BIOPL 240, 241. *Note that introductory biology can only count for distribution credit when taken as a two-semester sequence: 109–110, 105–106, or 101 and 103 plus 102 and 104, or 107–108, or a combination of the first term of one sequence and the second term of another.* Advanced placement in biology with a score of 4 or 5 (6 or 8 credits, respectively) may be applied to the Group 1 distribution area in accordance with regulations stipulated by the Arts College.

In the College of Human Ecology, the natural sciences distribution requirement is for at least 6 credits selected from BIO G 109–110, 101 and 103 plus 102 and 104, 105–106 or 107–108 or from specified courses in chemistry or physics. Advanced placement in biology with a score of 4 or 5 (6 or 8 credits, respectively) also satisfies the distribution requirement in the natural sciences.

Note: BIO G 101–102–103–104 should be taken as a unit by students of any college except those with advanced placement credit.

Switching from one introductory biology sequence to another at midyear may not be possible because of variation in presentation of topics. Students must receive permission of the instructor to switch sequences. Taking sequences in reverse or inconsecutive order is strongly discouraged.

USE OF ANIMALS IN THE BIOLOGICAL SCIENCES CURRICULUM: CORNELL UNIVERSITY

Students wishing to enroll in biology ("BIO") courses should know and understand the following criteria relative to the use of animals in the teaching program, as passed by the faculty of the Division of Biological Sciences in 1988, and reaffirmed in 1997:

1. "Live animals will be used for teaching in certain courses in the biological sciences. Some animals will require humane euthanasia after they have been used for teaching.
2. Courses bearing the "BIO" description conform to the rules for the care of such animals as outlined in Guiding

Principles in the Care and Use of Animals (as approved by the Council of the American Physiological Society), the Guide for the Care and Use of Laboratory Animals. (DHEW publication 86–23, revised 1996; see p. 14, *Courses of Study*), the Animal Welfare Act, and the New York State Public Health Law. Within these regulations, and in keeping with the principle of Academic Freedom of the Faculty, the use of animals to aid in teaching any biological sciences discipline is at the discretion of the professor in charge.

3. Each course, as well as research projects, in which animals are used receives a formal review annually by the Cornell University Institutional Animal Care and Use Committee (IACUC).
4. Any concerns regarding the use of live animals in teaching should be addressed first to the faculty member responsible for that course. He or she is required to be in compliance with all applicable regulations and guidelines. Alternatively, students may choose to address their concerns to the director of the Cornell Center for Research Animal Resources, Dr. Fred Quimby, at 253–3520. The director may initiate discussion with the faculty member responsible for a particular course without involving the student if he or she would prefer to remain anonymous.
5. Enrollees in those courses in the biological sciences in which animal use is a component may, at the professor's discretion, be asked to sign copies of this statement (USE OF ANIMALS...) at the first meeting of the course."

ADVANCED PLACEMENT

For information on credit for advanced placement in Biological Sciences, please see the section on Advanced Placement in the front of this publication.

THE MAJOR

The major of biological sciences is available to students enrolled in either the College of Agriculture and Life Sciences or the College of Arts and Sciences. The undergraduate program is coordinated for students in both colleges through the Office of Undergraduate Biology, where students submit their applications to the major and obtain biology faculty advisers.

During the second semester of the sophomore year, all students who intend to major in biological sciences must apply for acceptance into the major with the Office of Undergraduate Biology, in 200 Stimson Hall. Students in the College of Agriculture and Life Sciences who were admitted directly to the major complete the application process to declare a program of study area and to assure satisfactory progress toward completion of the major. Acceptance into the major requires completion of the course sequences in introductory biology, chemistry, and mathematics (see requirements 1–3 below), plus one semester of organic chemistry lectures. In addition, a 2.75 Cornell cumulative grade-point average is required for final acceptance into the major except for those students admitted directly to the major as freshmen (College of Agriculture and Life Sciences students only) or as transfers. Students in the process of completing these prerequisites for admission to the major may be accepted on a *provisional* basis. Final acceptance into the major is required for graduation with a biological sciences major. It is the student's responsibility to assure that final acceptance has been granted.

Whenever possible, students should include the introductory biology, chemistry, and mathematics sequences in their freshman schedule and complete the organic chemistry lecture course in their sophomore year. Students are not encouraged to continue with the major in biological sciences unless performance in these four subjects gives evidence of capacity to perform satisfactorily at a more advanced level.

The requirements for the biological sciences major are listed below. These courses, with the exception of the language requirement, should be taken for a letter grade, unless the course is offered for S-U grades only.

1) **Introductory biology for majors** (one year): BIO G 101 and 103 plus 102 and 104, or 105–106. BIO G 107–108, offered during the eight-week Cornell Summer Session for 8 credits, also satisfies the introductory biology requirement for majors. Students may choose to accept advanced placement if they have received a score of 5 on the Advanced Placement Examination of the College Entrance Examination Board (CEEB). Students with a score of 4 must fulfill the introductory biology requirement by taking BIO G 101–102, 101 and 103, 102 and 104, or 103–104. These students should consult information available in the course office (1140 Comstock Hall) and in the Biology Center (216 Stimson Hall) to determine which semester to complete the introductory biology requirement. For students in doubt, completion of BIO G 101 and 103 is advised. These students receive a total of 8 introductory biology credits (4 AP credits plus 4 course credits).
2) **General chemistry** (one year): Chemistry 207–208,* or 206–208, or 215–216.*
3) **College mathematics** (one year): one semester of calculus (Mathematics 106, 111, 191 or their equivalent) plus one semester selected from the following:
   a. a second semester of calculus (Mathematics 112, 192, or their equivalents.
   b. a course in finite mathematics (Biometry 101, 417, Mathematics 105, 231).
   c. a course in statistics (Biometry 261, Mathematics 171, Agriculture and Resource Management 210, Psychology 350, Industrial and Labor Relations 210 and 211).

Students interested in quantitative aspects of biology (e.g., computational, physical, population biology) are advised to satisfy the mathematics requirement with two semesters of calculus.

4) **Organic chemistry**: Chemistry 257 and 251, or 357–358 and 251, or 357–358 and 301, or 359–360 and 251, or 359–360 and 301.
5) **Physics:** Physics 207–208,* 112–213,* or 101–102. Those who take Physics 112–213 are advised to complete Physics 214 as well.
6) **Genetics:** BIOGD 281.
7) **Biochemistry:** BIOBM 330, or 331 and 332, or 333.
8) **Evolutionary Biology:** BIOES 278 or BIOPL 448.
9) **A program of study** selected from the outline below.
10) **Foreign language:** students registered in the College of Agriculture and Life Sciences must satisfy the foreign language requirement for the biology major by (a) presenting evidence of successful completion of three or more years of study of a foreign language in high school or (b) attaining a score of 560 or more on the reading portion of the College Entrance Examination Board achievement test or (c) achieving "qualification" status in a language as defined by the College of Arts and Sciences or (d) successfully completing at least 6 college credits in a foreign language. Students registered in the College of Arts and Sciences must satisfy the language requirement as stated by that college.

*Since modern biology has an important physical and quantitative orientation, students are advised to undertake basic science courses that emphasize this approach. Asterisks in the above list indicate the courses that provide this orientation, but all courses listed are acceptable.

Although not required for the biological sciences major, a course in statistics is recommended for students planning graduate study or a research career. Students should consult their faculty advisers when choosing appropriate courses in statistics.

Note: Core courses cannot count twoards the Program of Study Requirements.

Programs of Study and Requirements

As noted in the list of requirements above, students accepted into the biological sciences major must choose a program of study. The program of study requirements are designed to help students achieve depth in one area of biology while ensuring that the selected advanced courses form a coherent and meaningful unit. Because of the flexibility allowed in satisfying these requirements, students should consult their faculty advisers. The possible programs of study are listed below.

1) *Animal Physiology:* BIOAP 311, Introductory Animal Physiology, Lectures; BIOAP 313, Histology: The Biology of the Tissues; BIOAP 316, Cellular Physiology; and BIOAP 319, Animal Physiology Experimentation. The Program of Study in Animal Physiology emphasizes whole-animal, tissue, and cell physiology, and provides considerable opportunity for studies using live animals. It is intended especially for students contemplating careers in biomedical

practice or research. Advanced courses, though not required, include BIOAP 419, Advanced Animal Physiology Experimentation, which permits selected students to conduct supervised research projects of their choice, and BIOAP 458, Mammalian Physiology, which provides in-depth coverage of selected topics in mammalian and human physiology.

2) *Biochemistry:* Chemistry 300, Quantitative Chemistry; six credits of organic chemistry (Chemistry 357–358 or 359–360); a minimum of four credits of organic chemistry laboratory (Chemistry 301–302 or 251–252–302 or 301 or 251–252); four credits of biochemistry laboratory courses (BIOBM 430); and Physical Chemistry (Chemistry 389–390 or 287–288 or 287–390 or 389–288). Note that Chemistry 288 is designed for biologists. Five hours of Biochemistry are recommended (331 and 332 or 330 and 334) and students interested in graduate work in biochemistry should take Physics 207–208 and a third semester of calculus in preparation for CHEM 389–390. Be sure to complete CHEM 207–208 or 215–216 during the freshman year.

3) *Molecular and Cell Biology*. Chemistry 357–358 or 359–360; BIOBM 432, Survey of Cell Biology; 4 credits of BIOBM 430, Laboratories in Biochemistry, Molecular and Cell Biology, and at least 7 additional credits of courses that have a cell biological or molecular biological orientation. The 7 additional hours should include at least two courses from the following list (underlined courses are recommended as providing breadth in molecular and cell biology): BIOAP 619, Lipids; BIOAP 658, Molecular Mechanisms of Hormone Action; BIOBM 434, Applications of Molecular Biology; BIOBM 437, Eukaryotic Cell Proliferation; BIOBM 631, Protein Structure and Function; BIOBM 632, Membranes and Bioenergetics; BIOBM 633, Biosynthesis of Macromolecules; BIOBM 635, Mechanisms of Metabolic Regulation and Mammalian Gene Expression; BIOBM 636, Cell Biology; BIOBM 639, The Nucleus; BIO G 305, Immunology; BIOBM 407, Nature of Sensing and Response: Signal Transduction in Biological Systems; BIOGD 385, Developmental Biology; BIOGD 483, Molecular Aspects of Development; BIOGD 484, Molecular Evolution; BIOGD 486, Advanced Eukaryotic Genetics; BIOGD 682, Fertilization and the Early Embryo; BIOPL 343, Molecular Biology and Genetic Engineering of Plants; BIOPL 347, Laboratory in Molecular Biology and Genetic Engineering of Plants; BIOPL 444, Plant Cell Biology; BIOPL 641, Laboratory in Plant Molecular Biology; BIOPL 652, Plant Molecular Biology II; BIOMI 290, General Microbiology, Lectures; BIOMI 408, Viruses and Disease; BIOMI 485, Bacterial Genetics; BIOMI 692, Protein-Nucleic Acid Interactions; BIONB 222, Neurobiology and Behavior II: Introduction to Neurobiology; BIONB 325, Neurodiseases-Molecular Aspects; BIONB 425, Natural History of Ion Channels; BIONB 495, Molecular and Genetic Approaches to Neurosciences. Five hours of biochemistry are recommended (BIOBM 331 and 332 or 330 and 334). Be sure to complete CHEM 207–208 or 215–216 during the freshman year.

4) *Ecology and Evolutionary Biology:* BIOES 261, Ecology and the Environment, and 10 credits from the following course lists, including at least one course from each group:

   (a) BIOPL 241, Introductory Botany; BIOES 274, The Vertebrates: Structure, Function, and Evolution; BIOES 373, Biology of the Marine Invertebrates; BIOES 466 and 468, Physiological Plant Ecology, Lectures and Laboratory; BIOES 471, Mammalogy; BIOES 472, Herpetology; BIOES 475, Ornithology; BIOES 476, Biology of Fishes; ENTOM 212, Insect Biology.

   (b) BIOES 263, Field Ecology; BIOPL 448, Plant Evolution and the Fossil Record; BIOES 452, Herbivores and Plants: Chemical Ecology and Coevolution; BIOES 455, Insect Ecology; BIOES 456, Stream Ecology; BIOES 457 and 459, Limnology: Ecology of Lakes, Lectures and Laboratory; BIOES 461, Population and Evolutionary Ecology; BIOES 462, Marine Ecological Processes; BIOES 463 and 465, Plant Ecology and Population Biology, Lectures and Laboratory; BIOES 464, Macroevolution; BIOES 473, Ecology of Agricultural Systems; BIOES 478, Ecosystem Biology; BIOES 479, Paleobiology; BIOGD 481, Population Genetics.

Note: One 400-level, 4-credit course (including 4 credits from BIOSM 364) offered at Shoals Marine Laboratory may be applied toward the 10 credits. Students are encouraged to gain experience in some aspect of field biology through course work at a biological field station or work experience.

Note: The Ecology and Evolutionary Biology program of study offers an undergraduate specialization in Marine Biology and Oceanography. A description of this specialization can be found in the section entitled COURSES IN MARINE SCIENCE.

Note: The Organization for Tropical Studies (OTS) offers an Undergraduate Semester Abroad Program, featuring two courses in biology (Fundamentals of Tropical Biology and Field Research in Tropical Biology) and one course each in Environmental Policy and Latin American Culture. Cornell biology majors, with a concentration in Ecology and Evolutionary Biology, who complete the OTS Program as part of Cornell Abroad, can substitute the credit earned from the biology courses for two 3-credit courses at the 300 level from list (b). The OTS Program is administered through Duke University. Applications are available at Cornell Abroad, 474 Uris Hall.

5) *General Biology:* The Program of Study in General Biology requires a minimum of 13 credit hours from courses offered by the Division of Biological Sciences in addition to courses counted toward requirements 1–10 above. These 13 credits must include

   1) One course from each of the three different programs of study from among the nine other programs of study. Only those courses specifically listed as fulfilling a program of study requirement are acceptable without permission of instructor.

   2) a course with a laboratory, and

   3) a minimum of two upper-level (300 and above) courses of two or more credits each.

100-level courses are not acceptable for meeting any of these requirements. BIOPL 341 may not count as the lab course; BIO G 498 may not be used to fulfill the requirements of this program of study. BIO G 499 (minimum of 2 credits, but no more than 3 credits) may count as one of the upper-level courses, and may count as the laboratory course with approval of the adviser, but it cannot count as a course representing a program of study.

Note: It is possible to use a single course to fulfill more than one requirement. For example, BIOES 472, Herpetology, could count in all three areas: as a course in the Ecology & Evolutionary Biology program of study, as an upper level course, and as a course with a lab.

6) *Genetics and Development:* A minimum of 13 credits, usually chosen from the following courses: BIOGD 385, Developmental Biology; BIOGD 387, Developmental Aspects of Evolution; BIOGD 389, Embryology; BIOGD 480, Seminar in Developmental Biology; BIOGD 481, Population Genetics; BIOGD 482, Human Genetics and Society; BIOGD 483, Molecular Aspects of Development; BIOGD 484, Molecular Evolution; BIOGD 486, Advanced Eukaryotic Genetics; BIOMI 485, Bacterial Genetics, BIONB 493, Developmental Neurobiology; BIOPL 343, Molecular Biology and Genetic Engineering of Plants.

   Students may also choose from the following courses to complete the 13-credit requirement: BIOGD 682, Fertilization and Early Development; BIOGD 684, Advanced Topics in Population Genetics; BIOGD 687, Developmental Genetics; BIOBM 633, Biosynthesis of Macromolecules; BIOBM 639, The Nucleus; BIOES 663, Theoretical Population Genetics; BIOMI 694, Genetics of Diverse Bacteria; BIOPL 641, Laboratory in Plant Molecular Biology; BIOPL 644, Plant Growth and Development; BIOPL 652, Plant Molecular Biology II; BIOPL 653, Plant Molecular Biology I; PL BR 606, Advanced Plant Genetics.

   Up to 3 credits for this program of study may be chosen from other biological sciences courses, including BIO G 499, Undergraduate Research in Biology, with approval of the faculty adviser.

7) *Microbiology:* BIOMI 290, General Microbiology, Lectures; BIOMI 291, General Microbiology, Laboratory; BIOMI 300, Seminar in Microbiology;

and at least three courses chosen from the following: BIOMI 391, Advanced Microbiology Laboratory; BIOMI 415, Bacterial Diversity; BIOMI 416, Bacterial Physiology; and BIOMI 485, Bacterial Genetics.

8) *Neurobiology and Behavior:* The two-semester introductory course sequence, Neurobiology and Behavior I and II (BIONB 221 and 222) with discussion section (4-credits per term), and 7 additional credits. These additional credits must include a course from the neurobiology and behavior offerings (this course can NOT be BIONB 420, 720 or BIOG 499). However, BIONB 420, 720 and BIO G 499 MAY be used to supplement this neurobiology and behavior course to fulfill the 7 additional credits. Please consult with your advisor for courses that may be applied towards the 7 additional credits that are not listed in the Biological Sciences course offerings. BIO G 498 may not be used to fulfill the requirements of this program of study.

Note: Students who declare the Program of Study in Neurobiology and Behavior after taking BIONB 221 or 222 for only 3 credits must complete additional course work in neurobiology and behavior. These students should consult the chair of the Section of Neurobiology and Behavior (W363 Seeley G. Mudd Hall) to determine what course(s) to use to make up the deficiency.

9) *Plant Biology:* Students choose one area of study from the following two options:

Option (a) *Botany:* Students are required to take Introductory Botany (BIOPL 241). Students should then choose, with the aid of their faculty adviser, a minimum of three of the following courses, for a total of at least 10 additional credits, to round out their botanical training: BIOPL 242 and 244, Plant Physiology, Lectures and Laboratory; BIOPL 247, Ethnobiology; BIOPL 248, Taxonomy of Vascular Plants; BIOPL 342 and 344, Plant Physiology, Lectures and Laboratory; BIOPL 343 and 347, Molecular Biology and Genetic Engineering of Plants, Lectures and Laboratory; BIOPL 345, Plant Anatomy; BIOPL 444, Plant Cell Biology; BIOPL 445, Photosynthesis; BIOPL 447, Molecular Systematics; BIOPL 448, Plant Evolution and the Fossil Record; BIOES 463 and 465, Plant Ecology and Population Biology, Lectures and Laboratory; or BIOES 466 and 468, Physiological Plant Ecology, Lectures and Laboratory.

Option (b) *Plant Biotechnology:* Students are required to take BIOPL 343 and 347, Molecular Biology and Genetic Engineering of Plants, Lectures and Laboratory. Students choose, in consultation with their faculty adviser, a minimum of 10 additional credits from the following list: BIOPL 241, Introductory Botany; BIOPL 242 and 244, Plant Physiology, Lectures and Laboratory; BIOPL 342 and 344, Plant Physiology, Lectures and Laboratory; BIOPL 444, Plant Cell Biology; BIOPL 648, Plant Biochemistry; PL BR 401, Plant Cell and Tissue Culture; or PL BR 402, Plant Tissue Culture Laboratory.

10) *Systematics and Biotic Diversity:* A minimum of 13 credits from the following two groups, including at least 7 credits from group A, and 3 from group B; and at least two laboratory courses (marked with *). BIOG 499, Undergraduate Research in Biology, with approval of the advisor, can be used in fulfillment of up to four credits in Group A, and can count as one laboratory course if it has a laboratory component of 2 or more credits.

(a) *BIOES 274, The Vertebrates: Structure, Function, and Evolution; *BIOES 371, Human Paleontology; *BIOES 373, The Invertebrates: Form, Function, and Evolution; *BIOES 471, Mammalogy; *BIOES 472, Herpetology; *BIOES 475, Ornithology; *BIOES 476, Biology of Fishes; BIOMI 290, General Microbiology, Lectures; *BIOMI 291, General Microbiology, Laboratory; BIOMI 415, Bacterial Diversity, Lectures; *BIOPL 241, Introductory Botany; *BIOPL 243, Taxonomy of Cultivated Plants; BIOPL 247, Ethnobiology; *BIOPL 248, Taxonomy of Vascular Plants; BIOPL 343, The Healing Forest; BIOPL 645, Families of Tropical Flowering Plants—Lecture; *BIOPL 646, Families of Tropical Flowering Plants—Lab; *ENTOM 212, Insect Biology; ENTOM 215, Spider Biology: Life on a Silken Thread; *ENTOM 322, Insect Morphology; *ENTOM 331, Introductory Insect Systematics; *ENTOM 471, Freshwater Invertebrate Biology; *ENTOM 631, Systematics of the Coleoptera; PL PA 309, Introductory Mycology; *PL PA 319, Field Mycology.

(b) BIOES 464, Macroevolution; BIOES 479, Paleobiology; *BIOPL 440, Phylogenetic Systematics; BIOPL 447, Molecular Systematics; *BIOPL 448, Plant Evolution and the Fossil Record; *BIOPL 453, Historical Biogeography; BIOPL 442, Current Topics in Ethnobiology.

11) *Independent Option:* A special program for students interested in nutrition is available under this option. Students interested in courses in biophysics should contact the Office of Undergraduate Biology (200 Stimson Hall) for further information. In addition, students who want to undertake a course of study not covered by the nine existing programs of study or the special program may petition the Biological Sciences Curriculum Committee. Information on independent options and Curriculum Committee petition forms are available in the Office of Undergraduate Biology, 200 Stimson Hall.

Independent Research and Honors Program

Individual research projects under the direction of a faculty member are encouraged as an aspect of study within a program of study. Applicants for research projects are accepted by the individual faculty members, who take into account students' previous academic accomplishments, interests and goals, and the availability of space and equipment suitable for the proposed project. Students accepted for independent research enroll for credit in Biological Sciences BIO G 499, Undergraduate Research in Biology, with the written permission of the faculty supervisor. Students register for this course in 200 Stimson Hall. Any faculty member in Biological Sciences may act as a supervisor. Faculty supervisors outside Biological Sciences are acceptable only if a faculty member of Biological Sciences agrees to take full responsibility for the quality of the work. Students may not earn credit for research conducted outside of Cornell. Information on faculty research activities and undergraduate research opportunities is available in the Behrman Biology Center, 216 Stimson Hall.

Research credits may not be used in completion of the following program of study areas: animal physiology; biochemistry; cell biology; ecology and evolutionary biology; microbiology; plant biology. Up to 3 credits of research may be used to complete the program of studies in general biology, genetics and development, systematics and biotic diversity, as well as 4 credits of research in neurobiology and behavior.

The honors program in biological sciences is designed to offer advanced training in laboratory or field research through the performance of an original research project under the direct guidance of a member of the Cornell faculty. Applications for the honors program are available in the Office of Undergraduate Biology, 200 Stimson Hall, and must be submitted early in the senior year to the Honors Program Committee by the announced deadline. Application forms for the honors program are separate from the enrollment forms for BIO G 499, Undergraduate Research in Biology. To qualify for the program, students must have been accepted into the biological sciences major, have completed at least 30 credits at Cornell, and have an overall Cornell cumulative grade-point average of at least 3.00. In addition, students must have at least a 3.00 Cornell cumulative grade-point average in all biology, chemistry, mathematics, and physics courses. (Grades earned in courses in other departments that are used to fulfill major requirements are included in this computation.) In addition, candidates must have a Cornell faculty member in Biological Sciences to supervise their research. Students who select supervisors outside of Biological Sciences must arrange for a cosigner within Biological Sciences. The cosigner must agree to meet with the student on a regular basis, report to the Honors Program Committee on the progress of the work approximately two months before the thesis is due, and to serve as a reviewer of the thesis. An honors candidate usually enrolls for credit in BIO G 499, Undergraduate Research in Biology under the direction of the faculty member acting as honors supervisor, although it is not necessary. Students choosing to earn credit for honors research must enroll in BIO G 499, Undergraduate Research in Biology, separately from the honors program. Requirements of the honors program include participation in honors research seminars during two semesters, submission of an acceptable honors thesis, completion of all major requirements, and maintenance of the 3.00 Cornell cumulative grade-point average through graduation. Recommendation to the faculty that a

candidate graduate with honors and at what level of honors is the responsibility of the Honors Program Committee. The student's final grade point average is a factor in determining the level of honors recommended.

Students interested in the honors program should consult their faculty advisers early during their junior year. Students are strongly encouraged to begin their research projects in their junior year, although they are not formally admitted to the honors program until the beginning of their senior year. Students who are considering study abroad during their junior year should consult with a member of the Honors Committee during their sophomore year to plan a reasonable schedule for honors research. The Honors Program requires that student participants attend honors seminars in which they give oral presentations during the first and second semesters of their senior year. Therefore, students who are considering studying away from campus during their senior year should consult with a member of the Honors Committee no later than the beginning of the first semester of their junior year. Details pertaining to thesis due dates, seminars, and other requirements may be obtained from the Office of Undergraduate Biology, 200 Stimson Hall. Information on faculty research activities is available in the Behrman Biology Center, 216 Stimson Hall. Deviation from any of the requirements of the Honors Program requires a petition in the form of a letter to the Honors Program Committee, c/o Registrar, Office of Undergraduate Biology, 200 Stimson Hall.

CURRICULUM COMMITTEE

Many decisions pertaining to the curriculum, to division-wide requirements, and to the programs of study are made by the Biological Sciences Curriculum Committee. The committee consists of faculty and elected student members and welcomes advice and suggestions from all interested persons.

ADVISING

Students in need of academic advice are encouraged to consult their advisers, come to the Behrman Biology Center (216 Stimson Hall) or the Office of Undergraduate Biology, 200 Stimson Hall.

Students interested in marine biology should visit the Cornell Marine Programs Office, G14 Stimson Hall.

Students interested in the multidisciplinary program of Biology and Society should see "Special Programs and Interdisciplinary Studies," in the College of Arts and Sciences section of this catalog.

INDEX OF COURSES

The following course identifiers are used to denote biological sciences courses in specific areas: General Courses, BIO G; Animal Physiology, BIOAP; Biochemistry, Molecular and Cell Biology, BIOBM; Ecology and Systematics, BIOES; Genetics and Development, BIOGD; Microbiology, BIOMI; Neurobiology and Behavior, BIONB; Plant Biology, BIOPL; Shoals Marine Laboratory, BIOSM.

Note: Biological sciences ("BIO") courses count as agriculture and life sciences credits for students in the College of Agriculture and Life Sciences and as arts and sciences credits for students in the College of Arts and Sciences.

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GENERAL COURSES (BIO G)

Biological Sciences teaches three introductory biology course sequences during the academic year: BIO G 101–104, BIO G 105–106, and BIO G 109–110; and one during the eight-week summer session: BIO G 107–108, BIO G 101–104, 105–106, and 107–108 are intended for biological sciences majors and other students needing 8 credits from an introductory sequence for majors (for example, students in a premedical curriculum). Any of these sequences meet the prerequisite for upper-level courses listing "one year of introductory biology for majors" as a prerequisite. BIO G 109–110 is a course sequence intended for non-majors, and meet the prerequisite for many, but not all, upper-level courses listing "one year of introductory biology" as a prerequisite. Students can earn a maximum of 8 credits in introductory biology (including advanced placement credits).

BIO G 101–102 Biological Sciences, Lectures

101, fall; 102, spring. 2 credits each term. Prerequisite: concurrent enrollment in BIO G 103 (fall) or 104 (spring). Passing grade (D or better) in 101 is prerequisite to 102 unless permission is obtained from instructor. May not be taken for credit after BIO G 105–106 or 109–110. S-U grades optional, with permission of instructor. Lecs, M W F 9:05 or 10:10. 2 lecs each week; to accommodate these, students must reserve all 3 days. Evening prelims: fall, Sept. 23 and Nov. 9; spring, Feb. 24 and Apr. 6. C. D. Hopkins.

Designed both for students who intend to specialize in biological sciences and for those who want to obtain a thorough knowledge of biology as part of their general education. The fall semester covers the chemical and cellular basis of life, energy transformations, physiology, neurobiology, and behavior. The spring semester covers genetics, development, evolution, and ecology. Each topic is considered in the light of modern evolutionary theory and discussions of plant and animal systems are integrated. For those students who object to animal dissection, alternative materials are available for study. However, testing will involve identification of important structures in real organisms.

BIO G 103–104 Biological Sciences, Laboratory

103, fall; 104, spring. 2 credits each term. Prerequisite: concurrent enrollment in BIO G 101 (fall) or 102 (spring). 103 is prerequisite to 104 unless permission is obtained from instructor. No admittance after second week of classes. S-U grades optional, with permission of instructor. Lab, M T W or R 1:25–4:25, M or W 7:30–10:30 p.m., or T R or S 8–11. One 3-hour lab each week and a weekly lec for discs, special lecs, etc. J. C. Glase, P. R. Ecklund, and staff.

BIO G 103–104 is designed to provide laboratory experience with major biological phenomena in order to support an understanding of the important concepts, principles, and theories of modern biology. A second objective of the laboratory course is to help students gain expertise in the methods used by biologists to construct new knowledge. Students are exposed to basic concepts, research methods, including laboratory and data transformation techniques, and instrumentation in the major areas of biology. First-semester topics include biochemistry, physiology, plant biology, and behavior. In the second semester, laboratory experience is provided in the areas of genetics, biotechnology, immunology, invertebrate diversity, population plant growth and development, and ecology. During the first semester, dissection of a doubly-pithed frog is included. Pithing is done by the instructor. Dissection of several invertebrates occurs during the second semester. For those students who object to animal dissection, alternative materials are available for study. However, testing will involve identification of important structures in real organisms.

BIO G 105–106 Introductory Biology

105, fall; 106, spring. 4 credits each term (or 2 credits, with permission of instructor). Enrollment limited to 200 students. Prerequisite: 105 is prerequisite to 106, unless written permission is obtained from instructor. May not be taken for credit after BIO G 101–104 or 109–110. No admittance after first week of classes. Estimated cost for dissection kit, $11. S-U grades optional, with permission of instructor. Lec, T 9:05 (1st lec of fall term, R 8/26 9:05); additional study and lab hours to be arranged. C. H. McFadden and staff.

Designed primarily for biology majors, preprofessionals, and other students who desire a challenging, broad introduction to fundamental concepts of biology. Cell biology, physiology, anatomy (accompanied by preserved vertebrate dissection), and biochemistry are strongly emphasized in the fall semester. Subjects in the spring semester are genetics, development, ecology, evolution, behavior, and the diversity of organisms (accompanied by preserved and live invertebrate dissection). Students who plan to concentrate in anatomy and physiology should consider taking this course because of the strong emphasis on organismal biology. Because some testing involves the use of pre-dissected specimens, students who object to dissections should take BIO G 101–104. The course uses an autotutorial format and offers considerable flexibility in scheduling. Completion of the course requires mastery of a group of core units. Testing on these units is primarily by oral examination. Students who elect to take the course must be able to meet deadlines. Four formal laboratory sessions are offered each semester; additional laboratory work is included in the core units. Evaluation is based on written reports on experimental work, practical exams, and a comprehensive final exam.

BIO G 107–108 General Biology

Summer (8-week session; 107, weeks 1–4; 108, weeks 5–8). 4 credits each. Prerequisite: one year of college or permission of instructor; BIO G 101–103, 105, or 107 is a prerequisite for 108. Fee, $25 for weeks 1–4; $15 for weeks 5–8. Lecs, M-R 9–12; labs, M T R 1:30–4:30, F 9–12. Staff.

Designed for students who plan further study in biology and for students who want a broad course in biology as part of their general education. BIO G 107 covers biological metabolism, first at the molecular level and then progressively to the organ system level. The laboratory work involves an introduction to some major techniques, vertebrate dissection, and a survey of plant organization. BIO G 108 seeks to integrate the topics of genetics, developmental biology, population

biology, and ecology in a general consideration of biological evolution. The laboratory work is a continuation of the material covered in BIO G 107 and involves more techniques, a survey of animal organization, and the design and performance of a field study. BIO G 107–108 fulfills the introductory biology requirement for majors and forms a suitable introductory biology course sequence for students intending to go to medical school. For those students who object to animal dissection, alternative materials are available for study. However, testing will involve identification of important structures in real organisms.

BIO G 109–110 Biological Principles
109, fall; 110, spring. 3 credits each term. Limited to 600 students. A passing grade in 109 or 101–103 or 105 is prerequisite to 110 unless *written* permission is obtained from the *instructor* and the student has at least 3 credits of college biology. Since 109–110 together constitute an integrated survey, 109 cannot be used to satisfy the College of Arts and Sciences or College of Agriculture and Life Sciences distribution requirement unless it is followed by 110 or an exemption is obtained from the instructor. May not be taken for credit after BIO G 101–104 or 105–106. This course sequence may be used to fulfill the distribution requirement in the Colleges of Agriculture and Life Sciences, Arts and Sciences, and Human Ecology but may *not* be used as an introductory course for the major in biological sciences. *Note that this course satisfies the prerequisite for many, but not all second- and third-level courses in biology.* Letter grade only. Lecs, M W F 9:05 or 10:10; lab, M T W R or F 2–4:25 or T 10:10–12:35. Students do not choose lab sections during course enrollment; lab assignments are made during first day of classes. Each student must attend lab on alternate weeks. Evening prelims: fall, Sept. 23 and Nov. 9; spring, Feb. 24 and Apr. 4. A. Blackler, R. Turgeon, H. Greene, C. Eberhard, and staff.

Students who do not plan to major in biology may take this broad introductory course in modern biology. The content is designed to appeal to anyone who seeks a comprehensive knowledge of biology as part of a general education. Laboratory sections enable small groups of students to meet with the course staff and are used for problem-solving experiments, demonstrations, and discussions. No live dissections are involved; there are dissections of vertebrate, invertebrate and plant material. For those students who object to dissection, alternative materials are available for study and there is no grade penalty for omitting or observation of animals. Testing, for students choosing to be tested, will involve identification of important structures in real organisms.

BIO G 170 Evolution of the Earth and Life (also GEOL 102)
Spring. 3 credits. S-U grades optional. Lecs, T R 9:05 or 11:15; lab, T W or R 2:00–4:25; field trips during lab. J. L. Cisne.

Earth systems and their evolution. Earth history's astronomical context. Plate tectonics, continental drift, and their implications for climate and life. Coevolution of life and the atmosphere. Precedents for ongoing global change. Dinosaurs; mass extinctions; human ancestry. Laboratories on reconstructing geological history and mapping ancient geography. Fossil-collecting on field trips.

BIO G 200 Special Studies in Biology
Fall, spring, or summer. 1–3 credits. Prerequisites: transfer- or special-student status and written permission from the Office of Undergraduate Biology. Students must register in 200 Stimson Hall. S-U grades optional, with permission of instructor. Hours to be arranged. Staff.

A registration device for students who want to take only a portion of a regular biological sciences course—for example, only the lectures or only the laboratory in a course that includes both. Only students who have already had training equivalent to the portion of the regular course that is to be omitted may register in this manner. This course may not be substituted for 100–level courses and may not be used in fulfillment of college distribution requirements except by permission from the Office of Undergraduate Biology

[BIO G 202 The Diversity of Life
Fall. 3 credits. S-U grades optional. Lecs, M W F 2:30. Not offered 1999–2000. J. I. Davis, J. J. Doyle, E. Rodriguez.

The main focus of this course is on the diversity of living and extinct species. This diversity is examined from an evolutionary perspective, with attention to the principles employed in the discovery of species and in the analysis of relationships among them. Interactions between humans and other species are examined during the latter portion of the semester.]

BIO G 207 Evolution (also HIST 287 and S&TS 287)
Fall or summer. 3 credits. Intended for students with no background in college biology. May not be taken for credit after BIOES 278. Does not meet the evolutionary biology requirement for the biological sciences major. S-U grades optional. Fall: Lecs, T R 10:10; disc, 1 hour each week to be arranged. W. B. Provine. Summer (3-week session) (also S&TS 287). Lecs/disc, M-F 9:30–10:45 and 1:00–2:15. A. S. Kondrashov.

Evolution is the central concept in biology. This course examines evolution in historical and cultural contexts. This course aims to understand the major issues in the history and current status of evolutionary biology, and explore the implications of evolution for culture. Issues range from controversies over mechanisms of evolution in natural populations to the conflict between creationists and evolutionists.

BIO G 209 Introduction to Natural Science Illustration
Summer (6-week session). 2 credits. Limited to 12 students. Prerequisite: freehand drawing or permission of instructor. S-U grades optional. Lecs and labs, T R 6:30–9:30 p.m. B. S. King.

An introduction to the art of natural science illustration for publication, and to the techniques of various media including pencil, pen and ink, watercolor, colored pencil, scratchboard, and carbon dust. Potentials and limitations of line and half-tone reproduction, copyright, and portfolio presentation are discussed.

BIO G 305 Basic Immunology Lectures (also VETMI 315)
Fall. 3 credits. Strongly recommended: basic courses in microbiology, biochemistry, and genetics. S-U grades optional, with permission of instructor. Lecs, T R 8:30–9:55. J. A. Marsh.

A survey of immunology, with emphasis on the biological functions of the immune response.

BIO G 320 Principles of Toxicology (also VETMI 320)
Spring. 3 credits. Prerequisites: 1 year each of introductory biology and chemistry, with lab; 1 semester of organic chemistry lecture or waiver by instructor. Lec T R 1:25–2:40. S. Penningroth, R. Dietert, and S. Bloom.

An introduction to the interdisciplinary science of toxicology is presented, including selected material from biology, chemistry, ecology and pharmacology. Basic principles are illustrated by examining several "toxicological contexts," for example, DDT toxicity to wildlife reproduction. Risk management is introduced as a new discipline in which regulatory agencies integrate science-based quantitative risk assessment with economic and social considerations to implement politically acceptable cleanups at hazardous chemical waste sites. Students form teams and present toxicological analyses of hypothetical "risk scenarios," recommending acceptable risk management strategies in response to environmental contamination. Occasional research talks by toxicology faculty introduce students to basic research in this interdisciplinary branch of Biological Science.

This is an introductory level course in toxicology. The format is lecture, supplemented by case examples. It is appropriate for non-majors seeking basic literacy in environmental and human toxicology. It also serves as a "gateway course" for students interested in 400- and 600-level toxicology courses.

BIO G 400 Undergraduate Seminar in Biology
Fall or spring. Variable credit (1–3 credits assigned for individual seminar offerings). May be repeated for credit. S-U grades optional. Sem to be arranged. Staff.

From time to time specialized seminars on topics of interest to undergraduates are offered by visiting faculty or faculty from the Sections of Ecology and Systematics, Genetics and Development, or Plant Biology. Topics and instructors are listed in the division's catalog supplement issued at the beginning of the semester. For students interested in Biochemistry, Physiology, or Neurobiology, please see descriptions under appropriate section.

Section 02 Development and Evolution (also BIOGD 480, BIOES 760–02, and BIOGD 780)
Fall*. 2 credits. Prerequisites: BIOGD 281 and BIOES 278. S-U grades only. Lecs and Discs T 12:20–2:25 p.m. Students will also be required to attend five seminars on M 4:00–5:30 p.m. M. Wolfner, A. McCune.

Five leading international experts will describe recent advances in data and theory at the intersection of developmental biology and evolutionary biology. Topic coverage will center around pattern formation and the origin of metazoan body plans. During the Tuesday class meeting prior to each expert's visit,

students and course faculty will present and discuss recent papers by the upcoming speaker. The following week, students will be required to attend the speaker's seminar on Monday at 4:00 p.m. and then meet with the speaker during class on the following day for continued discussion of the topic.

*Fall 1999 is the only time that this special course will be offered, at least in this seminar-coupled format. Graduate students should register for BIOES 760 or BIOGD 780; undergraduates should register for BIO G 400 or BIOGD 480.

BIO G 401 Introduction to Scanning Electron Microscopy
Fall or spring, weeks 1–8. 1 credit. Limited to 8 students (fall), 12 students (spring). S-U grades optional. Lec, M 10:10; lab, T R or F 9:05–12:15 or T W or R 1:25–4:25. Fee may be charged. M. V. Parthasarathy.
An introductory course that includes the principle and use of the scanning electron microscope. Students use biological material to explore and understand some of the fine biological architecture. In addition to preparing the specimens, the students use the scanning electron microscope to study and obtain micrographs of features that interest them.

BIO G 403 Transmission Electron Microscopy for Biologists
Fall. 1, 3, or 4 credits (4 credits if student takes both sections). Limited to 12 students. Prerequisites: BIOAP 313, BIOPL 345 or 443. S-U grades optional. Lec, T 11:15; labs, M W or T R 1:25–4:25. Two sections: Sec 01, 1 credit, weeks 1–4; sec 02, 3 credits, weeks 5–12. Students may register for one or both sections. Fee may be charged. M. V. Parthasarathy.
Section 01, 1 credit, weeks 1–4, covers the principles and use of the transmission electron microscopy (TEM), with emphasis on proper operation of the instrument and interpretation of images obtained. Negatively stained materials are used for viewing with the transmission electron microscope. Section 02, 3 credits, weeks 5–12, covers the principles and techniques of preparing biological material for transmission electron microscopy. Using animal, plant, and microbe materials this section studies chemical fixtures, cryofixations, ultrathin sectioning, immunogold localization, quantitative microscopy, and metal shadowing techniques. Students have two additional weeks to complete laboratory assignments at the end of each section.

BIO G 405 Biology of the Neotropics
Fall. 2 credits. Prerequisite: introductory biology (majors, non-majors, or equivalent), or permission of instructor. S-U grades optional. Sem, W 7:30–9:30 p.m. P. H. Wrege, A. S. Flecker.
This seminar is an introductory survey of the biology of the New World tropics, with primary focus on moist lowland forests. The objectives are to learn the basic characteristics and phenomena important to understanding neotropical biology, to gain firsthand knowledge of the resources in tropical biology available at Cornell, and to learn how to organize and execute a meaningful seminar presentation.

BIO G 408 Presentation Skills Biologists
Spring. 1 credit. Prerequisites: previous research experience. Preference given to students accepted into the Honors Program. L. Southard and G. Hess.
This course will cover oral and written communication skills used in presenting research to other scientists. Topics covered will include organization of scientific papers, presentation tips for research seminars, and preparation of visual aids using Power Point. All students will present a 10-minute seminar on their research and will evaluate other presentations.

BIO G 410 Teaching Contemporary Biology
Fall. 3 credits. Prerequisite: one year introductory biology; permission of instructor. L. Southard and S. Merkel.
This course provides students with the opportunity to experience teaching high school science. Students will concentrate on a topic of current public interest, then develop teaching plans appropriate for high school students. The first part of the course consists of lectures, discussion, and laboratory experiments, which will familiarize the students with the scientific content of the course. Students will then work in teams with high school teachers to develop their presentations. The final part of the course will include practice presentations and teaching at regional high schools.

BIO G 431 Frontiers in Biophysics
Fall. 1/2 credit. S-U grades only. Lec to be arranged. G. Feigenson and staff.
A day of lectures on Saturday 9/25 giving an overview of current research in biophysics at Cornell by faculty from different departments across the university. Designed for undergraduates who are considering a career in biophysics and for graduate students who are interested in biophysics research opportunities at Cornell.

BIO G 450 Light and Video Microscopy for Biologists
Spring. 3 credits. Limited to 12 students. Prerequisites: one year of introductory biology and permission of instructor. Lecs, T R 1:25–2:30; lab, R 2:30–4:30. R. O. Wayne.
Theoretical and practical aspects of light microscopy, including brightfield, darkfield, phase-contrast, polarization, Hoffman-modulation contrast, interference, differential-interference contrast, and fluorescence microscopy, as well as video- and computer-based digital image enhancement, are studied. Students learn both qualitative and quantitative techniques to probe noninvasively the structure and function of living plant cells.

BIO G 467 Seminar in the History of Biology (also HIST 415, B&SOC 447, and S&TS 447)
Summer (6-week session). 4 credits. Limited to 18 students. S-U grades optional. W. B. Provine.
Specific topic changes each year.

[BIO G 469 Food, Agriculture, and Society (also B&SOC 469 and S&TS 469)
Spring. 3 credits. Limited to 20 students. Prerequisite: an introductory ecology course or permission of instructor. S-U grades optional. Lecs, T R 1:25–2:40. Not offered 1999–2000. A. G. Power.
A multidisciplinary course dealing with the social and environmental impact of food production in the United States and developing countries. Agroecosystems of various kinds are analyzed from biological, economic, and social perspectives. The impacts of traditional, conventional, and alternative agricultural technologies are critically examined in the context of developed and developing economies. Specific topics include pest management, soil conservation, plant genetic resources, biotechnology, and sustainable development.]

BIO G 498 Teaching Experience
Fall or spring. 1–4 credits. Enrollment limited. Prerequisites: previous enrollment in the course to be taught or equivalent. *Arts students may not count this course toward graduation. They may, however, upon petition to their class dean, carry fewer than 12 other credits and remain in good standing. This would affect Dean's List eligibility, but not eligibility for graduating with distinction.* S-U grades optional, with permission of instructor. Hours to be arranged. Staff.
Designed to give qualified undergraduate students teaching experience through actual involvement in planning and assisting in biology courses. This experience may include supervised participation in a discussion group, assisting in a biology laboratory, assisting in field biology, or tutoring. Biological sciences courses currently offering such experience include BIO G 105–106; BIOAP 311, 313, 319; BIOBM 330, 331; BIOES 274, 475; and BIOMI 291, 292.

BIO G 499 Undergraduate Research in Biology
Fall or spring. Variable credit. *Students in the College of Arts and Sciences may not register for more than 6 credits per term with one supervisor or 8 credits per term with more than one supervisor.* Prerequisite: written permission of staff member who supervises the work and assigns the grade. *Students must register in the Office of Undergraduate Biology in 200 Stimson Hall.* Each student must submit an independent study statement describing the proposed research project during course registration. (Applications are available in the college offices and in 200 Stimson Hall.) Any faculty member in Biological Sciences may act as a supervisor. Cornell faculty supervisors outside Biological Sciences are acceptable only if a faculty member of Biological Sciences agrees to serve as cosigner, taking full responsibility for the quality of the work. Supervisors outside of Cornell are not acceptable. S-U grades optional. Hours to be arranged. Staff.
Practice in planning, conducting, and reporting independent laboratory and library research programs. Research credits may *not* be used for completion of the following programs of study: animal physiology; biochemistry; cell biology; ecology and evolutionary biology; microbiology; plant biology. Up to 3 credits of research may be used to complete the Program of Studies in general biology and genetics and development, and 4 credits of research in neurobiology and behavior.

BIO G 705 Advanced Immunology Lectures (also VETMI 705)
Spring. 4 credits. Prerequisite: BIO G 305 or permission of instructor. Offered alternate years. Next offered spring 2002. Lecs, M W F 9:05. Coordinator: R. G. Bell.

Coverage at an advanced level of molecular and cellular immunology.

[BIO G 706 Immunology of Infectious Diseases and Tumors (also VETMI 719)
Spring. 2 credits. Prerequisite: BIO G 305 or permission of instructor. S-U grades optional, with permission of instructor. Lec, R 10:10–12:05. Offered alternate years. Next offered spring 2001. Coordinator: R. G. Bell.
Coverage at an advanced level of the immunology of diseases caused by selected viruses, protozoa, and helminthis, and tumor immunology.]

Related Courses in Other Departments

The Sea: An Introduction to Oceanography (Biological Sciences [BIOES] 154)

Medicine and Civilization (Biology and Society 322)

Pathogenic Bacteriology and Mycology (Biological Sciences [BIOMI] 404 and Veterinary Microbiology 318)

Viruses and Disease (Biological Sciences [BIOMI] 408 and Veterinary Microbiology 408)

ANIMAL PHYSIOLOGY (BIOAP)

BIOAP 212 Human Physiology for Non-Biology Majors
Spring. 3 credits. May not be taken for credit after BIOAP 311. Limited to 130 students. This course may be used toward the science distribution requirement of the College of Arts and Sciences and the Group B distribution requirement of the College of Agriculture and Life Sciences. This course may not be used to fulfill the requirements of any program of study in the biological sciences major. Lecs, M W F 1:25; disc, M W or F 2:15. Evening prelims: March 2 and Apr. 13. P. W. Concannon and staff.
Introduction to the physiology of all major organ systems and the relation of that physiology to human health and disease. Emphasis on understanding of major body functions and control mechanisms regulating each organ system. Students develop a fundamental understanding of how their bodies work that will be the basis of making informed decisions about their own health and medical needs and those of their families. Taught by staff of research physiologists and cooperating physicians.

[BIOAP 214 Biological Basis of Sex Differences (also B&SOC 214 and WOMNS 214)
Fall. 3 credits. Limited to non-biology majors and freshman, sophomore, and junior biology majors; senior biology majors may register with permission of instructor. Prerequisite: one year of introductory biology. S-U grades optional. Lecs, T R 8:30–9:55. Offered alternate years. Not offered fall 1999. J. E. Fortune.
The structural and functional differences between the sexes are examined. Emphasis is placed on mechanisms of mammalian reproduction; where possible, special attention is given to studies of humans. Current evidence on the effects of gender on nonreproductive aspects of life (behavior, mental, and physical capabilities) is discussed. The course is intended to provide students with a basic knowledge of reproductive endocrinology and with a basis for objective evaluation of sex differences in relation to contemporary life.]

BIOAP 311 Introductory Animal Physiology, Lectures (also VETPH 346)
Fall. 3 credits. Prerequisites: one year of college biology, chemistry, and mathematics. Recommended: previous or concurrent course in physics. S-U grades optional, with permission of instructor. Lecs, M W F 11:15. Evening prelims: Sept. 28 and Oct. 28. E. R. Loew and staff.
A general course in animal physiology emphasizing principles of operation, regulation, and integration common to a broad range of living systems from the cellular to the organismal level. Structure/function relationships are stressed along with underlying physico-chemical mechanisms.

BIOAP 312 Farm Animal Behavior (also ANSC 305)
Spring. 2 credits. Prerequisites: introductory course in animal physiology. Recommended: at least one animal production course or equivalent experience. S-U grades optional. Lecs, T R 11:15. E. A. Oltenacu, K. A. Houpt.
The behavior of production species (avian and mammalian) influences the success of any management program. Students study behaviors relating to communication, learning, social interactions, reproduction, and feeding of domestic animals, and their physiological basis. Management systems for commercial livestock production and their implications for animal behavior and welfare are stressed.

BIOAP 313 Histology: The Biology of the Tissues
Fall. 4 credits. Prerequisite: one year of introductory biology. Recommended: BIOBM 330 or 331, or their equivalents; and previous or concurrent enrollment in BIOAP 311. S-U grades optional, with permission of instructor. Lecs, T R 1:25; labs, T R 2:30–5:00. Evening prelims: Oct. 1 and Nov. 5. C. Wahl.
Provides students with a basis for understanding the microscopic, fine-structural, and functional organization of vertebrates, as well as methods of analytic morphology at the cell and tissue levels. Dynamic interrelations of structure, composition, and function in cells and tissues are emphasized. The course may include work with vertebrate animals.

BIOAP 316 Cellular Physiology
Spring. 4 credits. Limited to 72 students, with preference given to students studying in animal physiology. Each lab limited to 36 students. Prerequisite: concurrent or previous enrollment in BIOBM 330 or 331 and 332 or 333. Lecs, M W F 9:05; lab, M or T 1:25–5:00. Evening prelims: Feb. 29, Apr. 6, and May 2. A. Quaroni and staff.
Lectures introduce students to the most current information on the way cells function and regulate themselves and neighboring cells and on what molecules are involved in these regulatory processes. Laboratories provide an introduction to cell and organ culture and to immunological techniques used to study cell structure and function *in vivo* and *in vitro*. Experiments performed in the laboratory are closely related to, and provide practical experience with, subjects covered in the lectures. Vertebrate animals are used in this course. No experimentation is performed on live animals.

BIOAP 319 Animal Physiology Experimentation
Fall. 4 credits. Designed for upper-level undergraduate and graduate students studying in physiology, and other students interested in biomedically related professions. Graduate students in the Field of Physiology and related fields without equivalent background are strongly encouraged to enroll. Each of 2 afternoon laboratory sections is limited to 40 students. Prerequisite: concurrent or previous enrollment in BIOAP 311 or permission of instructor. Lec, R 12:20; lab, M or W 12:20–5:00 (includes disc section). R. A. Corradino.
A series of student-conducted *in vitro* and *in vivo* experiments designed to illustrate basic physiological processes in animals, with emphasis on relevance to humans, and to introduce students to physiology research techniques, instrumentation, experimental design, and interpretation of results. Techniques include anesthesia, surgical procedures, vivisection under anesthesia, and real-time computer recording and analysis of data. Experiments with living tissues and live animals examine properties of blood, muscle, and nerves; cardiovascular, respiratory, and renal function and their control; and endocrine regulation of renal, cardiovascular, and reproductive tissue activity. Experimental resources include live animals, frogs, rats, and rabbits, which are euthanized after the laboratory exercises. Written reports of laboratory activities are required. Grading is based on evaluation of these reports, take-home case studies, laboratory performance, and weekly quizzes.

BIOAP 419 Advanced Animal Physiology Experimentation
Spring. 3 credits. Prerequisite: BIOAP 319 previous semester or permission of instructor. Limited to 12 students selected on the basis of project proposals. Lab to be arranged. Coordinator and adviser: R. A. Corradino.
Advanced research on selected aspects of laboratories conducted in BIOAP 319, Animal Physiology Experimentation. Close supervision is provided.

BIOAP 458 Mammalian Physiology
Spring. 3 credits. Enrollment limited. Graduate student auditors allowed. Prerequisite: BIOAP 311 or equivalent. Students not meeting this prerequisite must obtain written permission of instructor in T8 014 Vet Research Tower before the first class. Lecs, M W F 10:10. Evening prelims: Feb. 22, Mar. 28, and Apr. 18. K. W. Beyenbach and staff.
The course offers an in-depth treatment of selected topics in mammalian and human physiology. Emphasis is on concepts and a working knowledge of physiology. Selected topics include: basic functional elements of biological systems; recurrent themes in physiology; design of multicellular animals; mammalian fluid compartments; homeostasis; membrane and epithelial transport; electrophysiology; cardiovascular physiology, gastrointestinal physiology; renal physiology; and acid/base physiology. The lectures incorporate clinical correlations whenever appropriate. Occasional guest lecturers talk about work and careers in basic research and/or clinical medicine. Recommended for biological sciences majors, pre-med and pre-vet students, and beginning graduate students in physiology, nutrition, and animal science.

BIOAP 619 Lipids (also NS 602)
Fall. 2 credits. Lecs, T R 11:15. A. Bensadoun.
Advanced course on biochemical, metabolic, and nutritional aspects of lipids. Emphasis is placed on critical analysis of current topics in lipid methodology; lipid absorption; lipoprotein secretion, molecular structure, and catabolism; molecular biology, function and regulation of lipoprotein receptors; mechanism of hormonal regulation of lipolysis and fatty acid synthesis; and cholesterol metabolism and atherosclerosis.

BIOAP 658 Molecular Mechanisms of Hormone Action
Spring. 2 credits. Prerequisite: permission of instructor. Minimum enrollment of 6 students registered for credit required. Letter grade only. Offered alternate years. Lecs, T R 10:10. R. A. Corradino.
An advanced course developed from the current literature on general endocrine mechanisms. Primarily a lecture course with student discussion.

BIOAP 710–718 Special Topics in Physiology
Fall or spring. 1 or 2 credits for each topic. May be repeated for credit. Enrollment in each topic may be limited. S-U grades optional, with permission of instructor. Lectures, laboratories, discussions, and seminars on specialized topics. Four topics offered fall 1999; topics to be offered announced for spring 2000.

BIOAP 711 Readings in Applied Animal Behavior
Fall. 1 credit. Prerequisite: BIOAP 311 or equivalent. Offered alternate years. Lec, 1 hour each week to be arranged. K. A. Houpt.

[BIOAP 712 Thermoregulation and Exercise
Fall. 1 credit. Offered alternate years. Not offered 1999–2000. D. Robertshaw.
An examination of the competing demands on the body of exercise and heat exposure with particular emphasis on the cardiopulmonary system and integration of thermoregulatory reflexes.]

[BIOAP 713 The Physiological Control Systems That Control Ingestive Behavior: Food and Water Intake
Fall. 1 credit. Not offered fall 1999. T. R. Houpt.
A variety of species will be considered with emphasis on common mammalian species: rat, dog, goat, pig, horse, and human. A mixed lecture/seminar format will be used.]

BIOAP 715 Stress Physiology: To Be Discussed as Part of Animal Welfare
Fall. 1 credit. Prerequisite: BIOAP 311 or equivalent required. Offered alternate years. K. A. Houpt.
The emphasis will be on physiological assessment of stress.

BIOAP 719 Graduate Research in Animal Physiology (also VETPH 628)
Fall or spring. Variable credit. Prerequisites: written permission of the section chair and of the staff member who supervises the work and assigns the grade. Students must register in Vet Research Tower 825. S-U grades optional. Hours to be arranged. Staff.
Similar to BIO G 499 but intended for graduate students who are working with faculty members on an individual basis.

BIOAP 757 Current Concepts in Reproductive Biology
Fall. 3 credits. Limited to 20 students. Prerequisites: undergraduate degree in biology and a strong interest in reproductive biology. S-U grades optional. Lec/disc, T R 10:10–12:05. Offered alternate years. J. E. Fortune, W. R. Butler, and staff.
A team-taught survey course in reproductive physiology/endocrinology. Lectures by a number of reproductive biologists on various aspects of male reproductive function (endocrine regulation, testis function, spermatogenesis, and sperm physiology/function); female reproductive function (endocrinology, ovarian development and functions, oocyte physiology/function); fertilization and early embryo development; pregnancy; parturition; puberty; and reproductive technology. Student participation in the form of discussions and/or presentations.

BIOAP 811 Advanced Physiological Methods I
Fall. 2 credits. Enrollment limited. Prerequisites: graduate student status or permission of course coordinator. S-U grades only. Lab to be arranged. Coordinator: J. Ray.
This is a course primarily for graduate students in physiology and related disciplines. Experiments are carried out in the laboratories of physiology faculty members to acquaint graduate students with the latest techniques/methods in physiological research. Three modules are offered each semester by arrangement with the course coordinator.

BIOAP 812 Advanced Physiological Methods II
Spring. 2 credits. Enrollment limited. Prerequisites: graduate student status or permission of course coordinator. S-U grades only. Lab to be arranged. Coordinator: J. Ray.
This is a course primarily for graduate students in physiology and related disciplines. Experiments are carried out in the laboratories of physiology faculty members to acquaint graduate students with the latest techniques/methods in physiological research. Three modules are offered each semester by arrangement with the course coordinator.

Related Courses in Other Departments

Adaptations of Marine Organisms (Biological Sciences [BIOSM] 413)

Advanced Work in Animal Parasitology (Veterinary Microbiology 737)

Animal Development (Veterinary Anatomy 507)

Animal Reproduction and Development (Animal Science 300)

Developmental Biology (Biological Sciences [BIOGD] 385)

Embryology (Biological Sciences [BIOGD] 389)

Fundamentals of Endocrinology (Animal Science 427)

Insect Morphology (Entomology 322)

Integration and Coordination of Energy Metabolism (Biological Sciences [BIOBM] 637 and Nutritional Sciences 636)

Neuroanatomy (Veterinary Anatomy 504)

Sensory Function (Biological Sciences [BIONB] 492)

Teaching Experience (Biological Sciences [BIO G] 498)

Undergraduate Research in Biology (Biological Sciences [BIO G] 499)

BIOCHEMISTRY, MOLECULAR AND CELL BIOLOGY (BIOBM)

BIOBM 132 Orientation Lectures in Biochemistry
Spring, weeks 1–3. No credit. Primarily for freshmen, sophomores, and transfer students. S-U grades only (registered students receive an unsatisfactory grade for nonattendance). Lec, S 10:10–11:00, for first three S of semester. Section chair and staff.
Discussions by six professors about their research and promising areas for research in the future.

BIOBM 233 Introduction to Biomolecular Structure
Fall. 2 credits. Limited to 30 students. Prerequisites: CHEM 207–208 or equivalents. Lecs, T R 2:30–3:20. S. E. Ealick.
This course is intended for students with a basic understanding of chemistry who are considering a program of study in biochemistry. The interrelationship between the structure and function of biologically important molecules are explored. Emphasis is placed on understanding the way in which the three-dimensional arrangements of atoms determine the biological properties of both small molecules and macromolecules such as proteins and enzymes. The study of molecular structure is aided by interactive computer graphics for visualizing three-dimensional structures of molecules.

BIOBM 330–332 Principles of Biochemistry
Introductory biochemistry is offered in three formats: individualized instruction (330) and lectures (331 and 332) during the academic year and lecture (333) during the summer. *Individualized instruction is offered to a maximum of approximately 250 students each semester. Lectures given fall semester (331), spring semester (332), and summer (333).*

BIOBM 330 Principles of Biochemistry, Individualized Instruction
Fall or spring. 4 credits. Prerequisites: one year of introductory biology for majors and one year of general chemistry and CHEM 257 or 357–358 (CHEM 358 may be taken concurrently) or equivalent, or permission of instructor. Concurrent registration in BIOBM 334 is encouraged. May not be taken for credit after BIOBM 331, 332, or 333. S-U grade optional for graduate students only. Hours to be arranged. Evening prelims: fall, Oct. 5 and Nov. 4; spring, Feb. 29 and Apr. 6. J. E. Blankenship, P. C. Hinkle, and staff.
Fourteen units that cover protein structure and function, enzymes, basic metabolic pathways, DNA, RNA, protein synthesis, and an introduction to gene cloning. No formal lectures; autotutorial format.

BIOBM 331 Principles of Biochemistry: Proteins and Metabolism
Fall. 3 credits. Prerequisites: one year of introductory biology for majors and one year of general chemistry and CHEM 257 or 357–358 (CHEM 257 or 357 should not

be taken concurrently) or equivalent, or permission of instructor. May not be taken for credit after BIOBM 330 or 333. S-U grades with permission of instructor. Lecs, M W F 10:10. Evening prelim: Oct. 21. G. W. Feigenson.

The chemical reactions important to biology, and the enzymes that catalyze these reactions, are discussed in an integrated format. Topics include methods for studying proteins, protein folding, enzyme catalysis, bioenergetics, and key reactions of synthesis and catabolism.

BIOBM 332 Principles of Biochemistry: Molecular Biology

Spring. 2 credits. Prerequisites: one year of introductory biology for majors and previous or concurrent registration in organic chemistry, or permission of instructor. May not be taken for credit after BIOBM 330 or 333. S-U grades optional, with permission of instructor. Lecs, T R 12:20. B. K. Tye.

A comprehensive course in molecular biology that covers the structure and properties of DNA, DNA replication and recombination, synthesis and processing of RNA and proteins, the regulation of gene expression, and the principles and uses of recombinant DNA technologies.

BIOBM 333 Principles of Biochemistry: Proteins, Metabolism, and Molecular Biology

Summer (8-week session). 4 credits. Prerequisites: one year of introductory biology for majors and one year general chemistry and CHEM 257, or 357–358, or equivalents, or permission of the instructor. May not be taken for credit after BIOBM 330, 331, or 332. S-U grades with permission of instructor. Lecs, M W F 10:00–12:00. S. Ely or H. T. Nivison.

The content of this course is similar to that of BIOBM 330; however, it is presented in lecture format rather than as individualized instruction. The topics include the structure and function of proteins, enzyme catalysis, metabolism, and the replication and expression of genes.

BIOBM 334 Computer Graphics and Molecular Biology

Fall or spring. 1 credit. Prerequisite: concurrent registration in BIOBM 330. If space permits, students who have completed BIOBM 331 and have either taken or are concurrently taking, BIOBM 332 will be permitted to register during the first week of classes. Disc to be arranged. J. E. Blankenship, P. C. Hinkle, and staff.

Visualization of complex biomolecules using Silicon Graphics computers. Group presentations on current topics in molecular biology.

BIOBM 407 Nature of Sensing and Response: Signal Transduction in Biological Systems (Also PLPA 407)

Spring. 3 credits. Prerequisite: BIOBM 330 or 333 or 331 and previous or concurrent registration in 332. Recommended: BIOGD 281. S-U grades optional. Lec T R 10:10–11:25. T. P. Delaney.

The responses of organisms and cells to their surroundings are examined to illustrate how biological systems sense their biotic and abiotic environment and communicate sensing into appropriate responses. A wide variety of response systems will be explored to identify their unique features and to illustrate how similar processes are utilized by widely divergent organisms. Examples are drawn from prokaryote, plant and animal systems for environmental sensing, control of development and responses during disease. Discussion will also examine the role of genetics and biochemistry in understanding signal transduction pathways, as well as the way these systems are perturbed by mutation and disease.

BIOBM 430 Laboratories in Biochemistry, Molecular, and Cell Biology (also BIONB 430)

Fall, spring, summer. 2 or 4 credits (students are expected to sign up for two sections for a total of 4 credits; limited space available for students taking only one section). Enrollment limited. Prerequisites: BIOBM 330, or 331 and previous or concurrent enrollment in 332, or 332 and previous or concurrent enrollment in 331, or 333, and permission of instructor. Strongly recommended: BIOGD 281. Form to apply for admission to this course is found on the Web (http://www.bio.cornell.edu/biochem/biobm430/signup.html). ***Registration in the course is official only if the form is completed before a student preregisters***. Class assignments are affected by the date the enrollment form is returned. Preference given to undergraduate majors in the Biochemistry or Molecular and Cell Biology Programs of Study, and to graduate students with a minor in the Field of Biochemistry, Molecular and Cell Biology. Labs, M W 12:20–4:25 (disc, F 1:25–2:25) or T 9:05–4:25 (disc, R 1:25–2:25) or R 9:05–4:25 (disc, T 1:25–2:25). Each section is seven weeks during the semester; which sections are offered in each semester depends on scheduling constraints and student preferences.

Section 01 Experimental Molecular Biology

2 credits. S. Ely and H. T. Nivison.

Experiments include cloning of DNA fragments, restriction mapping, DNA sequencing, Southern blotting, and PCR. The experiments emphasize quantitative aspects as well as experimental design.

Section 02 Experimental Proteins and Enzymology

2 credits. S. Ely and H. T. Nivison.

Experiments include purification of enzymes by salt fractionation, ion exchange chromatography, and affinity chromatography, determination of kinetic parameters for an enzyme, analysis of proteins by rate zonal sedimentation, SDS-polyacrylamide gel electrophoresis, and immunoblotting.

Section 03 Experimental Cell Biology

Spring only. 2 credits. T. Huffaker.

Experiments include culture of animal cells, purification and analysis of subcellular components, immunofluorescence electron microscopy, and in vitro assays.

[Section 04 Experimental Molecular Neurobiology

Spring. Next offered spring 2001. D. Deitcher.

Experiments include PCR, cloning of DNA fragments, RNA purification, restriction digests, bacterial transformation, and DNA sequencing. Experiments will emphasize how molecular techniques can be applied to studying neurobiological problems.]

BIOBM 432 Survey of Cell Biology

Spring. 3 credits. Prerequisite: BIOBM 330, 333, or 331, and previous or concurrent registration in 332, or equivalent. S-U grades optional for graduate students only. Lecs, M W 8:40–9:55. W. J. Brown and staff.

A survey of a wide array of topics focusing on the general properties of eucaryotic cells. The topics include methods used for studying cells, the structure and function of the major cellular organelles, and analyses of cellular processes such as mitosis, endocytosis, cell motility, secretion, cell-to-cell communication, gene expression, and oncogenesis. Some of the material is covered in greater depth in BIOBM 437; BIOGD 483; BIOBM 632, 636, and 639.

BIOBM 434 Applications of Molecular Biology to Medicine, Agriculture, and Industry

Fall. 3 credits. Enrollment limited to 36 students. Prerequisites: BIOBM 330 or 333 or 331 and 332. Recommended: BIOGD 281. S-U grades optional. Lecs, M W F 11:15. J. M. Calvo, S. Ely.

By considering some recent applications of biology, you my extend your knowledge of molecular biology and integrate information from biochemistry, cell biology, genetics, immunology, virology, microbiology, and plant biology. Topics include large scale sequencing of genomes, drug discovery based upon genomics, mapping and cloning human disease genes, DNA vaccines, transgenic animals, engineering plants resistant to insects, and gene therapy. Problem solving and oral presentations are important aspects of this course.

BIOBM 435–436 Undergraduate Biochemistry Seminar

435, fall; 436, spring. 1 credit each term. May be repeated for credit. Limited to upperclass students. Prerequisite: BIOBM 330 or 333 or 331 and 332 or written permission of instructor. S-U grades only. Sem time to be arranged. Organizational meeting first W of each semester at 4 p.m. Fall: G. P. Hess; spring: staff.

Selected papers from the literature on a given topic are evaluated critically during six or seven two-hour meetings.

BIOBM 437 Eukaryotic Cell Proliferation (also TOX 437)

Fall. 3 credits. Prerequisite: BIO G 101–102 or BIO G 105–106 and BIOBM 330 or BIOBM 331–332. Recommended: BIOGD 281 and BIOBM 432. S-U grades optional. Lecs, T R 12:20–1:35. R. H. Chen.

The course covers a wide spectrum of the issues related to cell proliferation in eukaryotes. Topics include regulation of cell division cycle, signal transduction pathways, growth factor receptors, oncogenes, cancer viruses, tumor suppressors, and apoptosis. Additional lectures will discuss aspects of differentiation and development that are related to the cell cycle.

BIOBM 631 Protein Structure and Function

Fall. 3 credits. Prerequisites: BIOBM 330 or 333 or 331 and 332 and organic chemistry. Recommended: physical chemistry. S-U grades optional. Lecs, M W F 9:05. L. Nicholson.

Presentations on the principles of protein structure and the nature of enzymatic catalysis. Specific topics include protein

folding, stability, dynamics and evolution, folded conformations and structure prediction, ligand binding energetics, and the structural basis of catalysis.

BIOBM 632 Membranes and Bioenergetics
Spring. 2 credits. Prerequisite: BIOBM 330 or 333 or 331 and 332 or equivalent. Lecs, T R 11:15. Offered alternate years. P. C. Hinkle.
Structure and dynamics of biological membranes, physical methods, model membranes, ionophores, ion-transport ATPases, mitochondrial and chloroplast electron transfer chains, and examples of transport from plants, animals, and bacteria. Emphasis given to structure of membrane proteins.

BIOBM 633 Biosynthesis of Macromolecules
Fall. 2 credits. Prerequisite: BIOBM 330 or 333 or 331 and 332. Recommended: BIOGD 281. Lecs, T R 9:05. J. W. Roberts, D. B. Wilson.
Synthesis of DNA, RNA, and proteins, and regulation of gene expression.

BIOBM 635 Mechanisms of Metabolic Regulation and Mammalian Gene Expression (also NS 635)
Spring. 2 credits. Prerequisites: at least 4 credits of Principles of Biochemistry and CHEM 358 or 360, or permission of instructor. Offered alternate years. Lecs, T R 9:05. M. N. Kazarinoff, N. Noy, P. Stover.
"Molecular mechanisms by which sensory, hormonal, and nutritional inputs cause changes in enzyme activity in order to regulate metabolic transformations." For course description see Nutritional Sciences 635.

BIOBM 636 Cell Biology
Spring. 2 credits. Prerequisites: BIOBM 330 or 333 or 331 and 332, and 432, or their equivalents. Lec, T 9:05–11:00. A. P. Bretscher.
Lectures cover studies aimed at elucidation of the functional organization of eucaryotic cells. Examples are drawn from research employing molecular, genetic, biochemical and cell biological approaches. Advanced discussion of topics such as the cytoskeleton, secretion, endocytosis, cell polarity and related topics are presented. Together with BIOBM 437, 632, and 639 this course provides broad coverage of the cell biology subject area.

BIOBM 637 Integration and Coordination of Energy Metabolism (also NS 636)
Fall. 3 credits. Prerequisite: BIOBM 330 or 331 or 333 or equivalent. Lecs, M W F 9:05. Evening prelims to be arranged. W. J. Arion.
"The elements and dynamics of energy metabolism in humans and higher animals are developed systematically through biochemical characterizations of the metabolic components and structure of major tissues and organs." For course description see Nutritional Sciences 636.

BIOBM 639 The Nucleus
Spring. 2 credits. Prerequisite: BIOBM 330 or 333 or 331 and 332 or equivalent. Recommended: BIOGD 281. Lec, T R 12:20. J. T. Lis.
Lectures on topics of eucaryotic gene organization, regulation of gene expression, RNA processing, chromatin structure, the structure and movement of chromosomes, and the architecture of the nucleus. This course covers the structure and function of the nucleus at the molecular and cell biological levels, and together with BIOBM 437, 632 and 636, provides broad coverage of the cell biology subject area.

[BIOBM 692 Protein-Nucleic Acid Interactions (also BIOMI 692)
Spring. 3 credits. Prerequisites: BIOBM 330 or 331 or 333 and 633. Lecs, T R 10:10–11:25. Offered alternate years. Not offered 1999–2000. J. D. Helmann.
For course description, see BIOMI 692.]

BIOBM 730 Protein NMR Spectroscopy (also VETPR 730)
Spring. 2 credits. Prerequisites: CHEM 389 and 390 or CHEM 287 and 288 or permission of instructor. S-U grades optional. Lec to be arranged. L. K. Nicholson, R. E. Oswald.
The student acquires the tools necessary for in-depth understanding of multidimensional, multinuclear NMR experiments. Schemes for magnetization transfer, selective excitation, water suppression, decoupling, and others are presented. The application of these techniques to proteins for resonance assignment, structure determination, and dynamics' characterization is studied.

BIOBM 732–737 Current Topics in Biochemistry
Fall or spring. 1/2 or 1 credit for each topic. May be repeated for credit. Prerequisite: BIOBM 330 or 333 or 331 and 332 or equivalent. S-U grades only.
Lectures and seminars on specialized topics. Topics for fall and spring to be announced in the division's course supplement published at the beginning of each semester.

[BIOBM 738 Macromolecular Crystallography (also CHEM 788)
Spring. 3 credits. S-U grades optional. Prerequisite: permission of instructor. Lecs, M W F 10:10. Offered alternate years. Not offered 1999–2000. D. J. Thiel, S. E. Ealick, J. C. Clardy.
Lectures briefly cover the fundamentals of crystallography and focus on methods for determining the 3-dimensional structures of macromolecules.]

BIOBM 750 Cancer Cell Biology (also VETPA 750)
Spring. 3 credits. Prerequisite: BIOBM 330 or 333 or 331 and 332 or equivalent. Offered alternate years. Lecs to be arranged. J. Guan, R. Levine, B. Pauli, A. Yen.
"Course covers molecular, cellular and genetic aspects of cancer." For course description see VETPA 750.

BIOBM 751 Ethical Issues and Professional Responsibilities (also TOX 751)
Spring. 2 credits. Limited to graduate students beyond first year. S-U grades only. Sem, W 2:30–4:25. Additional sections may be offered. Organizational meeting will be held on Wednesday, Jan. 26, 2:30 P.M., in 180 Biotechnology Building. Staff.
Ethical issues in research and the professional responsibilities of scientists are discussed in a case-study format. Topics to be discussed include regulations; data selection, manipulation, and representation; fraud, misconduct, and whistle-blowing; conflicts of interest and commitment; authorship, ownership, and intellectual properties; peer review and confidentiality; scientific response to external pressure; legal liabilities; and professional codes of ethics.

BIOBM 830 Biochemistry Seminar
Fall or spring. No credit. Sem, F 4:00. Staff.
Lectures on current research in biochemistry, presented by distinguished visitors and staff members. Lectures are open to everyone, but registration is limited to graduate students in Biochemistry, Molecular and Cell Biology.

BIOBM 831 Advanced Biochemical Methods I
Fall. 6 credits. Required of, and limited to, first year graduate students in the Field of Biochemistry, Molecular and Cell Biology. S-U grades only. Labs and Discs 12 hours each week TBA. Organizational meeting first R of semester, 10:10. V. M. Vogt and staff.
The first half of this course comprises an intensive laboratory covering fundamental aspects of modern molecular biology and cell biology. The second half of the course compromises research in the laboratory of a professor chosen by the student (See BIOBM 832). Students must enroll separately for each half.

BIOBM 832 Advanced Biochemical Methods II
Spring. 6 credits. Required of, and limited to, first year graduate students in the Field of Biochemistry, Molecular and Cell Biology. S-U grades only. Lab TBA. Staff.
Research in the laboratories of two different professors chosen by the student. Arrangements are made jointly between the Director of Graduate Studies and the research advisor.

BIOBM 833 Research Seminar in Biochemistry
Fall or spring. 1 credit each term. May be repeated for credit. Required of, and limited to, second-, third-, and fourth-year graduate students majoring in biochemistry. S-U grades only. Sem, M 12:20–1:30. T. C. Huffaker.
Each student presents one seminar per year on his or her thesis research and then meets with instructors and thesis committee members for evaluation.

BIOBM 835–836 Methods and Logic in Biochemistry, Molecular and Cell Biology
835, fall; 836, spring. 1 credit each term. Limited to first-year graduate students majoring in the Field of Biochemistry, Molecular and Cell Biology. S-U grades only. Sem and disc to be arranged. Fall: G. P. Hess; spring: staff.
A seminar course with critical discussion by students of original research papers. A variety of topics in biochemistry, molecular and cell biology are covered.

Related Courses in Other Departments

Lipids (Biological Sciences [BIOAP] 619 and Nutritional Sciences 602)

Molecular Aspects of Development (Biological Sciences [BIOGD] 483)

Molecular Biology Techniques for Animal Biologists (Animal Science 650)

Molecular Mechanisms of Hormone Action (Biological Sciences [BIOAP] 658 and Veterinary Medicine 758)

Teaching Experience (Biological Sciences [BIO G] 498)

Undergraduate Research in Biology (Biological Sciences [BIO G] 499)

ECOLOGY AND EVOLUTIONARY BIOLOGY (BIOES)

BIOES 154 The Sea: An Introduction to Oceanography (also GEOL 104)

Spring. 3 or 4 credits (4-credit option includes one 2 1/2 hour laboratory each week). S-U grades optional. Lecs, T R 11:40–12:55; labs, M or W 2:00–4:25, or M 7:30–9:55 p.m. C. H. Greene, W. M. White.

A survey of the physics, chemistry, geology, and biology of the oceans for both science and non-science majors. Topics include: sea-floor spreading and plate tectonics, marine sedimentation, chemistry of seawater, ocean currents and circulation, the oceans and climate, ocean ecology, coastal processes, marine pollution, and marine resources.

BIOES 261 Ecology and the Environment

Fall or summer. 4 credits. Prerequisite: one year of introductory biology. S-U grades optional. Lecs, M W F 11:15; disc, W or R 1:25, 2:30, or 3:35. N. G. Hairston, L. O. Hedin, P. P. Feeny.

An introduction to the science of ecology, the study of interactions between organisms and their environments. Major topics include demography, succession, biodiversity, biogeochemistry and ecosystems, and the evolution of adaptations. The influences of enemies, competitors, and mutualists on populations and communities are discussed. The effects of climate and human activities on ecological processes are also considered. Ecological principles are used to explain the issues associated with several environmental problems.

BIOES 263 Field Ecology

Fall. 2 credits. Limited to 25 students. Prerequisite: concurrent or previous enrollment in BIOES 261. Lec, R 1:25; lab, F 12:20–5:00; 1 weekend field trip to the Hudson Valley. P. L. Marks.

Field exercises designed to give students direct experience with field work, with emphasis on developing observational skills, journal keeping, and a landscape perspective. Topics include plant succession, niche relationships of insects, influence of herbivores and competition on plant performance, decomposition of soil litter, foraging behavior, census methods, and use of scientific collections.

BIOES 264 Birds in Biology

Fall. 3 credits. Limited to 25 students. May not be taken for credit after BIOES 475. Intended primarily for biology non-majors. S-U grades optional. Lecs and disc T R 8:40–9:55; two field trips TBA. A. A. Dhondt.

This course explores exciting new insights in biology using detailed examples drawn from bird studies. Subject matter is suitable for non-majors, but of interest to majors as well. Topics will be drawn from a variety of biological disciplines. These include behavioral ecology (mating systems, territorial behavior, song), population ecology (migration, population limitation, micro-evolution, competition), evolutionary biology (trade-offs in life histories, optimal clutch size), and conservation biology (habitat fragmentation, inbreeding, acid rain). Lectures will be interspersed with discussion of selected papers.

BIOES 267 Introduction to Conservation Biology

Fall. 3 credits. May not be taken for credit after NTRES 450. Intended for both science and non-science majors. Completion of BIOES 267 is not required for NTRES 450. S-U grades optional. Lecs, M W 9:05; disc, F 9:05 or R 2:30. A. S. Flecker, J. W. Fitzpatrick.

An exploration of biological concepts related to conserving the Earth's biodiversity, introducing ecological and evolutionary principles important for understanding major conservation problems. Topics include patterns of species and ecosystem diversity, causes of extinction, genetic risks of small populations, design of nature preserves, strategies for protecting endangered species, ecosystem restoration, and the value of biodiversity.

BIOES 274 The Vertebrates: Structure, Function, and Evolution

Spring. 4 credits. Prerequisite: one year of introductory biology. Lecs, M W F 12:20; labs, M T or W 1:25–4:25. Fee, $25. K. R. Zamudio.

An introductory course in vertebrate organismal biology which explores the structure and function of vertebrates with an emphasis on trends in vertebrate evolution. Lectures will cover topics such as the origin and evolution of various vertebrate groups, sensory systems, thermoregulation, life history, locomotion, feeding, size, and scaling. Laboratories include dissections of preserved vertebrate animals and noninvasive live animal demonstrations.

[BIOES 275 Human Biology and Evolution (also ANTHR 275 and NS 275)

Fall. 3 credits. S-U grades optional, with permission of either instructor. Lecs, W F 10:10; disc, M 10:10. Offered alternate years. Not offered 1999–2000. K. A. R. Kennedy, J. D. Haas.

An introduction to the biology of *Homo sapiens* through an examination of human evolution, biological diversity, and modes of adaptation to past and present environments. Evolutionary theory is reviewed in relation to the current evidence from the fossil record and studies of the evolution of human behavior. A survey of human adaptation covers a complex of biological and behavioral responses to environmental stress. Human diversity is examined as the product of long-term evolutionary forces and short-term adaptive responses. Topics such as creationism, the Piltdown fraud, the sociobiology debate, genetic engineering, race and IQ, and racism are presented as examples of current issues in human biology.]

BIOES 278 Evolutionary Biology

Fall or spring. 3 or 4 credits. (4-credit option involves writing component and two discussion sections per week; limited to 20 students each semester. Students may not preregister for the 4-credit option; interested students complete an application form on the first day of class.) Limited to 300 students. Prerequisite: one year introductory biology or permission of instructor. S-U grades optional. Lecs, T R 9:05; disc, 1 hour each week to be arranged. Evening prelims: fall, Sept. 23 and Oct. 28; spring, Feb. 24 and Mar. 30. Fall, M. A. Geber, staff; spring, M. Shulman.

The course considers explanations for patterns of diversity and for the apparent "good fit" of organisms to the environment. Topics covered include the genetic and developmental basis of evolutionary change, processes at the population level, the theory of evolution by natural selection, levels of selection, concepts of fitness and adaptation, modes of speciation, long-term trends in evolution, rates of evolution, and extinction. Students taking the 4-credit option read additional materials from the primary literature and write a series of essays in place of the regular prelims.

BIOES 371 Human Paleontology (also ANTHR 371)

Fall. 4 credits. Prerequisite: one year of introductory biology or ANTHR 101 or permission of instructor. Lecs, M W F 2:30; lab, 1 hour each week to be arranged; occasional field trips. Offered alternate years. K. A. R. Kennedy.

A broad survey of the fossil evidence for human evolution with special attention to skeletal and dental anatomy, geological contexts, paleoecology, dating methods, archaeological associations, and current theories of human origins and physical diversity.

BIOES 373 Biology of the Marine Invertebrates

Fall (but taken in the previous summer at the Shoals Marine Laboratory [SML]). 4 credits. Limited to 30 students. Prerequisite: one year of introductory biology for majors. Permission of faculty required for 1999 because it will be off campus. Offered alternate years. Two week, full-time course (August 6-August 20). Daily and evening lectures, laboratories, and field work. Total cost for room, board, and overhead at SML: $800. C. D. Harvell, J. G. Morin, SML Faculty.

An introduction to the biology and evolution of the major invertebrate phyla, concentrating on marine representatives. In addition to the evolution of form and function, lectures cover aspects of ecology, behavior, physiology, chemical ecology, and natural history of invertebrates. The Shoals Marine Laboratory exposes students to a wealth of marine and terrestrial invertebrates in their natural habitats. Regular field excursions allow an excellent opportunity to study freshly collected and *in situ* representatives of most of the major phyla.

[BIOES 452 Herbivores and Plants: Chemical Ecology and Coevolution (also ENTOM 452)

Spring. 3 credits. Prerequisites: one year of introductory biology, BIOES 261, CHEM 253 or 357/358 and 251 or 301, or permission of instructor. S-U grades optional. Lecs, M W F 11:15. Field trips, additional lectures, or laboratory demonstrations may be held in place of F lecture. Offered alternate years. Not offered 1999–2000. P. P. Feeny.

Topics include significance of plant chemistry in mediating interactions between plants and herbivorous animals; mechanisms and strategies of plant finding and exploitation by animals, especially insects, and of defense and escape by plants; evolutionary hypotheses for ecological patterns of resistance and attack;

and implications for human food and agriculture.]

BIOES 455 Insect Ecology (also ENTOM 455)
Fall. 3 credits. Prerequisites: BIOES 261 or equivalent and ENTOM 212 or knowledge of another taxon. S-U grades optional. Lecs, M W F 11:15. Offered alternate years. R. B. Root.
Topics include the nature and consequences of biotic diversity, biogeography, coevolution, adaptive syndromes exhibited by various guilds, population regulation, impact of insects on ecosystems, comparative and functional analysis of communities, and differences in the organization of natural and managed systems. Ecological and evolutionary principles are integrated by thorough study of exemplars.

[BIOES 456 Stream Ecology (also ENTOM 456 and NTRES 456)
Spring. 4 credits. Recommended: BIOES 261. S-U grades optional. Lecs, T R 9:05; labs, T W or R 1:25–4:25. Field project with lab papers. Offered alternate years. Not offered 1999–2000. B. L. Peckarsky, M. B. Bain.
Lecture: addresses the patterns and processes occurring in stream ecosystems, including channel formation; water chemistry; watershed influences; plant, invertebrate, and fish community structure; nutrient cycling; trophic dynamics, colonization and succession; community dynamics; conservation; and the impacts of disturbances. **Lab:** a field project includes descriptive and experimental techniques and hypotheses testing related to environmental assessment.]

[BIOES 457 Limnology: Ecology of Lakes, Lectures
Fall. 3 credits. Prerequisite: BIOES 261 or written permission of instructor. Recommended: introductory chemistry. Lecs, M W F 11:15. Offered alternate years. Not offered 1999–2000. N. G. Hairston, Jr.
The study of continental waters, with emphasis on lakes and ponds. Factors regulating nutrient cycling processes, population and community dynamics of freshwater organisms, and physical and chemical properties of fresh water are considered.]

[BIOES 459 Limnology: Ecology of Lakes, Laboratory
Fall. 2 credits. Prerequisite: concurrent or previous enrollment in BIOES 457. Lab, T W or R 1:25–4:25; 1 weekend field trip. Fee, $10. Offered alternate years. Not offered 1999–2000. N. G. Hairston, Jr. and staff.
Laboratories and field trips devoted to studies of the biological, chemical, and physical properties of lakes and other freshwater environments. Vertebrate dissection (fish) during one laboratory exercise and during a portion of weekend field trip.]

[BIOES 461 Population and Evolutionary Ecology
Spring. 4 credits. Prerequisites: BIOES 261 or 278 plus two semesters of calculus, or permission of instructor. S-U grades optional. Lecs, M W F 9:05; lab, M or T 1:25–4:25. Offered alternate years. Not offered 1999–2000. D. W. Winkler, A. S. Kondrashov.
Problems of ecology are viewed from an evolutionary perspective, exploring issues of adaptation and fitness by developing advanced understanding of demography and interspecific interactions. Blending theory and empirical findings, the course explores population dynamics; life-history theory; dispersal; competition; predation; parasite-host coevolution; mutualisms; and sexual, kin, and group selection. Methods of estimation and analysis are learned in laboratory.]

[BIOES 462 Marine Ecological Processes (also GEOL 462)
Spring. 3 credits. Limited to 75 students. Prerequisite: BIOES 261. Lecs and disc, M W F 10:10. Offered alternate years. Not offered 1999–2000. C. D. Harvell, C. H. Greene.
Lectures and discussion focus on current research in broad areas of marine ecology with an emphasis on processes unique to marine systems. A synthetic treatment of multiple levels of organization in marine systems including organismal, population, community, ecosystems, and evolutionary biology. Examples are drawn from all types of marine habitats, including polar seas, temperate coastal waters, and tropical coral reefs.]

[BIOES 463 Plant Ecology and Population Biology, Lectures
Fall. 3 credits. Prerequisite: BIOES 261 or 278 or equivalents, or permission of instructor. Recommended: some taxonomic familiarity with vascular plants and concurrent enrollment in BIOES 465. Lecs, M W F 11:15. Offered alternate years. Not offered 1999–2000. M. A. Geber, P. L. Marks.
This course examines the biological and historical factors affecting the structure of plant communities, and the distribution, abundance, and population dynamics of individual species. The influence of the environment, disturbance history, competition, and herbivory on the organization of plant communities are considered. Plant populations are also studied through an analysis of plant life histories and plant-plant and plant-animal interactions. Throughout the course an attempt is made to blend empirical patterns, experimental results, and theory. Readings are drawn from the primary literature.]

BIOES 464 Macroevolution
Spring. 4 credits. Limited to 25 students. Prerequisite: BIOES 278 or permission of instructor. S-U grades optional, with permission of instructor. Lecs, T R 10:10–11:25; disc, 1 hour each week to be arranged. Offered alternate years. A. R. McCune.
An advanced course in evolutionary biology centered on large-scale features of evolution. Areas of emphasis include patterns and processes of speciation, phylogeny reconstruction, the origins and fate of variation, causes of major evolutionary transitions, and patterns of diversification and extinction in the fossil record. Discussion of these problems involve data and approaches from genetics, morphology, systematics, paleobiology, development, and ecology.

[BIOES 465 Plant Ecology and Population Biology, Laboratory
Fall. 1 credit. Prerequisite: concurrent enrollment in BIOES 463. Lab, F 12:05–5:00. Offered alternate years. Not offered 1999–2000. M. A. Geber, P. L. Marks.
Field and laboratory exercises designed to give firsthand experience with the ecology and population biology of plants. Emphasis is on making observations and measurements of plants in the field and greenhouse, and on data analysis.]

[BIOES 466 Physiological Plant Ecology, Lectures
Spring. 3 credits. Limited to 45 students. Prerequisite: BIOES 261 or introductory plant physiology. S-U grades optional, with permission of instructor. Lecs, M W 8:40–9:55; optional disc to be arranged. Offered alternate years. Not offered 1999–2000. Staff.
A detailed survey of the physiological approaches used to understand the relationships between plants and their environment. Lectures explore physiological adaptation; limiting factors; resource acquisition and allocation; photosynthesis, carbon, and energy balance; water use and water relations; nutrient relations; linking physiology, development, and morphology; stress physiology; life history and physiology; the evolution of physiological performance; and physiology at the population and community and ecosystem levels. Readings draw from the primary literature and textbooks.]

[BIOES 468 Physiological Plant Ecology, Laboratory
Spring. 2 credits. Limited to 15 students. Prerequisite: previous or concurrent enrollment in BIOES 466. Lab, W 1:25–4:25, plus additional lab hours to be arranged. Offered alternate years. Not offered 1999–2000. Staff.
A detailed survey of the physiological approaches used in understanding the relationships between plants and their environment. Laboratories apply physiological techniques to specific ecological problems and cover aspects of experimental design and computer-aided data analysis. Most laboratories run past the three-hour period, with students spending an average of 3 hours/week in additional lab time for this course.]

[BIOES 471 Mammalogy
Fall. 4 credits. Recommended: BIOES 274. S-U grades optional, with permission of instructor. Lecs, M W F 12:20; lab, M T or W 1:25–4:25; 1 weekend field trip required. Carpooling to the Vertebrate Collections at Research Park is necessary several times during the semester. Fee, $15. Offered alternate years. Not offered 1999–2000. Staff.
Lectures on the evolution, classification, distribution, and adaptations of mammals. Laboratory and fieldwork on systematics, ecology, and natural history of mammals of the world, with primary emphasis on the North American fauna. Systematics laboratories held in the museum at Research Park. Live animals are studied in the field and are sometimes used in the laboratory for nondestructive demonstrations or experiments. The systematics laboratory exercises are based on museum specimens.]

[BIOES 472 Herpetology
Spring. 4 credits. Limited to 35 students. Recommended: BIOES 274. S-U grades optional, with permission of instructor. Lecs, T R 12:20; labs, T R 1:25–4:25; occasional field trips and special projects. Fee, $30. Offered alternate years. Not offered 1999–2000. H. W. Greene.
Lectures cover various aspects of the biology of amphibians and reptiles, including evolution, zoogeography, ecology, behavior,

and physiology. Laboratory topics include systematics, morphology, and behavior. Live animals are studied in the field and are used in the laboratory for nondestructive demonstrations and experiments. The systematics laboratory exercises are based on museum specimens and dissection of preserved materials.]

[BIOES 473 Ecology of Agricultural Systems (also SCAS 473)

Fall. 3 credits. Limited to 45 students. Prerequisite: BIOES 261 or permission of instructor. S-U grades optional. Lecs and discs, T R 2:30–3:45. During the first 6 weeks of class, the Thursday meetings may run to 5:00 because of field trips. Offered alternate years. Not offered 1999–2000. A. G. Power, E. C. M. Fernandes.

Analysis of the ecological processes operating in agricultural systems, with an emphasis on the interactions between organisms. Topics include nutrient dynamics in agroecosystems, plant competition and facilitation, intercropping, the ecology of species invasions, mutualism in agroecosystems, plant-herbivore relations, plant-pathogen interactions, biological pest control, and evolutionary processes in agriculture. Case studies from both the tropics and the temperate zone are used to illustrate important concepts.]

[BIOES 474 Laboratory and Field Methods in Human Biology (also ANTHR 474)

Spring. 5 credits. Limited to 16 students with permission of instructor obtained by preregistering in E231 Corson. Prerequisite: one year of introductory biology or ANTHR 101 or permission of instructor. Lecs and labs, T R 10:10–12:05; additional hours to be arranged. Independent research project required. Offered alternate years. Not offered 1999–2000. K. A. R. Kennedy.

Practical exercises and demonstrations of modern approaches to the methodology of biological anthropology. Emphasis on comparative human anatomy, osteology, description of skeletal subjects, paleopathology, skeletal maturation, and relevant field techniques for the archaeologist and forensic anthropologist.]

[BIOES 475 Ornithology

Fall. 4 credits. Limited to 30 students, with permission of instructor obtained by preregistering in E241 Corson. Recommended: BIOES 274. S-U grades optional, with permission of instructor. Lecs and labs, T R 12:20–4:25; occasional field trips and special projects. Carpooling to the Vertebrate Collections at Research Park is necessary once a week. Fee, $15. Offered alternate years. Not offered 1999–2000. D. W. Winkler.

Lectures cover various aspects of the biology of birds, including anatomy, physiology, systematics, evolution, behavior, ecology, and biogeography. Laboratory includes dissection of dead material, studies of skeletons and plumages, and specimen identification of avian families of the world and species of New York. Independent projects emphasize research skills.]

[BIOES 476 Biology of Fishes

Fall. 4 credits. Limited to 24 students. Recommended: BIOES 274 or equivalent experience in vertebrate zoology. S-U grades optional, with permission of instructor. Lecs, M W F 10:10; lab, M 1:25–4:25; with additional lab time TBA; two field trips. A small lab fee may be required. Offered alternate years. Not offered 1999–2000. A. R. McCune.

An introduction to the study of fishes: their structure, evolution, distribution, ecology, physiology, behavior, classification, and identification, with emphasis on local species. Two field trips, including one full day weekend trip required. Live animals are studied in the field and are sometimes used in the laboratory for nondestructive demonstrations or experiments. The systematics and dissection laboratories use preserved specimens.]

BIOES 478 Ecosystem Biology

Fall. 4 credits. Prerequisite: BIOES 261 or equivalent. S-U grades optional. Lecs and discs, T R 10:10–12:05. Offered alternate years. L. O. Hedin.

Analysis of ecosystems in terms of energy flow and nutrient cycles, emphasizing an experimental approach and comparative aspects of terrestrial, freshwater, and marine ecosystems. Consideration of anthropogenic effects on ecosystems, such as from acid precipitation and offshore oil pollution. Analysis of climate change and regional environmental change from an ecosystem perspective.

BIOES 479 Paleobiology (also GEOL 479)

Fall. 4 credits. Prerequisites: one year of introductory biology for majors and either BIOES 274, GEOL 375, BIOES 373, or permission of instructor. S-U grades optional. Lecs, M W F 12:20; lab to be arranged. W. Allmon.

A survey of the major groups of organisms and their evolutionary histories. Intended to fill out the biological backgrounds of geology students and the geological backgrounds of biology students concerning the nature and significance of the fossil record for their respective studies.

BIOES 660 Field Studies in Ecology and Systematics

Fall or spring. Variable credit. Prerequisites: BIOES 261, a taxon-oriented course, and permission of instructor. S-U grades optional, with permission of instructor. Lecs and field trips to be arranged. Estimated costs: to be announced. Staff.

This course provides students with opportunities to learn field techniques and new biotas by participating in an intensive series of field exercises. Extended field trips may be scheduled during fall break, intersession, or spring break. The regions visited, trip objectives, and other details are announced by the various instructors at an organizational meeting held at the beginning of the semester. Meetings on campus are devoted to orientation and reports on completed projects.

[Section 01: Life Histories of Marine and Freshwater Invertebrates

Fall. 2 credits. Prerequisite: undergraduates must have previous experience or course work with marine or freshwater invertebrates. Two extended weekend field trips in early September and October. Fee: $100 (to help cover transportation and housing at Shoals Marine Lab). Offered alternate years. Not offered 1999–2000. C. D. Harvell, N. G. Hairston, Jr.

Field trips to the Shoals Marine Lab and Shackelton Point Field Station. Students employ experimental approaches to study the evolution of invertebrate life histories.]

Section 02: Graduate Field Course in Ecology

Spring. 3 credits. Restricted to graduate students. A fee will be required to help cover food and lodging for trip to Florida. Offered alternate years. P. L. Marks, R. B. Root.

The course is designed to give graduate students experience in defining questions and designing field investigations. The class is based at the Archbold Biological Station in central Florida over spring break and during the following week. The class visits several ecosystems including sand pine scrub, cattle ranches, cypress swamps, everglades, and coral reefs.

BIOES 661 Environmental Policy (also ALS 661 and B&SOC 461)

Fall and spring. 3 credits each term. (Students must register for 6 credits each term, since an "R" grade is given at the end of the fall term.) Limited to 12 students. Prerequisite: permission of instructor. Sem, R 2:30–4:30. D. Pimentel.

This course uses an interdisciplinary approach to focus on complex environmental problems. Ten to twelve students, representing several disciplines, investigate significant environmental problems. The research team spends two semesters preparing a scientific report for publication in *Science* or *BioScience*.

[BIOES 663 Theoretical Population Genetics

Fall. 3 credits. Prerequisites: knowledge of basic population genetics (e.g., BIOGD 481), and some mathematics (e.g., MATH 111). Primarily for graduate students; permission of instructor required for undergraduates. S-U grades optional. Lec, 2 hours each week to be arranged; lab (computer), 3 hours each week to be arranged. Offered alternate years. Not offered 1999–2000. A. S. Kondrashov.

Theoretical population genetics (TPG) is one of the areas of current evolutionary biology. The course explains why TPG is successful in its domain and what its limitations are. Students analyze the effects of seven elementary factors of population dynamics (mutation, selection, drift, migration, segregation, recombination, and non-random mating). Consideration of biologically relevant situations when several factors act simultaneously (migration-drift, mutation-selection-drift, segregation-recombination-selection, etc.) leads to studying the changes of not only the population state, but of the "rules of the game" themselves (evolution of reproductive isolation, life history, recombination, mutability, etc.). Students study in detail several topics of general biological interest (maintenance of quantitative variability, evolution of aging, and sexual selection). Active use of computers in analyzing the models, but no formal training in programming required.]

[BIOES 665 Limnology Seminar

Spring. 1 credit. May be repeated for credit. Primarily for graduate students; written permission of instructor required for undergraduates. S-U grades optional. Sem to be arranged. Offered alternate years. Not offered 1999–2000. N. G. Hairston, Jr.

A seminar course on advanced topics in freshwater ecology.]

BIOES 668 Principles of Biogeochemistry
Spring. 4 credits. Limited to 20 students. Prerequisite: solid background in ecology, environmental chemistry, or related environmental science. Permission of instructor required for undergraduates. S-U grades optional. Lecs and discs, T R 10:10–12:05. Offered alternate years. R. W. Howarth, L. O. Hedin.
Lectures cover the biotic controls on the chemistry of the environment and the chemical control of ecosystem function. Emphasis is on cycles of major elements and minor elements globally and in selected ecosystems, stressing the coupling of element cycles. A comparative approach is used to illustrate similarities and differences in element cycling among ecosystems. Analysis of both theoretical and applied issues, including global atmospheric changes and factors controlling the acidification of lakes and soils.

[BIOES 669 Plant Ecology Seminar
Spring. 1 credit. May be repeated for credit. Suggested for students majoring or minoring in plant ecology. S-U grades optional. Sem to be arranged. Not offered 1999–2000. Staff.
Includes review of current literature, student research, and selected topics of interest to participants.]

BIOES 670 Graduate Seminar in Vertebrate Biology
Fall or spring. 1 credit. May be repeated for credit. Primarily for graduate students; written permission of instructor required for undergraduates. S-U grades only. Sem to be arranged. Staff.
Seminar presentations and discussions by students on areas of current research in vertebrate biology. Topics vary from semester to semester.

[BIOES 673 Human Evolution: Concepts, History, and Theory (also ANTHR 673)
Fall. 3 credits. Prerequisite: one year of introductory biology, ANTHR 101, or permission of instructor. Lec, M 2:30; sem and disc, W 7:30–9:30 p.m. Offered alternate years. Not offered 1999–2000. K. A. R. Kennedy.
A survey of the historical background of present-day concepts of human evolutionary variations and adaptations in space and time. The formation of biological anthropology as an area of scientific inquiry within the social and biological sciences is reviewed. Students select their own topics within a broad range of readings in the history of Western concepts of human origins, diversity, and place in nature.]

BIOES 760 Special Topics in Evolution and Ecology
Fall or spring. 1–3 credits. May be repeated for credit. Enrollment limited. S-U grades optional, with permission of instructor. Hours to be arranged. Staff.
Independent or group intensive study of special topics of current interest. Content varies and is arranged between student and staff member.

Section 02 Development and Evolution (also BIO G 400, BIOGD 480, and BIOGD 780)
Fall*. 2 credits. Prerequisites: BIOGD 281 and BIOES 278. S-U grades only. Lecs and discs T 12:20–2:25 p.m. Students will also be required to attend five seminars on M 4:00–5;30 p.m. M. Wolfner, A. McCune.
Five leading international experts will describe recent advances in data and theory at the intersection of developmental biology and evolutionary biology. Topic coverage will center around pattern formation and the origin of metazoan body plans. During the Tuesday class meeting prior to each expert's visit, students and course faculty will present and discuss recent papers by the upcoming speaker. The following week, students will be required to attend the speaker's seminar on Monday at 4:00 p.m. and then meet with the speaker during class on the following day for continued discussion of the topic.

*Fall 1999 is the only time that this special course will be offered, at least in this seminar-coupled format. Graduate students should register for BIOGD 780; undergraduates should register for BIOGD 480.

BIOES 763 Workshop in Biogeochemistry
Fall or spring. 1 credit. Limited to 15 students. Prerequisite: BIOES 668. S-U grades only. Workshop and disc, TBA. Staff.
Provides a workshop-forum in which graduate students interact with invited world-leaders in biogeochemistry. Workshop topics will change each semester. A one-week workshop will be preceded by seven, one-hour preparatory discussions of readings.

BIOES 767 Current Topics in Ecology and Evolutionary Biology
Fall. 4 credits. Prerequisite: permission of instructor required for undergraduates. S-U grades only. Lecs and discs, T R 10:10–12:05; 1 weekend field trip. Staff.
Critical evaluation and discussion of theory and research in ecology and evolutionary biology. Lectures by faculty and student-led discussions of topics in areas of current importance.

Related Courses in Other Departments

Advanced Soil Microbiology (Soil, Crop, and Atmospheric Sciences 666)

Animal Social Behavior (Biological Sciences [BIONB] 427)

Early People: The Archaeological and Fossil Record (Anthropology 203 and Archaeology 203)

Evolution of the Earth and Life (Biological Sciences [BIO G] 170 and Geological Sciences 102)

Marine Sciences Courses (Biological Sciences [BIOSM] 363–370, 477)

Mathematical Ecology (Biometry and Statistics 662)

Related Courses in Entomology (Entomology 212, 331, 370, 453, 471, 631, 634, 672)

Related Courses in Natural Resources (Natural Resources 301, 302, 418, 450, 496)

Taxonomy of Vascular Plants (Biological Sciences [BIOPL] 248)

Teaching Experience (Biological Sciences [BIO G] 498)

Undergraduate Research in Biology (Biological Sciences [BIO G] 499)

Undergraduate Seminar in Biology (Biological Sciences [BIO G] 400)

GENETICS AND DEVELOPMENT (BIOGD)

[BIOGD 184 Understanding Genetics
Spring. 3 credits. May not be taken for credit after BIOGD 281 or 282. This course may be used toward the science distribution requirement of the College of Arts and Sciences and the Group B distribution requirement of the College of Agriculture and Life Sciences. This course may not be used to fulfill the requirements for any program of study in the biological sciences major. S-U grades optional. Lecs, M W F 2:30. Offered alternate years. Not offered 1999–2000. T. D. Fox.
An introduction to genetics for students majoring in fields other than biology. Genetics is a rapidly developing science that is providing insight into all aspects of biology and practical tools which increasingly affect our lives. The course shows how major conclusions about inheritance have been derived from the experimental evidence, drawing on examples from the biology of humans, other animals, plants, fungi, and bacteria. It also illustrates current and future applications of genetic discoveries. For example, the basic principles of inheritance, in conjunction with methods for the isolation and detection of specific gene fragments, is used to understand the detection of genetic diseases and the identification of individuals (DNA fingerprinting). Other topics to be covered include the origin of mutations, use of genetic methods to alter the properties of organisms and the influence of inheritance on behavior.]

BIOGD 281 Genetics
Fall, spring, or summer (8-week session). 5 credits. Not open to freshmen in fall semester. Enrollment may be limited to 200 students. Prerequisite: one year of introductory biology or equivalent. No admittance after first week of classes. Lecs, T R 10:10–12:05; lab, T W or F 2:30–4:25; additional hours to be arranged. Students do not choose lab sections during course enrollment; lab assignments are made during first day of classes. Problem-solving sessions strongly recommended, T or W 8:30–9:45 (additional session to be arranged if necessary). P. J. Bruns, T. D. Fox, M. L. Goldberg, R. J. MacIntyre.
A general study of the fundamental principles of genetics in eukaryotes and prokaryotes. Discussions of gene transmission, gene action and interaction, gene linkage and recombination, gene structure, gene and chromosome mutations, genes in populations, and extrachromosomal inheritance. Aspects of recombinant DNA technology are discussed. In the laboratory, students perform experiments with microorganisms and conduct an independent study of inheritance in *Drosophila*.

BIOGD 282 Human Genetics
Spring. 2 or 3 credits (2 credits if taken after BIOGD 281). Each discussion limited to 25 students. Prerequisite: one year of introductory biology or equivalent; permission of instructor required for students who have taken BIOGD 281. S-U grades optional. Lecs, M W 10:10 (lecs, also F 10:10 1st 3 weeks only); disc, R 10:10 or F 10:10 or 11:15. R. A. Calvo.
A course designed for nonmajors. Lectures provide the technical background needed to understand controversial personal, social, and

legal implications of modern genetics that are discussed in section meetings.

BIOGD 385 Developmental Biology
Fall. 3 credits. Prerequisite: BIOGD 281. Lecs, M W F 11:15. K. J. Kemphues.
An introduction to the morphogenetic, cellular, and genetic aspects of the developmental biology of animals.

BIOGD 387 Developmental Aspects of Evolution
Spring. 2 credits. Prerequisite: BIOGD 281. S-U grades optional. Lecs, T R to be arranged. Offered alternate years. A. W. Blackler.
An examination of the developmental mechanisms that underlie evolutionary change and organismal diversity and of the developmental constraints that contribute to evolutionary conservatism.

BIOGD 389 Embryology
Spring. 3 credits. Preference given to seniors. Prerequisites: one year of introductory biology and a knowledge of mammalian adult anatomy. Lecs, T R 10:10; labs, T or R 2–4:25. A. W. Blackler.
A course in the embryonic development of vertebrate animals, with emphasis on the comparative aspects of morphogenesis and function at the tissue and organ levels. The laboratory has a strong morphogenetic bias, emphasizing the comparative aspects of developmental anatomy and preparation for medical studies.

BIOGD 480 Development and Evolution (also BIOES 760-02/BIOG 400/ BIOGD 780)
Fall*. 2 credits. Prerequisites: BIOGD 281 and BIOES 278. S-U grades only. Lecs and discs T 12:20–2:25 p.m. Students will also be required to attend five seminars on M 4:00–5:30 p.m. M. Wolfner, A. McCune.
Five leading international experts will describe recent advances in data and theory at the intersection of developmental biology and evolutionary biology. Topic coverage will center around pattern formation and the origin of metazoan body plans. During the Tuesday class meeting prior to each expert's visit, students and course faculty will present and discuss recent papers by the upcoming speaker. The following week, students will be required to attend the speaker's seminar on Monday at 4:00 p.m. and then meet with the speaker during class on the following day for continued discussion of the topic.

*Fall 1999 is the only time that this special course will be offered, at least in this seminar-coupled format. Graduate students should register for BIOGD 780; undergraduates should register for BIOGD 480.

BIOGD 481 Population Genetics
Fall. 4 credits. Prerequisite: BIOGD 281, BIOES 278, or equivalents. Lecs, M W F 10:10; disc, M 2:30 or T 1:25. C. F. Aquadro.
Population genetics is the study of the transmission of genetic variation through time and space. The class explores how to quantify this variation, what the distribution of variation tells us about the structure of natural populations, and about the processes that lead to evolution. Topics include the diversity and measurement of genetic variation, mating and reproductive systems, selection and fitness, genetic drift, migration and population structure, mutation, multilocus models, the genetics of speciation, quantitative traits, and the maintenance of molecular variation. Emphasis is placed on DNA sequence variation, and the interplay between theory and the data from experiments and natural populations. Specific case studies include the population genetic issues involved in DNA fingerprinting, the genetic structure and evolution of human populations, and the study of adaptation at the molecular level. Examples are drawn from studies of animals, plants, and microbes.

BIOGD 482 Human Genetics and Society
Fall. 3 credits. Enrollment limited to 24 senior biological sciences majors, with preference given to students studying genetics and development. Prerequisites: BIOGD 281 and BIOBM 330 or 333 or 331 and 332, and written permission of instructor. S-U grades optional. Disc, T 2:30–4:25 and R 2:30–3:30. R. A. Calvo, P. J. Bruns.
Presentation of some of the science and technology, plus discussion of the ethical, social, and legal implications of recent advances in human genetics. Among the topics considered are assisted reproductive strategies, eugenics, genetic counseling, genetic screening (pre-implantation, prenatal, neonatal, presymptomatic, carrier, and workplace), wrongful life and wrongful birth, genetic effects of abused substances, genetics and behavior, and therapy for genetic diseases. Students lead many discussions. There is a major writing component in the course.

[BIOGD 483 Molecular Aspects of Development
Spring. 3 credits. Prerequisites: BIOGD 281; BIOBM 332 or 330 or 333; and BIOGD 385 or permission of instructor. Lecs, T R 2:30–4:00. Offered alternate years. Not offered 1999–2000. M. F. Wolfner.
An advanced course in developmental biology, with emphasis on the molecular events underlying developmental processes. Simultaneously, a molecular biology course that focuses on how development modulates and uses transcriptional, post-transcriptional, translational and post-translational regulation of gene expression and cellular events such as signal transduction and cell-cell communication. Numerous developmental systems are discussed and analyzed in microorganisms, plants and, especially, animals including fruit flies, nematode worms, and vertebrates such as mice, frogs, and humans. Course readings include original research articles. Discussion emphasizes specific experiments and approaches, results and their interpretation.]

BIOGD 484 Molecular Evolution
Spring. 3 credits. Prerequisites: BIOGD 281 and organic chemistry. Lecs, T R 11:15. Offered alternate years. R. J. MacIntyre.
An analysis of evolutionary changes in genes and their protein products. Theories on the evolution of the genetic code, the construction of phylogenetic trees from biochemical data and the role of gene duplications in evolution are discussed. The second half of the course concerns the evolution and the organization of genomes from viruses to higher eukaryotes, including the evolution of satellite DNA sequences and transposable elements.

BIOGD 485 Bacterial Genetics (also BIOMI 485)
Fall. 2 credits. Graduate students, see BIOMI 685. Prerequisite: BIOGD 281. Recommended: BIOMI 290 and BIOBM 330 or 331 and 332 or 333. Lecs, W 7:30–9:25 p.m. Staff.
For course description, see BIOMI 485.

BIOGD 486 Advanced Eukaryotic Genetics
Spring. 4 credits. Enrollment may be limited to 50 students. Prerequisites: BIOGD 281, BIOBM 330 or 333 or 331 and 332. S-U grades optional. Lecs, T 12:20–2:15 and R 12:20–1:10; disc R 1:25–2:15 or F 11:15–12:05. E. E. Alani.
The course develops fundamental skills in eukaryotic genetic analysis through lectures and by reading, analyzing, and presenting research articles. Concepts are presented within the context of a well-studied field, such as chromosome segregation. The basic tools that have been developed to study this field are used to analyze other topics such as vegetative and meiotic cell cycle control, embryonic development, pathogen resistance in plants, and human genetics.

BIOGD 682 Fertilization and the Early Embryo
Spring. 2 credits. Prerequisites: BIOGD 281; BIOBM 332, 330 or 333; and BIOGD 385 or permission of instructor. Lec, R 2:30–4:25. Offered alternate years. M. F. Wolfner.
This course treats the earliest events in the formation of a new organism. The methods and findings of genetic, developmental, and molecular analyses are discussed. Readings in the recent literature and discussions focus on pre-gastrulation embryos from several animal species. Topics include fertilization (sperm/egg binding, sperm entry into egg), pro-nuclear fusion, egg activation, initiation and terminating the cleavage, division period, cytoplasmic determinants, changes in nuclear and cytoplasmic architecture.

[BIOGD 684 Advanced Topics in Population Genetics
Spring. 2 credits. Limited to 20 students. Prerequisites: BIOGD 481 or equivalent and written permission of instructor. S-U grades optional. Lec, T 2:30–4:25. Offered alternate years. Next offered spring 2001. C. F. Aquadro.
An in-depth exploration of current areas of research in population genetics. Readings primarily from recent books and the current literature. Specific topics are announced the previous fall and in the division's catalog supplement. Format includes lectures, discussion, and presentations by students.]

[BIOGD 685 Advanced Bacterial Genetics (BIOMI 485)
Fall. 2 credits. Limited to graduate students in Biological Sciences; see BIOMI 485. Prerequisites: BIOGD 281 or equivalent, BIOBM 330 or 331 and 332 or equivalent, and permission of instructor. Recommended: BIOMI 290 or equivalent. Lec, W 7:30–9:25; disc, R 10:10–11:00. Not offered 1999–2000, 2000–2001. Staff.
For course description, see BIOMI 685.]

[BIOGD 687 Developmental Genetics
Fall. 2 credits. Limited to 20 students. Prerequisites: BIOGD 281 and 385 or their equivalents. S-U grades optional. Lec to be arranged. Offered alternate years. Next offered fall 2000. K. J. Kemphues.

Selected topics focus on the use of genetic analysis in understanding mechanisms of development. Topics are drawn primarily from studies in fruitflies, nematodes, mice and fish. Possible topics include pattern formation, cell lineage, neural development, maternal information in development, germ cell development, sex determination, and intercellular communication. Students read current literature and are encouraged to discuss each topic in class.]

BIOGD 780 Development and Evolution (also BIOES 760–02/BIOG 400/ BIOGD 480)
Fall*. 2 credits. Prerequisites: BIOGD 281 and BIOES 278. S/U grades only. Lecs and Discs T 12:20–2:25 p.m. Students will also be required to attend five seminars on M 4:00–5:30 p.m. M. Wolfner, A. McCune.
Five leading international experts will describe recent advances in data and theory at the intersection of developmental biology and evolutionary biology. Topic coverage will center around pattern formation and the origin of metazoan body plans. During the Tuesday class meeting prior to each expert's visit, students and course faculty will present and discuss recent papers by the upcoming speaker. The following week, students will be required to attend the speaker's seminar on Monday at 4:00 p.m. and then meet with the speaker during class on the following day for continued discussion of the topic.

*Fall 1999 is the only time that this special course will be offered, at least in this seminar-coupled format. Graduate students should register for BIOGD 780; undergraduates should register for BIOGD 480.

BIOGD 781 Problems in Genetics and Development
Fall. 2 credits. Limited to first-year graduate students in the Field of Genetics and Development. Disc to be arranged. Staff.
An introduction to the research literature in selected areas through weekly problem sets and discussions.

[BIOGD 782–783 Current Genetics/ Development Topics
Spring. 1/2 or 1 credit for each topic. May be repeated for credit. S-U grades only. Lectures and seminars on specialized topics to be announced. Not offered 1999–2000. Staff.]

BIOGD 786 Research Seminar in Genetics and Development
Fall and spring. 1 credit. Limited to and required of second-, third-, and fourth-year graduate students in Genetics and Development. S–U grades only. Sem, W 12:20–1:30. Staff.
Each graduate student presents one seminar per year based on his or her thesis research. The student then meets with the thesis committee members for an evaluation of the presentation.

BIOGD 787 Seminar in Genetics and Development
Fall and spring. 1 credit. Limited to graduate students in Genetics and Development. S–U grades only. Sem, M 4–5:00. Staff.
Seminars in current research in genetics and developmental biology conducted by distinguished visitors and staff.

Related Courses in Other Departments

Advanced Plant Genetics (Plant Breeding 606)

Animal Development (Veterinary Anatomy 507)

Biosynthesis of Macromolecules (Biological Sciences [BIOBM] 633)

Current Topics in Biochemistry (Biological Sciences [BIOBM] 731–736)

Evolutionary Biology (Biological Sciences [BIOES] 278)

Laboratory in Molecular Biology and Genetic Engineering of Plants (Biological Sciences [BIOPL] 347)

Laboratory in Plant Molecular Biology (Biological Sciences [BIOPL] 641)

Molecular Biology and Genetic Engineering of Plants (Biological Sciences [BIOPL] 343)

Plant Cytogenetics (Plant Breeding 446)

Plant Genome Organization (PLBR 653–03)

Plant Growth and Development (Biological Sciences [BIOPL] 644)

Plant Molecular Biology I (Biological Sciences [BIOPL] 653)

Plant Molecular Biology II (Biological Sciences [BIOPL] 652)

Protein-Nucleic Acid Interactions (Biological Sciences [BIOMI] 692)

The Nucleus (Biological Sciences [BIOBM] 639)

Undergraduate Research in Biology (Biological Sciences [BIO G] 499)

MICROBIOLOGY (BIOMI)

[BIOMI 192 Microorganisms on the Planet Earth
Spring. 3 credits. May not be taken for credit after BIOMI 290. S-U grades optional. Lecs, M W F 11:15. Not offered 1999–2000, 2000–01. R. P. Mortlock.
A course in microbiology designed to introduce students, who have a limited background in science, to the microorganisms that populate our planet earth. Among the microorganisms studied are the bacteria, the archaebacteria, some of the single-celled plants and animals, and the viruses. Topics covered are the basic nature of microorganisms, their evolution on earth, their composition and growth, their role in the ecology of this planet, their role in human history and disease, and their use in bioengineering. This course is not a prerequisite for advanced courses in microbiology.]

BIOMI 290 General Microbiology Lectures
Fall, spring, or summer (6-week session). 2 or 3 credits (2 credits if taken after BIOMI 192). Prerequisites: one year of introductory biology for majors and one year of college chemistry, or equivalent. Recommended: concurrent registration in BIOMI 291. Lecs, M W F 11:15. Staff.
A comprehensive overview of the biology of microorganisms, with emphasis on bacteria. Topics include microbial cell structure and function, physiology, metabolism, genetics, diversity, and ecology. Applied aspects of microbiology are also covered such as biotechnology, the role of microorganisms in environmental processes, and medical microbiology.

BIOMI 291 General Microbiology Laboratory
Fall or spring, 2 credits. Summer (6-week session), 2 credits. Prerequisite: concurrent or previous enrollment in BIOMI 290. Lec, F 12:20; labs, M W 12:20–2:15 or 2:30–4:25, or T R 10:10–12:05, 12:20–2:15, or 2:30–4:25. C. M. Rehkugler.
A study of the basic principles and techniques of laboratory practice in microbiology, and fundamentals necessary for further work in the subject.

BIOMI 292 General Microbiology Discussion
Spring. 1 credit. Prerequisite: concurrent or previous enrollment in BIOMI 290. S-U grades only. Disc to be arranged. C. M. Rehkugler.
A series of discussion groups in specialized areas of microbiology to complement BIOMI 290.

BIOMI 300 Seminar in Microbiology
Spring. 1 credit. Required of biological science students in the microbiology program of study. Strongly recommended for students considering the microbiology program of study. S-U grades only. Sem, W 12:20. Staff.
A series of lectures and seminars designed to present students with laboratory safety training and acquaint them with research projects in microbiology on the Cornell campus.

BIOMI 391 Advanced Microbiology Laboratory
Fall. 3 credits. Prerequisites: BIOMI 290, 291, and BIOBM 330 or 331 or 333. Preference given to biological sciences students in the microbiology program of study. Lab, M W 1:25–4:25; disc, F 1:25. J. B. Russell, W. C. Ghiorse, J. P. Shapleigh, S. H. Zinder.
A laboratory course that illustrates basic principles of experimental microbiology. The course is organized into four modules which last three weeks each: 1) ecology, 2) physiology, 3) genetics, and 4) structure and function. Students are encouraged to take this course during their third year of study.

BIOMI 398 Environmental Microbiology
Spring. 3 credits. Prerequisite: BIOES 261 or BIOMI 290 or SCAS 260 or permission of instructor. Lecs, M W F 10:10. W. C. Ghiorse.
The biology, behavior, diversity, and function of microorganisms in natural environments are discussed in relation to past and present environmental conditions on Earth. The role of microorganisms in ecologically and environmentally significant processes is also considered through discussion of specific topics such as elemental cycles, nutrient cycling, transformation of pollutant chemicals, wastewater treatment, and environmental biotechnology.

[BIOMI 404 Pathogenic Bacteriology and Mycology (also VETMI 404)
Spring. 2 or 3 credits (3 credits with lecture and seminar with permission of instructor for undergraduates). Prerequisites: BIOMI 290 and 291. Strongly recommended: BIO G 305. Lecs, M W 10:10; sem, F 10:10. Offered alternate years. Not offered 1999–2000. M. Wiedmann.

This is a course in medical microbiology, presenting the major groups of bacterial and mycotic pathogens important to human and veterinary medicine. The emphasis of this course is infection and disease pathogenesis. Topics include disease causality; interactions of host, pathogen and environment, including immunity to bacteria and fungi; and principles of antimicrobial therapy and drug resistance. A companion seminar addresses the current and classic literature related to microbial pathophysiology on the cellular and molecular level.]

[BIOMI 406 Clinical Microbiology
Fall and spring. 15 credits each semester. Prerequisite: permission of instructor. Hours to be arranged. Not offered 1999–2000, 2000–2001. R. P. Mortlock.
Training and practical experience in clinical microbiology in the hospital laboratory of the Cornell Medical College and New York Hospital in New York City. Emphasis is on developing students' capability in the isolation and rapid identification of organisms from various types of clinical specimens. This course is intended to prepare the student for state and federal licensing in various areas of clinical microbiology. This is a full-time program, taking place from September to August of the student's senior year.]

BIOMI 408 Viruses and Disease I (also VETMI 408)
Spring. 3 credits. Prerequisites: BIOMI 290, 291; BIO G 305; and permission of instructor. Recommended: BIOGD 281. Lecs, M W 7:30 p.m. Offered alternate years. J. Casey.
The course covers basic concepts in virology with emphasis on virus-host interactions, strategies for gene regulation, and mechanisms of pathogenicity. Selected viral infections that result in immune dysfunction and neoplasia are highlighted in the context of approaches to prevent or reduce the severity of diseases.

[BIOMI 409 Viruses and Disease II (also VETMI 409)
Fall. 2 credits. Prerequisites: BIOMI 290 & 291. Recommended, BIOMI 408, BIOBM 330–332, BIOBM 432. Lecs, W 7–9:00 p.m. Offered alternate years. Not offered 1999–2000. G. Whittaker.
This course will be complementary to BIOMI 408, Viruses and Disease I, and will emphasize RNA viruses. The course will be complete in its own right. As such, completion of BIOMI 408 is not a requirement, but is encouraged. The structure and classification of viruses, virus entry, genome replication and assembly will be studied with particular emphasis on virus-host cell interactions. Vaccination, chemotherapy and evolution of viruses will also be discussed.]

BIOMI 415 Bacterial Diversity
Fall. 3 credits. Prerequisites: BIOMI 290, 291, and BIOBM 330 or 331 or 333. Lecs, M W F 11:15. S. H. Zinder.
A consideration of the physiology, ecology, genetics, and practical potential of important groups of bacteria. Topics include molecular methods for determining bacterial phylogeny and taxonomy, the evolution of diverse mechanisms of energy conservation, fixation of carbon and nitrogen, and adaptation to extreme environments.

BIOMI 416 Bacterial Physiology
Spring. 3 credits. Prerequisites: BIOMI 290, 291, and BIOBM 330 or 331 or 333, or their equivalents. Lecs, M W F 11:15. J. P. Shapleigh.
The concern is with the physiological and metabolic functions of bacteria. Consideration is given to chemical structure, regulation, growth, and energy metabolism. Special attention is given to those aspects of bacterial metabolism not normally studied in biochemistry courses.

BIOMI 417 Medical Parasitology (also VETMI 431)
Fall. 2 credits. Prerequisites: courses pertaining to zoology and biology. Offered alternate years. Lecs, T R 3:35–4:25. D. Bowman.
A systematic study of anthropod, protozoan, and helminth parasites of public health importance with emphasis on epidemiologic, clinical, and zoonotic aspects of these parasitisms.

BIOMI 485 Bacterial Genetics
Fall. 2 credits. Graduate students, see BIOMI 685. Prerequisite: BIOGD 281. Recommended: BIOMI 290 and BIOBM 330 or 331 and 332 or 333. Lecs, W 7:30–9:25 p.m. Staff.
Concepts and principles of formal genetic analysis as applied to prokaryotes, with emphasis on enterobacteria and their viruses. Topics include mutagenesis and isolation of mutants; genetic exchange, recombination and mapping; complementation, epistasis and suppression; transposons; gene expression and regulation; and genetics of bacterial pathogenesis.

BIOMI 652 (Section 03) Molecular Plant-Microbe Interactions (BIOPL 652, Sec 03)
Spring. 1 credit. Prerequisites: BIOGD 281, BIOBM 330 or 331 or 333, and BIOPL 653 (section 01) or their equivalents. S-U grades optional. Lecs, M W F 10:10 (12 lecs) first third of semester. S. C. Winans.
For course description, see BIOPL 652, Sec 03.

[BIOMI 685 Advanced Bacterial Genetics
Fall. 2 credits. Limited to graduate students; see BIOMI 485. Prerequisites: BIOGD 281 or equivalent, BIOBM 330 or 331 and 332 or equivalent, and permission of instructor. Recommended: BIOMI 290 or equivalent. Lec, W 7:30–9:25 p.m.; disc to be arranged. Not offered 1999–2000, 2000–2001. Staff.
Concepts and principles of formal genetic analysis as applied to prokaryotes, with emphasis on enterobacteria and their viruses. Lectures and some written assignments are shared with BIOMI 485; advanced topics from the primary literature are critically evaluated in the discussion.]

[BIOMI 692 Protein-Nucleic Acid Interactions
Spring. 3 credits. Prerequisites: BIOBM 330 or 331 or 333 and 633. Lecs, T R 10:10–11:25. Offered alternate years. Not offered 1999–2000. J. D. Helmann.
The physical and chemical bases of protein-nucleic acid interactions are explored including both theory and specific examples. Proteins considered include bacterial non-specific and sequence specific DNA and RNA binding proteins, nucleic acid polymerases, recombinases, topoisomerases, DNA repair enzymes, and nucleases.]

[BIOMI 694 Genetics of Diverse Bacteria
Spring. 3 credits. Prerequisite: BIOMI 485 or equivalent. Lecs, M W 2:30–3:45. Not offered 1999–2000. Staff.
Selected topics in bacterial diversity, with strong emphasis placed on underlying molecular mechanisms. Topics include interactions between bacteria and plants and animals, prokaryotic developmental biology, biodegradation of xenobiotics, and synthesis of antibiotics.]

BIOMI 791 Advanced Topics in Bacterial Genetics
Fall or spring. 1 credit. May be repeated for credit. Prerequisite: graduate standing in microbiology. S-U grades only. Disc, T 4–5:00. S. C. Winans.
Discussion and critical evaluation of selections from the contemporary literature in bacterial genetics and molecular biology.

BIOMI 795–796 Current Topics in Microbiology
Fall, 795; spring, 796. 1/2 or 1 credit for each topic. May be repeated for credit. Designed primarily for graduate students in microbiology. Prerequisite: upper-level courses in microbiology. S-U grades only. Lecs to be arranged. Staff.
Lectures and seminars on special topics in microbiology.

BIOMI 797 Graduate Seminar in Microbiology
Fall and spring. 1 credit each semester. All students in the Graduate Field of Microbiology must enroll for at least their first three semesters in residence. Students are expected to lead discussions on recent primary literature in microbiology. S-U grades only. Sem to be arranged. Staff.

BIOMI 798 Graduate Research Seminar in Microbiology
Fall and spring. 1 credit each semester. Required of all graduate students in the Graduate Field of Microbiology. S-U grades only. Sem to be arranged. Staff.
A seminar relating to the research activities of those enrolled. Students who have completed the BIOMI 797 series requirement are required to present a seminar concerning their research interests and activities at least once each year.

BIOMI 799 Microbiology Seminar
Fall and spring. Required of all graduate students in the Graduate Field of Microbiology and open to all who are interested. Sem to be arranged. Staff.

Related Courses in Other Departments

Advanced Food Microbiology (Food Science 607)

Advanced Immunology Lectures (Biological Sciences [BIO G] 705 and Veterinary Microbiology 705)

Advanced Soil Microbiology (Soil, Crop, and Atmospheric Sciences 666)

Advanced Work in Bacteriology, Virology, or Immunology (Veterinary Microbiology 707)

Bacterial Plant Diseases (Plant Pathology 647)

Basic Immunology, Lectures (Biological Sciences [BIO G] 305 and Veterinary Microbiology 315)

Ciliophorology (Biological Sciences [BIOSM] 409)

Ecology of Soil-Borne Pathogens (Plant Pathology 644)

Food Microbiology, Laboratory (Food Science 395)

Food Microbiology, Lectures (Food Science 394)

Immunology of Infectious Diseases and Tumors (Biological Sciences [BIO G] 706 and Veterinary Microbiology 719)

Introduction to Scanning Electron Microscopy (Biological Sciences [BIO G] 401)

Introductory Mycology (Plant Pathology 309)

Light and Video Microscopy for Biologists (Biological Sciences [BIO G] 450)

Limnology: Ecology of Lakes, Lectures (Biological Sciences [BIOES] 457)

Magical Mushrooms, Mischievous Molds (Plant Pathology 201)

Microbiology for Environmental Engineering (Civil and Environmental Engineering 451)

Plant Virology (Plant Pathology 645)

Principles of Biogeochemistry (Biological Sciences [BIOES] 668)

NEUROBIOLOGY AND BEHAVIOR (BIONB)

BIONB 221 Neurobiology and Behavior I: Introduction to Behavior

Fall. 3, 4, or 5 credits (4 credits with one discussion per week; 5 credits with two discussions per week and participation in the Writing in the Majors program). 4- or 5-credit option required of students in the neurobiology and behavior program of study. Each 4-credit discussion section is limited to 20 students, with preference given to students studying neurobiology and behavior. Enrollment in the 5-credit option is limited to 15 students. Students may not preregister for the 5-credit option; interested students complete an application form on the first day of class. Not open to freshmen. Prerequisite: one year of introductory biology for majors. May be taken independently of BIONB 222. S-U grades optional. Lecs, M W F 12:20; disc to be arranged. S. T. Emlen and staff.

A general introduction to the field of behavior. Topics include evolution and behavior, behavioral ecology, sociobiology, chemical ecology, communication, rhythmicity, orientation and navigation, and hormonal mechanisms of behavior.

BIONB 222 Neurobiology and Behavior II: Introduction to Neurobiology

Spring. 3 or 4 credits (4 credits with discussion and written projects). 4-credit option required of students studying neurobiology and behavior. Each discussion limited to 20 students, with preference given to students studying neurobiology and behavior. Not open to freshmen. Prerequisites: one year of introductory biology for majors and one year of chemistry. May be taken independently of BIONB 221. S-U grades optional. Lecs, M W F 12:20; disc to be arranged. R. Booker and staff.

A general introduction to the field of cellular and integrative neurobiology. Topics include neural systems, neuroanatomy, developmental neurobiology, electrical properties of nerve cells, synaptic mechanisms, neurochemistry, motor systems, sensory systems, learning, and memory. Some discussion sections include dissections of preserved brains.

BIONB 322 Hormones and Behavior (also PSYCH 322)

Spring. 3 credits; two lectures plus a section in which students will read and discuss original papers in the field, give an oral presentation, and write a term paper. Limited to juniors and seniors. Prerequisites: PSYCH 223 or BIONB 221 or BIONB 222 or one year of introductory biology plus a course in psychology. S-U grades optional, but not recommended. Lec M W F 11:15. E. Adkins-Regan.

A major focus of the course will be comparative and evolutionary approaches to the study of the relationship between reproductive hormones and sexual behavior in vertebrates, including humans. Also included will be hormonal contributions to parental behavior, aggression, stress, learning and memory, and biological rhythms.

BIONB 324 Biopsychology Laboratory (also PSYCH 324)

Fall. 4 credits. Limited to 20 upperclass students. Prerequisites: laboratory experience in biology or psychology, BIONB 221 and 222 or PSYCH 123 and 222; and permission of instructor. Labs, T R 1:25–4:25. T. DeVoogd.

Experiments designed to provide research experience in animal behavior (including learning) and its neural and hormonal mechanisms. A variety of techniques, species, and behavior patterns are included. Live animals are used in the laboratory.

BIONB 325 Neurodiseases—Molecular Aspects

Fall. 3 credits. Prerequisites: two courses from BIONB 222, BIOGD 281, BIOBM 330, or 331; co-registration in one of the two is acceptable. S-U grades optional. Lecs, T R 9:05; disc, T 1:30 or 2:30. T. R. Podleski.

The intent of this course is to teach students how to use recombinant DNA techniques for the study of neurodiseases. How are genes responsible for diseases identified and how are the functions of these genes studied? Attention is focused on those neural diseases in which significant advances have been made using these techniques, for example, Alzheimer's, Huntington's, Prion diseases, schizophrenia, depression, disorders affecting ion channels, and muscular dystrophies. Emphasis is placed on how these studies provide a useful approach to studying the mammalian nervous system by exposing the functions of genes that would be difficult to identify in other ways.

BIONB 326 The Visual System

Spring. 4 credits. Prerequisite: BIONB 222 or BIOAP 311, or permission of instructor. S-U grades optional. Lecs, M W F 10:10; disc, 1 hour each week to be arranged. Offered alternate years. H. C. Howland.

The visual systems of vertebrates are discussed in breadth and depth. Topics covered include the optics of eyes, retinal neurophysiology, structure and function of higher visual centers, and ocular development.

BIONB 328 Biopsychology of Learning and Memory (also PSYCH 332)

Spring. 3 credits. Prerequisites: one year of biology and either a course in biopsychology or BIONB 222. Lecs, M W F 11:15. T. DeVoogd.

This course surveys the approaches that have been or are currently being used in order to understand the biological bases for learning and memory. Topics include invertebrate, "simple system" approaches, imprinting, avian song learning, hippocampal and cerebellar function, and human pathology. Many of the readings are from primary literature.

BIONB 392 Drugs and the Brain

Spring. 3 credits. Prerequisites: BIONB 222 or equivalent and permission of instructor. S-U grades optional. Lecs, T R 10:10–11:25; disc to be arranged. Offered alternate years. R. Harris-Warrick.

An introduction to neuropharmacology. After a brief introduction to pharmacology, there is discussion of the major neurotransmitter families. Topics include the biological actions of the major psychoactive drugs on the brain, including cocaine, amphetamines, alcohol, psychedelics, marijuana, antidepressants and antipsychotics.

BIONB 396 Introduction to Sensory Systems (also PSYCH 396 and 696)

Spring. 3 or 4 credits (4 credits with term paper or web site). Registration for the 4-credit option requires permission of instructor. Prerequisites: an introductory course in biology or biopsychology, plus a second course in neurobiology or behavior or perception or cognition or biopsychology. Students are expected to have elementary knowledge of perception, neurophysiology, behavior, and chemistry. No auditors. Lecs, M W F 10:10. Offered alternate years. B. P. Halpern.

This course is taught using the Socratic method, in which the instructor asks questions of the students. Students read, analyze, and discuss in class difficult original literature dealing with both those characteristics of sensory systems that are common across living organisms and those sensory properties which represent adaptations of animals to particular habitats or environments. Classroom discussion can increase, but not decrease, a student's final grade. The principles and limitations of major methods used to examine sensory systems are considered. General principles of sensory systems and auditory, visual, and somesthetic systems are covered. One aspect of each system (e.g., localization of objects in space by sound, color vision, and thermoreception) is selected for special attention. Two or more textbooks, and a course packet of reproduced articles are used. At the level of *An Introduction to the Physiology of Hearing*, 2nd edition, by J. O. Pickles; *Physiological acoustics, neural coding, and psychoacoustics*, by W. L. Gulick, G. A. Gescheider, and R. D. Frisina; *The Retina: An approachable part of the brain*, by J. E. Dowling; *Handbook of Physiology—The Nervous System. III. Sensory Processes*, edited by J. M. Brookhard and V. B. Mountcastle.

BIONB 420 Topics in Neurobiology and Behavior

Fall or spring. Variable credit. May be repeated for credit. Primarily for undergraduates. S-U grades optional. To be arranged. Staff.

Courses on selected topics in neurobiology and behavior; can include lecture and seminar courses. Topics, instructors, and time of organizational meetings are listed in the division's catalog supplement issued at the beginning of the semester.

BIONB 421 Effects of Aging on Sensory and Perceptual Systems (also PSYCH 431 and 631)
Fall. 3 or 4 credits (4 credits with term paper or web site). Limited to 25 students. Prerequisites: introductory course in biology or psychology, plus a second course in perception, neurobiology, cognition, or biopsychology. No auditors. S-U grades optional. Lecs, T R 10:10–11:25. B. P. Halpern.
A literature-based examination of post-maturation changes in the perceptual, structural, and physiological characteristics of somesthetic, chemosensory, visual and auditory systems. Emphasis is on human data, with non-human information included when especially relevant. The course examines the current developments in human sensory prosthetic devices, and in regeneration of receptor structures. Brief written statements (by electronic mail) of questions and problems related to each set of assigned readings are required at least one day in advance of each class meeting. This course is taught using the Socratic Method, in which the instructor asks questions of the students. Students are expected to come to each class having already done, and thought about, the assigned readings. Use of e-mail and the internet are integral parts of the course.

[BIONB 422 Modeling Behavioral Evolution
Spring. 4 credits. Limited to 25 students. Prerequisites: BIONB 221, one year of calculus, one course in probability or statistics, and *permission of instructor* (Office: W309 Mudd Hall; phone: 254-4352). This course is open to advanced undergraduates and graduate students. S-U grades optional. Lecs, T R 2:30–4:00; computer lab, one class period per week to be arranged. Offered alternate years. Not offered 1999–2000. H. K. Reeve.
This is an intensive lecture and computer lab course on modeling strategies and techniques in the study of behavioral evolution. Population-genetic (including quantitative-genetic), static optimization, dynamic programming, and game-theoretic methods are emphasized. These approaches are illustrated by application to problems in optimal foraging, sexual selection, sex ratio evolution, animal communication, and the evolution of cooperation and conflict within animal social groups. Students learn to assess critically recent evolutionary theories of animal behavior, as well as to develop their own testable models for biological systems of interest or to extend pre-existing models in novel directions. The *Mathematica* software program is used as a modeling tool in the accompanying computer lab (no prior experience with computers required).]

[BIONB 424 Neuroethology (also PSYCH 424)
Spring. 3 credits. Prerequisites: BIONB 221 and 222. S-U grades optional. Lecs, T 9:05–11:05; R 9:05–9:55. Offered alternate years. Not offered 1999–2000. C. D. Hopkins.
In the 1950s through the 1970s, ethologists attempted to understand the mechanisms of animal behavior through the use of comparative methods, evolutionary analysis, careful observations of animals in their native habitats, and clever experimentation. Now, with the explosion of knowledge and techniques in the neurosciences, many of the ethologist's mechanisms are being explained in terms of neural systems. This course reviews the status of research in neuroethology, including mechanisms of acoustic communication in insects and in verebrates, echolocation in bats and sound localization in owls, electroreception and electrolocation, and visual processing. In addition, the course reviews studies of the neural systems involved in decision making, in initiating action, and in coordinating fixed acts. Assigned readings include original articles from the scientific literature. A term paper or equivalent is required. Recitations scheduled in class.]

[BIONB 425 Molecular Neurophysiology
Spring. 3 credits. Prerequisite: BIONB 222 or permission of instructor. S-U grades optional. Lecs, T R 2:55–4:10. Offered alternate years. Not offered 1999–2000. D. McCobb.
Course focuses on the roles of the primary proteins generating cellular electrical signals and ion channels in nerve cells and other excitable cells (e.g., muscle, heart, glands). Cutting-edge electrophysiological and molecular genetic experiments will be reviewed. Diversity of excitable properties deriving from channel structure will be considered in the contexts of behavior and behavioral plasticity (learning), neural development, and channel evolution. Course format includes written and oral presentations reviewing scientific literature in selected areas and proposing new experiments.]

[BIONB 426 Animal Communication
Spring. 4 credits. Limited to 50 students. Prerequisite: BIONB 221. Letter grade only. Lecs, T R 2:30–4:25; disc, one hour each week to be arranged. Offered alternate years. Not offered 1999–2000. Staff.
A detailed examination of the study of communication by non-human animals. The course begins with an exploration of different conceptual frameworks used in the study of communication, then turns to specific studies of the mechanisms, ontogeny, functional design, and evolutionary history of the signaling systems used by animals. The class considers how communication provides humans with a window on the minds of other animals. Readings are drawn from the primary literature.]

BIONB 427 Animal Social Behavior
Fall. 4 credits. Limited to 30 students. Prerequisites: BIONB 221 and BIOES 261 or 278, and advance permission of instructor. S-U grades optional, with permission of instructor. Lecs and discs, T R 2:30–4:25. Offered alternate years. P. W. Sherman.
An intensive course for upper-division students interested in behavorial ecology and sociobiology. Lectures, discussions, and student presentations examine topics including adaptation, communication, mating systems, sexual selection, sex ratios, inbreeding and outbreeding, conflict and cooperation in animal societies, eusociality, kin recognition, and Darwinian medicine.

BIONB 428 Topics in Behavior
Fall or spring. 2–4 credits. (Credits based on number of lectures and/or field exercises as outlined in the division's catalog course supplement and subject to approval through the associate director's office.) May be repeated for credit. Primarily for undergraduates. S-U grades optional.
Courses on selected topics in behavior; can include lecture and seminar courses; may include laboratory. Past topics have included animal orientation, insect behavior, biorhythms, and communication. Topics, instructors, and time of organizational meeting are listed in the division's catalog supplement issued at the beginning of each semester.

[BIONB 429 Olfaction and Taste: Structure and Function (also PSYCH 429)
Spring. 3 or 4 credits (4 credits with term paper or research project, which can, but need not, study nonhuman vertebrates). Preference given to junior and senior psychology and biology majors and graduate students. Graduate students, see PSYCH 629. Prerequisite: a 300-level course in biopsychology or equivalent. Lecs, T R 9:05. Offered alternate years. Not offered 1999–2000. B. P. Halpern.
The structural and functional characteristics of olfaction and taste are explored by reading and discussing current literature in these areas. Structure is examined at the light levels of electron microscopes as well as at the molecular level. Function is examined primarily in its neurophysiological and biochemical aspects. The emphasis is on vertebrates, especially air-breathing vertebrates in the case of olfaction, although there is some coverage of invertebrate forms. A textbook and a course packet of reproduced articles are used. At the level of *Smell and Taste in Health and Disease*, edited by T. V. Getchell, R. L. Doty, L. M. Bartoshuk, and J. B. Snow; *The Neurobiology of Taste and Smell*, edited by T. E. Finger and W. L. Silver.]

[BIONB 430 Experimental Molecular Neurobiology
Spring. 2 credits. Limited to 12 students. Prerequisites: co-meeting with BIOBM 430 lab. Mandatory registration via web page: www.bio.cornell.edu/biochem/biobm/signup.html. Disc, one hour each week on day other than lab day; Lab T or R all day, or M and W afternoons, to be coordinated with other BIOBM 430 sections. Letter grade only. Offered alternate years. Not offered 1999–2000. D. L. Deitcher.
Experiments include PCR, cloning of DNA fragments, RNA purification, restriction digests, bacterial transformation, and DNA sequencing. Experiments will emphasize how molecular techniques can be applied to studying neurobiological problems.]

BIONB 470 Biophysical Methods
Spring. 3 credits. Limited to 20 students. Prerequisites: solid knowledge of basic physics and mathematics through the sophomore level; some knowledge of cellular biology helpful but not required. Letter grades only. Lecs T R 8:40–9:55. M. Lindau.
An overview of the diversity of modern biophysical experimental techniques used in the study of biological systems at the cellular and molecular level. Topics covered will include methods that examine both structure and function of biological systems, with emphsis on the applications of these methods to biological membranes. The course format will include assigned literature reviews by the students on specific biophysics topics and individual student presentations on these

topics. The course in intended for students of the engineering, physics, chemistry, and biological disciplines who seek an introduction to modern biophysical experimental methods.

BIONB 491 Principles of Neurophysiology
Spring. 4 credits. Limited to 20 students. Prerequisite: BIONB 222 or written permission of instructor. S-U grades optional for graduate students. Lecs, M W 10:10; lab, M or T 12:20–4:25; additional hours to be arranged. B. R. Johnson.
A laboratory-oriented course designed to teach the theory and techniques of modern cellular neurophysiology. Lecture time is used to introduce laboratory exercises and discuss results, to supplement laboratory topics, and for discussion of primary research papers. Extracellular and intracellular recording and voltage clamp techniques are used to analyze motor neuron and sensory receptor firing properties, and examine the cellular basis for resting and action potentials and synaptic transmission. A variety of preparations are used as model systems. Computer acquisition and analysis of laboratory results are emphasized.

[BIONB 492 Sensory Function (also PSYCH 492)
Spring. 4 credits. Limited to 25 students. Prerequisite: a 300-level course in biopsychology or BIONB 222 or BIOAP 311, or permission of instructors. Students are expected to have a knowledge of elementary physics, chemistry, and behavior. S-U grades optional. Lecs, M W F 10:10; disc, hours to be arranged. Offered alternate years. Not offered 1999–2000. B. P. Halpern, H. C. Howland.
This course covers classical topics in sensory function such as vision, hearing, touch, and balance, as well as some more modern topics like sensory coding, location of stimulus sources in space, the development of sensory system, and nonclassical topics such as electroreception and internal chemoreceptors. Both human and nonhuman systems are discussed. In all cases the chemical, physical, and neurophysiological bases of sensory information are treated, and the processing of this information is followed into the central nervous system.

This course will be taught using the Socratic method, in which the instructors ask questions of the students, and their answers will be discussed. Students will be expected to come to each class having read, thought about, and prepared to discuss the assigned readings and other assigned information resources. Students will submit brief analyses of, and comments and questions on, all assignments by e-mail to the course's electronic mailing list a day before each class meeting. The mailing list will distribute submissions to all members of the class and to the instructors. In addition to these brief triweekly written exercise, a term paper or web site in the form of a review article will be required.]

[BIONB 493 Developmental Neurobiology
Fall. 3 credits. Prerequisite: BIONB 222 or permission of instructor. S-U grades optional, with permission of instructor. Lecs, T R 11:40–12:55. Offered alternate years. Not offered 1999–2000. R. Booker.
Lectures covering the development of the nervous system, taking examples from both vertebrates and invertebrates. Emphasis is on cellular and molecular issues, that is, how do nerve cells differentiate both morphologically and biochemically? The role of cues such as hormones and developmental genes in neural development is discussed. Readings are taken from original journal articles.]

[BIONB 494 Comparative Vertebrate Neuroanatomy
Spring. 3 credits. Intended for juniors, seniors, and graduate students. Prerequisite: BIONB 222 or equivalent. S-U grades optional. Lecs, T R 10:10–11:30. Offered alternate years. Not offered 1999–2000. A. H. Bass.
Organization and evolution of neuroanatomical pathways as substrates for species-typical vertebrate behaviors. The course is divided into three major sections: development, general principles of brain organization, and co-evolution of vertebrate brain and behavior.]

BIONB 495 Molecular and Genetic Approaches to Neuroscience
Fall. 3 credits. Limited to juniors, seniors, and graduate students. Prerequisites: BIONB 222 and BIOBM 330 or 332. Letter grade only. Lecs, T R 2:55–4:10. Offered alternate years. D. Deitcher.
Focus of the course is on how different molecular and genetic approaches have led to major advances in neuroscience. Lectures, student presentations, and discussions examine original research articles. Topics include ligand-gated channels, potassium channels, seven membrane spanning receptors, development of the neuromuscular junction, neurotransmitter release, second messengers, and learning and memory.

[BIONB 496 Bioacoustic Signals in Animals and Man
Spring. 3 credits. Limited to 12 junior, senior, and graduate students. Prerequisites: one year of introductory biology, PHYS 101–102 or 207–208, and permission of instructor. S-U grades optional. Lecs, M W 9:05; lab to be arranged. Offered alternate years. Not offered 1999–2000. C. W. Clark, R. R. Hoy.
Humans and most terrestrial animals live in a world of sound. Acoustic signals mediate social interactions and predator-prey behavior. This course teaches students about animal acoustical communication by introducing them to the different communication systems that are based on sound. The course presents the physical properties of sound, the physiological mechanisms of sound production and hearing, and an analysis of the behavioral context of signaling. In the laboratory students learn how to record, synthesize, and analyze acoustic signals with the aid of tape recorders and the Macintosh computer. Laboratories are designed around the lecture material and provide "real-world" exercises designed to stimulate discovery of the fundamental principles described in class. Class research projects on a selected topic in bioacoustics are required. The laboratory is based on software instrumentation running on a Macintosh II platform equipped with A/D-D/A data acquisition boards.]

[BIONB 623 Chemical Communication (also CHEM 622)
Fall. 3 credits. Primarily for research-oriented students. Limited to 30 students. Prerequisites: one year of introductory biology for majors or equivalent, course work in biochemistry, and CHEM 358 or equivalent. Lecs, M W 10:10; disc, F 10:10. Offered alternate years. Not offered 1999–2000. T. Eisner, J. Meinwald, W. L. Roelofs, and guest lecturers.
The production, transmission, and reception of chemical signals in communicative interactions of animals, plants, and microorganisms. Studies of insects are emphasized. Specific topics are treated with varying emphasis on chemical, biochemical, ecological, behavioral, and evolutionary principles.]

BIONB 626 Sex Differences in Brain and Behavior (also PSYCH 524)
Spring. 2 credits. Limited to 12 students. Prerequisite: BIONB 322 or permission of instructor. Discs and sems to be arranged. T. J. DeVoogd.
A survey of the newly discovered animal models for sex differences in the brain. Topics include the role of steroids in brain development, whether hormones can modify the structure of the adult brain, and the consequences of such sex differences in anatomy for behavior.

BIONB 720 Seminar in Advanced Topics in Neurobiology and Behavior
Fall or spring. Variable credit. May be repeated for credit. Primarily for graduate students; written permission of instructor required for undergraduates. S-U grades optional. Sem to be arranged. Staff and students.
Designed to provide several study groups each semester on specialized topics. A group may meet for whatever period is judged adequate to enable coverage of the selected topics. Ordinarily, topics are selected and circulated during the preceding semester. Discussion of current literature is encouraged. Suggestions for topics should be submitted by faculty or students to the chair of the Section of Neurobiology and Behavior.

BIONB 721 Introductory Graduate Survey in Neurobiology and Behavior
Fall. 2 credits. Required of graduate students majoring in neurobiology and behavior. Concurrent registration in BIONB 221 and 222 not required. S-U grades only. Lecs and discs, T 10:10–12:05. H. C. Howland.
Lectures, readings, and discussion to introduce first-year graduate students to the research activities of the faculty in the Graduate Field of Neurobiology and Behavior. Class meets weekly for two hours. Students will also prepare a research proposal on a potential topic for their thesis research (in the format of an NSF or NIH grant). This proposal will be prepared in consultation with one or more relevant faculty members.

[BIONB 723 Advanced Topics in Animal Behavior
Fall or spring. Variable credit. May be repeated for credit. Primarily for graduate students in behavior. Prerequisite: permission of instructor. S-U grades optional. Sem to be arranged. Not offered 1999–2000. Staff.
A seminar on a specific topic in animal behavior. The instructor presents lectures during the first few course meetings; the remainder of the course is devoted to student presentations. Topic and instructor are listed in the division's catalog supplement issued at the beginning of the semester.]

[BIONB 724 Field Methods in Animal Behavior
Fall or spring. Variable credit. May be repeated for credit. Primarily for graduate students in behavior. Prerequisite: permission of instructor. S-U grades optional. Sem and fieldwork to be arranged. Not offered 1999–2000. Staff.
A seminar-field experience course designed for first-year graduate students in animal behavior. Weekly seminars discussing field methodology, data collection, and hypothesis testing are followed by an intensive period (ten days to two weeks) in the field. Specific topics and field sites vary from semester to semester. Topic and instructor are listed in the division's catalog supplement issued at the beginning of the semester.]

[BIONB 790 Advanced Topics in Cellular and Molecular Neurobiology
Fall or spring. Variable credit. May be repeated for credit. Limited to graduate students and advanced undergraduates studying neurobiology and behavior. Prerequisite: BIONB 222. S-U grades optional. Lecs and sem to be arranged. Not offered 1999–2000. Staff.
A lecture-seminar course on selected topics in cellular and molecular neurobiology. Students read original papers in the scientific literature and lead discussions of these articles. Suggestions for topics may be submitted by faculty or students to the chair of the Section of Neurobiology and Behavior. Topic and instructor are listed in the division's catalog supplement issued at the beginning of the semester.]

[BIONB 792 Advanced Laboratory in Cellular and Molecular Neurobiology
Fall or spring. 2 credits. May be repeated for credit. Primarily for graduate students. Prerequisites: BIOBM 330 or 331 or equivalent, BIONB 491 or equivalent, and written permission of instructor. S-U grades optional. Lab to be arranged. Not offered 1999–2000. Staff.
A two-week intensive laboratory course designed to provide experience with a specific technique currently used in cellular and molecular neurobiology. The technique under study and instructor in charge vary from semester to semester and are listed in the division's catalog supplement issued at the beginning of the semester.]

[BIONB 793 Advanced Topics in Integrative Neurobiology
Fall or spring. Variable credit. May be repeated for credit. Primarily for graduate students; written permission of instructor required for undergraduates. S-U grades optional. Lecs and discs to be arranged. Not offered 1999–2000. Staff.
A course designed to provide in-depth knowledge of current research in anatomical and physiological bases of vertebrate and invertebrate behavior. Readings are primarily from specialty books and selected journal articles. Topic and instructor are listed in the division's catalog supplement issued at the beginning of the semester.]

[BIONB 794 Advanced Laboratory Techniques in Integrative Neurobiology
Fall or spring. Variable credit. May be repeated for credit. Prerequisite: permission of instructor based upon a personal interview. Lab to be arranged. Not offered 1999–2000. Staff.
A laboratory in the integrative, or neuroethological, approach to studies of animal behavior. Designed to provide practical working knowledge of research methods in anatomical, physiological, and behavioral approaches to studies of vertebrate and invertebrate behavior. Laboratory technique to be covered and instructor are listed in the division's catalog supplement issued at the beginning of the semester.]

Related Courses in Other Departments

Animal Behavior (Psychology 535)

Biochemistry and Human Behavior (Psychology 361 and Nutritional Sciences 361)

Brain and Behavior (Psychology 425)

Developmental Biopsychology (Psychology 422)

Evolution and Development (BIOGD 480/780; BIOES 760; BIO G 400)

Evolution of Human Behavior (Psychology 326)

Human Behavior: A Sociobiological Perspective (Anthropology 476)

Insect Behavior Seminar (Entomology 662)

Neurobiology of Animal Behavior (Biological Sciences [BIOSM] 327)

Primates and Evolution (Anthropology 490)

Primate Behavior and Ecology (Anthropology 390)

Teaching Experience (Biological Sciences [BIO G] 498)

The Brain and Sleep (Psychology 440/640)

Undergraduate Research in Biology (Biological Sciences [BIO G] 499)

OTS Undergraduate Semester Abroad Programs

Shoals Marine Laboratory Program

PLANT BIOLOGY (BIOPL)

BIOPL 240 Green World/Blue Planet
Spring. 3 credits. S-U grades optional. Lecs, T R 1:25–2:40. K. J. Niklas and staff.
The course focuses on helping individuals understand how scientific information relates to the issues they face as citizens, in management decision making, and in public policy. To what extent should genetic engineering of crop plants be permitted? Should we place limits on fossil fuel consumption as a means of limiting global warming and global climate change? Must human endeavors be restricted in certain areas to maintain diversity? The format of this course is interactive, with lectures and discussions about how we as a society deal with controversial issues.

BIOPL 241 Introductory Botany
Fall. 3 credits. Lecs, T R 9:05; lab, M T W or R 1:25–4:25, or M W 7:30–10:30 p.m. K. J. Niklas.
Introductory botany for those interested in the plant sciences. Emphasizes structure, reproduction, and classification of angiosperms and the history of life on earth. Laboratory emphasizes development of skills in handling plant materials, including identification. First and second weeks of laboratory are field trips, starting with the first day of classes. *Those who register for an evening laboratory are still required to attend the afternoon field trips.*

BIOPL 242 Plant Physiology, Lectures
Spring. 3 credits. Lecs, M W F 10:10. S-U grades optional. Primarily for undergraduates in agricultural sciences, but also for any Biological Sciences students wanting to know about plant function. Suitable as a second-level course for nonmajors to satisfy the biology distribution requirement. Prerequisites: one year of introductory biology and/or BIOPL 241. Recommended: one year of introductory chemistry. Concurrent enrollment in BIOPL 244 required of plant science undergraduates and highly recommended for other science majors. May not be taken for credit after BIOPL 342 except by written permission of instructor. Evening prelims Feb. 24 and March 30. P. J. Davies.
How plants function and grow. Examples deal with crop plants or higher plants where possible, though not exclusively. Topics include cell structure and function; plant metabolism, including photosynthesis; light relations in crops; plant-water relations; water uptake, transport, and transpiration; irrigation of crops; sugar transport; mineral nutrition; growth and development—hormones, responses to light, flowering, fruiting, dormancy, and abscission; stress; tissue culture; and genetic engineering of plants.

[BIOPL 243 Taxonomy of Cultivated Plants (also HORT 243)
Fall. 3 credits. Prerequisite: one year of introductory biology or written permission of instructor. May not be taken for credit after BIOPL 248. Lecs, M W 10:10; labs, W 2–4:25. Offered alternate years. Not offered 1999–2000. M. A. Luckow.
A study of ferns and seed plants, their relationships, and their classification into families and genera, emphasizing cultivated plants. Particular emphasis is placed on gaining proficiency in identifying and distinguishing families and in preparing and using analytic keys. Attention is also given to the economic importance of taxa, to the basic taxonomic literature, and to the elements of nomenclature.]

BIOPL 244 Plant Physiology, Laboratory
Spring. 2 credits. Prerequisite: concurrent enrollment in BIOPL 242. May not be taken for credit after BIOPL 344. Disc and lab, M T W or R 12:20–4:25. T. Silva.
Experiments exemplify concepts covered in BIOPL 242 and offer experience in a variety of biological and biochemical techniques, including use of small amounts of radioisotopes.

BIOPL 245 Plant Biology
Summer (6–week session). 3 credits. Limited to 24 students. Lecs, M-F 11:30–12:45; labs, M W 2–5:00. T. Silva.
Introductory botany, including plant identification. Emphasizes structure, reproduction, and classification of flowering plants. Much of the laboratory work is conducted outdoors taking advantage of several outstanding natural areas which are available for study. Those who lack college-level biology are expected to work closely with the instructor on supplemental instructional materials.

BIOPL 247 Ethnobiology
Fall. 3 credits. S-U grades optional. Lecs, T R 11:15; disc, R 12:20 or 1:25. D. M. Bates.
A consideration of the principles, methods, and issues of ethnobiology. Emphasis is on the past and present ecological, evolutionary, economic, and cultural interrelationships of humans in traditional and lay societies with their plants and animals, as a means of understanding the place and future of humans in the biosphere. Traditional medicines, underutilized organisms, resource management, and ownership of nature, and methodology are among the topics covered.

BIOPL 248 Taxonomy of Vascular Plants
Spring. 4 credits. Prerequisite: one year of introductory biology. May not be taken for credit after BIOPL 243. S-U grades optional. Lecs, M W F 9:05; lab, W or R 1:25–4:25. J. I. Davis.
An introduction to the classification of vascular plants, with attention to the goals of taxonomy, the processes of plant evolution, and the means of analyzing evolutionary relationships among plants. The laboratory concentrates on methods of plant identification and presents an overview of vascular plant diversity, with particular attention to the flowering plants.

BIOPL 340 Methods in Chemical Prospecting
Spring. 2 credits. Prerequisites: Intro Biology (BIOG 101–104, 105–106, 107–108) required. Completion or concurrent enrollment in organic chemistry, recommended. Lab to be arranged. Offered alternate years. J. Berry and E. Rodriguez.
Student participants will learn theory and methodologies, including biological assays and other techniques, related to investigation of natural products from the biological world, and apply these methodologies to individual research projects. Each student will present results of their research in a poster session, in addition to preparing a scientific report.

BIOPL 342 Plant Physiology, Lectures
Spring. 3 credits. Prerequisites: one year of introductory biology and either concurrent enrollment in BIOPL 344 or written permission of instructor. May not be taken for credit after BIOPL 242 unless written permission is obtained from instructor. Lecs, T R 10:10–11:25. T. G. Owens.
An integrated and interdisciplinary study of the processes that contribute to the growth, competition, and reproduction of plants. Topics include, but are not limited to, plant water relations, membrane properties and processes, photosynthesis, plant respiration, mineral and organic nutrition, stress physiology, control of growth and development, and responses to the environment. Emphasis is on the relationship between structure and function from the molecular to the whole-plant level.

BIOPL 343 Molecular Biology and Genetic Engineering of Plants
Fall. 2 credits. Prerequisite: one year general biology or permission of instructor. S-U grades optional. Lecs, T R 11:15. M. E. Nasrallah.
An introduction to current studies involving recombinant DNA technology and its application to the improvement of plants. The course emphasizes genetic transformation methodology, gene expression systems, and strategies for increasing productivity. The course is directed at undergraduates who wish to become familiar with the theory and practice of plant biotechnology.

BIOPL 344 Plant Physiology, Laboratory
Spring. 2 credits. Prerequisite: concurrent enrollment in BIOPL 342. May not be taken for credit after BIOPL 244. Similar to BIOPL 244 but at a more advanced level. Lab, W 1:25–4:25; disc, W 12:20. T. Silva.
Experiments exemplify concepts covered in BIOPL 342 and offer experience in a variety of biological and biochemical techniques, including use of small amounts of radioisotopes, with emphasis on experimental design.

BIOPL 345 Plant Anatomy
Fall. 4 credits. Limited to 15 students. Prerequisite: one year of introductory biology or a semester of botany. Lecs, M W 9:05; labs, M W 2–4:25. Offered alternate years. D. J. Paolillo.
A descriptive course with equal emphasis on development and mature structure. Lecture, laboratory, and reading are integrated in a study guide. The laboratory offers the opportunity to develop the practical skills required to make anatomical diagnoses and to write anatomical descriptions.

BIOPL 347 Laboratory in Molecular Biology and Genetic Engineering of Plants
Fall. 2 credits. Limited to 24 students. Prerequisite: BIOPL 343 or permission of instructor. Concurrent enrollment is BIOPL 343 is encouraged. S-U grades optional. Lab, W 12:25–4:25. M. E. Nasrallah.
A companion to BIOPL 343 with laboratory activities that focus on the practice of plant biotechnology. Students will transfer genes to plants by a variety of methods, and will analyze their expression in the host genome by use of reporter gene assays, and by the preparation and analysis of nucleic acids.

BIOPL 348 The Healing Forest
Spring. 2 credits. Prerequisites: BIOPL 247 or BIOPL 241, 243, or 248 or permission of instructor. Lec/disc, R 2:30–4:25. Offered alternate years. D. M. Bates, E. Rodriguez.
An ethnobotanical consideration of the role of plants in traditional and western medicine. Studies of indigenous and lay societies illustrate the ecological, systematic, biochemical, and cultural aspects of herbal medicines and are placed in the broader context of such interdependent themes as the conservation of biological and cultural diversity, human health, bioprospecting, compensation for indigenous knowledge, and sustainable development.

[BIOPL 440 Phylogenetic Systematics
Fall. 4 credits. Limited to 24 students. Prerequisite: graduate standing or permission of instructor. Lecs, T R 10:10; labs, T R 2:00–4:25. Offered alternate years. Not offered 1999–2000. K. C. Nixon.
Basic and advanced theory and methods of phylogenetic analysis. Students are introduced to cladistic analysis using parsimony and gain experience with computer-aided analysis of taxonomic data, including both morphological and molecular data sources. Topics discussed include applications of phylogenetic methods to biogeography and evolutionary studies.]

BIOPL 441 Systematics and Evolution of Crops
Fall. 2 credits. Prerequisite: an advanced-level course in the plant sciences with taxonomic content or permission of instructor. Lecs, R 12:20–2:15. Offered alternate years. D. M. Bates.
An integrated study of the systematics and evolution of agronomic and horticultural species. Processes of domestication, the evolutionary history of selected cultigens, the nature of weeds and land races, classification and nomenclature as applied to cultivated plants, and underexploited plant resources are among the topics considered.

BIOPL 442 Current Topics in Ethnobiology
Fall. 2 or 4 credits (4 credits with an independent research component and term paper). Prerequisites: BIOPL 247, 348, or permission of instructor. Offered alternate years. Lec/disc, T 2:30–4:25. E. Rodriguez, D. M. Bates.
Explorations of the interrelationships of plants and animals with humans from a wide range of perspectives. Topics considered are contemporary issues, theory, and methodology of ethnobotany and ethnobiology, and the role of plants and animals in human lives, in subsistence and exchange, and in thought.

BIOPL 443 Topics and Research Methods in Systematics
Fall or spring. 1–2 credits (1 credit per section). Prerequisite: written permission of instructor. S-U grades optional.
A series of 1-credit modules on specialized topics in systematics. Topics and instructors vary each semester. May not be taught every semester. Topics and instructors are listed in the division's catalog supplement issued at the beginning of the semester.

BIOPL 444 Plant Cell Biology
Fall. 4 credits. Limited to 24 students. Prerequisites: one year of introductory biology or permission of instructor. Lecs, M W F 9:05; lab, M or W 1:25–4:25. R. O. Wayne.
Evidence from microscopy, physiology, biochemistry, and molecular biology is used to try to unravel the mystery of the living cell. The dynamics of protoplasm, membranes, and the various organelles are studied. The mechanisms of cell growth and division, the relationship of the cytoskeleton to cell shape and motility, the interaction of the cell with its environment, and the processes that give rise to multicellular differentiated plants are investigated.

[BIOPL 445 Photosynthesis
Fall. 3 credits. Prerequisites: one year of college chemistry and mathematics. Recommended: one year of college physics and plant physiology. Lecs, M W F 10:10. Offered alternate years. Not offered 1999–2000. T. G. Owens.
An introduction to the processes of photosynthesis in plants, algae and bacteria. An interdisciplinary approach is emphasized incorporating biochemical, biophysical, physiological and molecular perspectives. The course will cover the range of processes involved in photosynthesis beginning with light harvesting and primary photochemistry through electron transport and inorganic carbon fixation. Emphasis will be placed on the regulation of photosynthesis from the cellular to the whole-plant level.]

BIOPL 447 Molecular Systematics
Fall. 3 credits. Prerequisites: BIOES 278 or BIOGD 281 or BIOBM 332, or written permission of instructor. Lecs, T R 8:30–9:55. Offered alternate years. J. J. Doyle.
The theory and practice of using molecular evidence, particularly DNA sequence data, for addressing diverse systematic and evolutionary questions. Emphasis is on phylogeny reconstruction, particularly in eukaryotic systems. The organization and evolution of nuclear and organellar genomes is described from the standpoint of their suitability for systematic and evolutionary studies.

[BIOPL 448 Plant Evolution and the Fossil Record
Spring. 3 credits. Prerequisite: BIOPL 241 or equivalent, or permission of instructor. Lecs, T R 9:05; lab, R 12:20–2:15. Offered alternate years. Not offered 1999–2000. K. J. Niklas, W. L. Crepet.
An introduction to evolution, surveying major changes in plants from the origin of life to the present. Emphasis is placed on plant form and function, adaptations to particular ecologic settings, and evolutionary theory as it relates to plants.]

BIOPL 453 Principles and Practice of Historical Biogeography (also ENTOM 453)
Fall. 3 credits. Prerequisite: a course in systematics or permission of instructor. S-U grades optional. Lecs, T R 10:10; lab/disc, R 2:30–4:25. Offered alternate years. J. K. Liebherr, M. A. Luckow.
This course provides a comprehensive survey of the current methods and techniques used in historical biogeography, and the development of modern biogeographic theory in the context of classical and ecological methods of analysis. Brief summaries of geological and paleontological aspects of biogeography are presented, and large-scale biogeographic patterns discussed. The laboratories focus on hands-on computer applications of modern techniques and discussion of controversial issues in biogeography.

BIOPL 466 Physiological Plant Ecology, Lectures (also BIOES 466)
Spring. 3 credits. Limited to 45 students. Prerequisite: BIOES 261 or introductory plant physiology. S-U grades optional, with permission of instructor. Lecs, M W 8:40–9:55; optional disc to be arranged. Offered alternated years. Staff.
For course description, see BIOES 466.

[BIOPL 468 Physiological Plant Ecology, Laboratory (also BIOES 468)
Spring. 2 credits. Limited to 15 students. Prerequisite: previous or concurrent enrollment in BIOES 466. Lab, W 1:25–4:25, plus additional lab hours to be arranged. Offered alternate years. Not offered 1999–2000. Staff.
For course description, see BIOES 468.]

BIOPL 641 Laboratory in Plant Molecular Biology
Spring. 4 credits. Prerequisites: BIOGD 281 or equivalent, BIOBM 330 or 331 or equivalent, and permission of instructor. Students (including graduate students) strongly advised to preregister by Nov. 29, in the Section of Plant Biology main office (Room 228, Plant Science Building). S-U grades optional. Lab, T 9:05–4:30. J. B. Nasrallah, M. R. Hanson.
Selected experiments on gene expression, gene transfer, and assay of reporter genes in plants. The course emphasizes the application of molecular biology methodology to plant systems. Additional lab time is required to complete assignments.

[BIOPL 642 Plant Mineral Nutrition (also SCAS 642)
Spring. 3 credits. Prerequisite: BIOPL 342 or equivalent. Lecs, M W F 10:10. Offered alternate years. Not offered 1999–2000. L. V. Kochian, R. M. Welch.
A detailed study of the processes by which plants acquire and use mineral nutrients from the soil. Topics include the uptake, translocation, and compartmentation of mineral elements; root-soil interactions; the metabolism of mineral elements; the involvement of mineral nutrients in various physiological processes; and the nutrition of plants adapted to extreme environmental stresses (e.g., acid soils). Specific mineral elements are emphasized to illustrate these topics.]

BIOPL 643 Plant Physiology, Advanced Laboratory Techniques
Spring. 4 credits. Prerequisites: organic chemistry, biochemistry, and a course in plant physiology. S-U grades only. Lab, T or W 8–5:00; disc, M 4:30–5:30. Requires minimum enrollment of 6 students. Offered alternate years. Staff.
An introduction to some modern methods in experimental plant biology. A partial list of techniques used includes fluorescence measurements, infrared CO_2 analysis, gel electrophoresis and Western blots, cellular electrode measurements, microtiter plate technology for enzyme assays, sensitive growth measurements, HPLC and GC-MS, and computer interfacing with laboratory equipment.

BIOPL 644 Regulatory Factors in Plant Growth and Development
Spring. 1–2 credits (1 credit per section). Prerequisites: BIOPL 242 or 342 or equivalent, or permission of instructor. Two modules, which can be taken together or in isolation. These mesh with BIOPL 652–03 and BIOPL 653–04 (Molecular Aspects of Plant Development II and I respectively). S-U grades optional. Offered alternate years.

Section 01 Plant Hormones
1 credit. Lecs M W F 9:05 (14 lecs) January 24-February 23. P. J. Davies.
Plant Hormones: their role in plant growth and development, analysis, biosynthesis and mode of action, including signal transduction, examined from a physiological, biochemical and molecular point of view. The course covers auxin, gibberellin, cytokinin, ethylene, abscisic acid, brassinosteroids and other compounds as appropriate.

Sec 02 Phytochrome and Photomorphogenesis
1 credit. Lecs M W F 9:05 (12 lecs) April 3-April 28. P. J. Davies.
A study of the regulation of plant growth and development by light as perceived through the pigments phytochrome and cryptochrome. This will include the biochemistry and molecular biology of phytochrome and the way in which phytochrome modulates plant growth, including molecular and genetic analysis of its effects and the mechanisms by which it acts. The role of phytochrome in detecting and modulating growth in natural and agricultural environments will also be covered.

[BIOPL 645 Families of Tropical Flowering Plants
Fall. 1 credit. Prerequisite: written permission of instructor. S-U grades only. Lec and disc, F 11:15. Offered every three years. Not offered 1999–2000. K. C. Nixon.
The families of flowering plants encountered solely or chiefly in tropical regions are considered in lectures, discussions, and demonstrations, with the aim of providing basic points of recognition for, and an understanding of, diversity and relationships in these families for the student venturing into the tropics.]

[BIOPL 646 Families of Tropical Flowering Plants: Field Laboratory
Intersession. 3 credits. Limited to 20 students, with preference given to graduate students from member institutions of the Organization for Tropical Studies. Prerequisite: BIOPL 243 or 248 or equivalent. Recommended: BIOPL 645. S-U grades only. For more details and application, contact the L. H. Bailey Hortorium, 467 Mann Library. Offered every three years. Not offered 1999–2000. K. C. Nixon.
An intensive orientation to families of tropical flowering plants represented in forests of the American tropics. Emphasis on field identification combined with laboratory analysis of available materials in a "whole-biology" context.]

BIOPL 647 Seminar in Systematic Botany
Fall or spring. 1 credit. May be repeated for credit. Prerequisite: written permission of course coordinator required for undergraduates. S-U grades optional. Sem, T 11:15–1:10. Bailey Hortorium staff.
Lectures and discussions led by staff, visitors, and students on topics of current importance to systematic botany.

[BIOPL 648 Plant Biochemistry
Spring. 3 credits. Prerequisites: organic chemistry, biochemistry, and a course in plant physiology. Lecs, M W F 9:05. Offered alternate years. Not offered 1999–2000. T. G. Owens and staff.
Selected areas of plant biochemistry are reviewed in the context of the plant life cycle and responses to the environment. Topics include metabolism of lipids, carbohydrates, organic acids, phenolic compounds, and proteins; nitrogen and sulfur assimilation; respiration; photosynthesis; development and replication of chloroplasts; and cell-wall composition and properties. Attention is paid to operation of control mechanisms.]

BIOPL 649 Physiology of Ion and Water Transport in Plants
Fall. 1–3 credits (1 credit per section). Prerequisite: BIOPL 342 or equivalent, or permission of the instructor. Offered alternate years. Three modules that may be taken independently, although section 01 is recommended before taking section 02. R. M. Spanswick.

Section 01 Basic Principles of Ion Transport and Electrophysiology
1 credit. Lecs T R 10:10–11:30 (9 lecs) August 26-Sepetember 23.
The biophysical basis of ion transport across cell membranes, including membrane structure, ion fluxes and their measurement, the thermodynamic criterion for active transport, and the relationship between ion transport and the electrical properties of cell membranes.

Section 02 Ion Transport in Plants
1 credit. Lecs TR 10:10–11:30 (9 lecs) September 28-October 28.
Transport of the major ions in plant cells and whole plants. Properties of proton ATPases and their relationship to the transport of ions, sugars and amino acids at the plasma membrane and tonoplast. Ion channels in plant cell membranes. Intercellular ion transport via plasmodesmata. Long distance ion transport in higher plants.

Section 03 Water Transport in Plants
1 credit. Lecs TR 10:10–11:30 (9 lecs) November 2-December 2.
Water relations of plant cells and tissues using water potential terminology. Permeability of plant cells to water and the role of aquaporins. Transport of water through whole plants, including transpiration, stomatal physiology and the effects of water stress.

[BIOPL 651 Quantitative Whole-Plant Physiology
Fall. 3 credits. Prerequisites: introductory physics, calculus, and plant physiology. S-U grades only. Lecs, T R 10:10–11:30. Offered alternate years. Not offered 1999–2000. R. M. Spanswick.
An exploration of the extent to which physiological processes and their interactions can be formulated in a quantitative manner and integrated to describe various aspects of plant behavior, including growth and yield. Consideration is given to characterization of the plant environment, energy balance, gas exchange, water relations, photosynthesis, respiration, translocation, nutrient supply, and the timing of developmental events.]

BIOPL 652 Plant Molecular Biology II
Spring. 1–4 credits (1 credit per section). Prerequisites: BIOGD 281 and BIOBM 330 or 332, or their equivalents. Recommended: BIOBM 331. S-U grades optional.
A series of four-week modules on specialized topics. Coordinator: S. H. Howell.

Section 01 Molecular Plant-Pathogen Interactions (also PLPA 662)
1 credit. Lecs, M W F 10:10 (12 lecs) Jan. 26-Feb. 21. T. P. Delaney, A. R. Collmer, O. C. Yoder.
An examination of the molecular properties that control the development of host-parasite interactions in both microorganisms (bacteria and fungi) and higher plants. Contemporary theories describing the genetic and molecular mechanisms of microbial pathogenesis and plant resistance are discussed.

Section 02 Molecular Plant-Microbe Interactions (BIOMI 652)
1 credit. S-U grades optional. Lecs, M W F 12:20 (12 lecs) Jan. 26-Feb. 21. S. C. Winans.
Course focuses on the interactions of *Agrobacteria* and *Rhizobia* with plants. Topics on *Agrobacterium*-plant interactions include plant-microbe recognition mechanisms, T-DNA transfer process, oncogenesis and use of *Agrobacterium* to produce transgenic plants. Topics on *Rhizobium*-plant interactions include regulation of nitrogenase activity and expression, organization and function of the *sym* plasmid, nodule development, and plant genetics involved in plant-microbe interaction.

Section 03 Molecular Aspects of Plant Development II
1 credit. S-U grades optional. Lecs, M W F 10:10 (12 lecs) Feb. 23-Mar. 27. S. H. Howell.
The molecular genetics of plant development. This module focuses on vegetative development and includes topics such as the development of the shoot, root, and vasculature and the operation of the vegetative shoot apical meristem. The module is a companion to BIOPL 653, Sec 04 (Plant Development I), which covers molecular aspects of reproductive development.

Section 04 Plant Gene Evolution and Phylogeny
1 credit. Lecs, M W F 1:25 (12 lecs) Mar. 29-Apr. 24. J. J. Doyle.
Practical applications of molecular systematics/evolution for plant molecular biologists and other non-systematists. The course focuses on two basic issues: methods and principles for inferring relationships among genes and the use of data to hypothesize relationships among plants. Evolutionary patterns and processes of genes and gene families are discussed, as well as rates of sequence evolution, paralogy and othology, the effects of recombination and concerted evolution of gene phylogenies, and the implications of using gene or allele phylogenies to infer organismal-evolutionary patterns. The principles of distance and parsimony methods are described, and computer methods for reconstructing gene phylogenies are discussed.

BIOPL 653 Plant Molecular Biology I
Fall. 1–5 credits (1 credit per section). Prerequisites: BIOGD 281 and BIOBM 330 or 332, or their equivalents. Recommended: BIOBM 331. S-U grades optional. Coordinator: S. H. Howell.
A series of four-week modules on specialized topics.

Section 01 Concepts and Techniques in Plant Molecular Biology (also PLPA 663–01)
1 credit. Lecs, M W F 10:10 (12 lecs) Sept. 1-Sept. 27. T. Delaney, G. B. Martin.
A review and update on molecular biology concepts relevant to plant sciences including DNA synthesis, RNA transcription and processing, and protein structure and translation. Methods applicable to plant molecular biology are described including isolation of nucleic acids, gel electrophoresis, recombinant DNA techniques, plant transformation, mutant production, and use of sequence databases.

Section 02 Plant Biotechnology (also PLBR 653.2 and PLPA 663)
1 credit. Lecs, M W F 1:25 (12 lecs) Sept. 29-Oct. 27. M. Zaitlin, E. D. Earle.
This course deals with production and uses of transgenic plants for agricultural and industrial purposes. Topics include procedures for gene introduction and control of gene expression, as well as strategies for obtaining transgenic plants that are resistant to insects, diseases, and herbicides, produce useful products, or have improved nutritional and food processing characteristics. Regulatory and social issues relating to plant biotechnology are discussed.

[Section 03 Plant Genome Organization (also PLBR 653.3)
1 credit. S-U grades optional. Lecs, M W F 10:10 (12 lecs). Offered alternate years. Not offered 1999–2000. S. D. Tanksley.
The structure and variation of plant nuclear genomes, including changes in genome size, centromere/telomere structure, DNA packaging, transposable elements, genetic and physical mapping, positional gene cloning, genomic sequencing and comparitive genomics.]

Section 04 Molecular Aspects of Plant Development I
1 credit. Lecs, M W F 10:10 (12 lecs) Oct. 29-Nov. 24. J. B. Nasrallah.
This module focuses on the molecular genetics of plant reproduction. Current approaches to the elucidation of the molecular signals and pathways that lead to the establishment of the differentiated state of floral cells and organs are discussed. Topics include the establishment of pattern during floral morphogenesis, cell death and sex determination, gamete development, cell-cell signaling during pollination, and fertilization. The module is a companion to BIOPL 652, Sec 02 (Molecular Aspects of Plant Development II), which covers molecular aspects of vegetative development.

Section 05 Molecular Biology of Plant Organelles
1 credit. S-U grades optional. Lecs, M W F 1:25 (12 lecs) Oct. 29-Nov. 29. M. R. Hanson (odd years), D. B. Stern (even years).
An in-depth examination of the molecular biology of plant mitochondria (odd years) and plastids (even years). Topics include the organization and expression of organelle genomes, RNA editing, organelle transformation, expression of nuclear genes for organelle proteins. Special topics include cytoplasmic male sterility and gene regulation during plastid development.

Section 06 Molecular Breeding and Genetic Diversity
1 credit. Lecs M W F 10:10 (12 lecs) September 29-October 27. Offered alternate years. S. D. Tanksley, S. Kresovitch.
Application of DNA markers to the evaluation of genetic diversity in natural populations and germplasm collection as well as the identification, manipulation and isolation of genes important to plant and animal productivity using molecular genetic techniques. Students will learn how to design and execute experiments for identification of quantitative trait loci (QTLs) as well as how to apply molecular markers to plant and animal breeding programs. Strategies will also be taught for the use of DNA polymorphisms in the management of genetic resources.

[BIOPL 654 Botanical Nomenclature
Fall. 1 credit. Prerequisite: written permission of instructor. S-U grades only. Lec and disc to be arranged. Offered alternate years. Not offered 1999–2000. Staff.
An analysis of the International Code of Botanical Nomenclature and its application to various plant groups.]

BIOPL 656 Topics in Plant Evolution
Spring. 1 credit. Prerequisite: BIOPL 448 or equivalent background in evolution, or written permission of instructor. Lab and disc to be arranged. Offered alternate years. K. J. Niklas.
A series of selected topics to provide a background in plant evolution, paleobotanical literature, and evolutionary theory. Among the topics discussed are the origin of a terrestrial flora, the evolution of the seed plants, and the origin and adaptive radiation of the angiosperms.

BIOPL 740 Plant Biology Seminar
Fall and spring. No credit (no official registration). Required of graduate students doing work in plant biology. Sem, F 11:15. Staff.
Lectures on current research in plant biology, presented by visitors and staff.

BIOPL 741 Problems in Plant Cell and Molecular Biology
Fall. 2 credits. Limited to first- and second-year graduate students in the Plant Cell and Molecular Biology Program. Disc to be arranged. Staff.
An introduction to the research literature in plant molecular and cellular biology through weekly problem sets and discussions.

BIOPL 742 Current Topics in Plant Molecular Biology
Fall or spring. 1 credit. Enrollment is limited. Primarily for graduate students, with preference given to majors or minors in plant molecular biology; written permission of instructor required for undergraduates. S-U grades only. Sem, 1 hour each week to be arranged. P. J. Davies.
Fall topic: molecular aspects of plant hormone biosynthesis, signal transduction and action. A seminar with critical presentation and discussion by students of original research papers concerning the molecular biology of plants. Staff direction varies each year and is announced a semester in advance.

BIOPL 743 Current Research in Plant Cell and Molecular Biology
Fall. 1 credit. Limited to graduate students; written permission from a member of the Plant Cell and Molecular Biology Program required for undergraduates. Lec to be arranged. Staff.
An introduction for graduate students to the research being conducted by Cornell faculty in the Plant Cell and Molecular Biology Program.

BIOPL 745 Current Topics in Systematics
Fall. 1 credit. Limited to graduate students, except by permission of instructor. S-U grades optional. Disc, T 12:20. Bailey Hortorium staff.
A seminar with presentations and discussion by students of original research papers in systematic biology.

BIOPL 746 Research Seminar in Systematic Botany
Spring. 1 credit. Limited to graduate students, except by permission of instructor. Disc, T 12:20. Bailey Hortorium staff.
A student-led seminar presentation based on his or her thesis research or a related topic.

BIOPL 749 Graduate Research in Botany
Fall or spring. Variable credit. May be repeated for credit. S-U grades optional. Hours to be arranged. Staff.
Similar to BIO G 499 but intended for graduate students who are working with faculty members on an individual basis.

BIOPL 840 Current Topics in Plant Physiology
Fall or spring. 2 credits. May be repeated for credit. S-U grades only. Sem to be arranged. P. J. Davies.
Fall topic: molecular aspects of plant hormone biosynthesis, signal transduction and action. Seminar reports by graduate students on current literature in experimental plant physiology or related areas.

Related Courses in Other Departments

Introductory Mycology (Plant Pathology 309)

Marine Botany: Ecology of Marine Plants (Biological Sciences [BIOSM] 449)

Mycology Conferences (Plant Pathology 649)

Phytomycology (Plant Pathology 709)

Plant Ecology and Population Biology, Lectures and Laboratory (Biological Sciences [BIOES] 463 and 465)

Plant Ecology Seminar (Biological Sciences [BIOES] 669)

Plant Cytogenetics Laboratory (Plant Breeding 446)

Teaching Experience (Biological Sciences [BIO G] 498)

Undergraduate Research in Biology (Biological Sciences [BIO G] 499)

COURSES IN MARINE SCIENCE

Cornell offers an extensive listing of undergraduate courses in marine science.

Undergraduates interested in pursuing studies in marine science are encouraged to explore the undergraduate specialization in Marine Biology offered through the Division of Biological Sciences, the undergraduate specialization in Ocean Sciences offered through the Science of Earth Systems Program, and the summer program of courses offered by the Shoals Marine Laboratory. Further information on these programs can be found at the Cornell Marine Programs Office, G14 Stimson Hall.

Undergraduate Specialization in Marine Biology and Oceanography

Biological Sciences majors in the ecology and evolutionary biology program of study have the option of specializing their program of study in the area of marine biology. This specialization is intended for students with interests in understanding the unique aspects of organismal biology in the marine environment. In addition to fulfilling the major and the ecology and evolutionary biology program of study requirements, students in marine biology are encouraged to enroll in the following courses:

1) BIOES 154, The Sea: An Introduction to Oceanography,
2) BIOSM 364, Field Marine Science or a 400-level BIOSM field course at the Shoals Marine Laboratory,
3) BIOES 462, Marine Ecology.

Undergraduate Specialization in Ocean Sciences

Science of Earth Systems majors have the option of specializing their program of study in the area of ocean sciences. This interdisciplinary specialization is intended for students with interests in understanding the interaction of biological, chemical, geological, and physical processes in ocean systems. In addition to fulfilling the Science of Earth Systems general requirements (see the SES program description in Interdisciplinary Centers, Programs, and Studies section of catalog), students in ocean sciences are required to take four advanced courses from the following list to fulfill their major requirements:

1) BIOES 373 Marine Invertebrate Zoology
2) BIOES 457 Limnology
3) BIOES 462 Marine Ecology
4) BIOES 478 Ecosystem Biology
5) BIOSM 309 Climates and Ecosystems
6) BIOSM 364 Field Marine Science
   BIOSM 375 Field Marine Ecology
7) BIOSM 365 Underwater Research
8) BIOSM 366 SEA: Introduction to Oceanography
9) BIOSM 369 SEA: Oceanography I
10) BIOSM 370 SEA: Oceanography II
11) BIOSM 371 SEA: Oceanography III
12) [BIOSM 402 Marine Pollution]
13) [BIOSM 413 Adaptations of Marine Organisms]
14) BIOSM 418 Tropical Marine Science
15) BIOSM 449 Seaweeds, Plankton and Seagrass
16) BIOSM 477 Marine Vertebrates
17) GEOL 375 Sedimentology and Stratigraphy
18) GEOL 455 Geochemistry
19) GEOL 475 Special Topics in Oceanography
20) GEOL 479 Paleobiology
21) NTRES 306 Coastal and Oceanic Law and Policy
22) NTRES 417 Wetland Resources

Students in both marine science specializations are exposed to an integrated program of study, emphasizing a natural progression of formal course work combined with ample opportunities for practical field experience.

SHOALS MARINE LABORATORY (BIOSM)

G14 Stimson Hall, 255–3717

The objective of the Shoals Marine Laboratory (SML) is to provide undergraduates, beginning graduate students, and other interested adults a unique opportunity to explore marine sciences in an island setting noted for its biota, geology, and history. SML has established a national reputation for excellence and has become North America's largest marine field station focusing on undergraduate education.

The summer population of Appledore Island is limited to about one hundred people at any one time. Participants and faculty members can literally and figuratively immerse themselves in their explorations, free from distractions common to most academic institutions. Because SML is a residential facility, a sense of community develops that makes courses and seminars at SML outstanding educational and intellectual experiences. Participants learn from and exchange ideas with a wide range of specialists whose primary interests are marine but whose perspectives often differ, providing fertile ground for lively discussions.

Credit courses at Shoals Marine Laboratory are full-time, intensive learning experiences. Courses may be taken sequentially, but not concurrently. A typical day combines lecture sessions, laboratory and field work, field trips to nearby islands and the mainland, and collecting and research excursions aboard the Laboratory's 47-foot research vessel, *John M. Kingsbury*. Field experience is an integral component of all courses, using Appledore's extensive intertidal zone, wading bird rookeries, and seabird colonies. Faculty, drawn from Cornell University, the University of New Hampshire, and other leading academic institutions, are selected not only based on their academic excellence, but also on their teaching ability in the field. In addition, numerous guest lecturers include engineers, coastal planners, and specialists from private industry, government, and the academic community.

The Ithaca campus functions of the Shoals Marine Laboratory are centered in the Cornell Marine Programs Office, G14 Stimson Hall. The office serves as an advising center for students interested in the marine sciences, maintains a browsing library with updated information on graduate study and career opportunities as well as on marine programs at other institutions, and administers the SEA Semester, a 17-credit program offered in cooperation with the Sea Education Association (SEA). SML and SEA offer a joint SEA/Island semester for 18 credits, which combines both programs (BIOSM 364, 366, 367, 368, 372).

The following marine sciences courses are currently administered by the Cornell Marine Programs Office.

BIOSM 160 The Oceanography of the Gulf of Maine
Summer. 4 credits. S-U grades optional. Limited to 24 students. A special 2-week course offered aboard the *SSV Corwith Cramer* and at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application, contact the SML office, G14 Stimson Hall or the Sea Education Association office at P.O. Box 6, Woods Hole, MA, 02543. Daily lecs, labs, and fieldwork for 2 weeks. SML faculty.

An exciting opportunity to explore the offshore and near-coastal environments of the Gulf of Maine for pre-college and first-year non-science majors. Students spend ten days aboard the Sea Education Association's *SSV Corwith Cramer* and sail from Woods Hole, MA, to the Isles of Shoals via Georges Bank and the Gulf of Maine. Besides operating the ship, students study the many characteristics of this unique ocean environment. Following the sea component, students spend seven days at the Shoals Marine Laboratory to collect data characteristic of the Isles of Shoals coastal environment.

BIOSM 161 Introduction to Field Marine Science
Summer. 4 credits. S-U grades optional. A special 2-week course offered in cooperation with Ryder University at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. Apply directly to Rider University, College of Continuing Studies. Contact Dr. Richard Alexander for application and information at: Alexander@enigma.rider.edu, (609) 895–5422. Offered alternate years.

This course allows students who are not biology majors to experience the breadth of the marine sciences under field conditions at an island laboratory. Aspects of biology, geology, earth science, chemistry, and physics are included. Specific topics include beach, salt marsh, tidal mud flat, tide pool, and benthic offshore environments; identification of marine plants and animals; chemical and physical oceanography; marine geology; and ecology of kelp beds and urchin barrens.

BIOSM 204 Biological Illustration
Summer. 2 credits. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Daily sessions for 1 week. SML faculty.

General discussion of scientific publishing, illustration labeling, color techniques, and printing processes. The course provides the scientist or science student a chance to experience several illustration techniques with the goal of obtaining an overview of scientific and wildlife illustrations. The student may choose a single technique to explore in depth. Course size is limited so that individual attention can be emphasized.

BIOSM 303 Ecology of Marine Fishes
Summer. 4 credits. Prerequisite: one year of college-level biology. SCUBA certification recommended, not required. S-U grades optional. A special two-week course offered at Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Daily lecs and fieldwork for 2 weeks. SML staff.

This course presents principles, models, and methods for analysis of dynamics of fish populations and communities, and analysis of current research emphasizing theory and its potential uses in fisheries' management. Lab and field activities emphasize collection and analysis of data from the Gulf of Maine and adjacent estuarine habitats.

[BIOSM 308 Marine Microbial Ecology
Summer. 4 credits. Prerequisite: one year of college-level biology. S-U grades optional. A special two-week course offered at Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Daily lecs and fieldwork for 2 weeks. Offered alternate years. Not offered 1999–2000. SML staff.

This course examines the fundamental role of marine microbial communities in the function of the biosphere. Lectures survey bacterial, protozoan, and micrometazoan assemblages from Arctic to deep sea vent communities. Laboratory exercises cover several principal techniques of field microbial ecology and explore the rich marine microbial environment surrounding the Isles of Shoals.]

BIOSM 309 Climates and Ecosystems
Summer. 4 credits. Prerequisite: one year of college-level biology; background preferred in physics/physical geography. S-U grades optional. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application consult the SML office, G14 Stimson Hall. Daily lecs, labs, and fieldwork for 2 weeks. SML faculty.

A study of the fundamentals of organism-environment interaction developed through defining and measuring abiotic factors including solar radiation, temperature, atmospheric moisture, precipital wind, and currents. On-site exploration of the dynamics of meteorology and the role of abiotic and biotic factors in the life of coastal and marine plants and animals including humans.

[BIOSM 329 Ecology of Animal Behavior
Summer. 4 credits. Prerequisite: one year of introductory college biology. Recommended: course work in ecology, psychology, or behavior. S-U grades optional. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Daily lecs, labs, and fieldwork for 2 weeks. Offered alternate years. Not offered 1999–2000. SML faculty.

The ecological significance of behaviors of coastal organisms, with emphasis on field and laboratory research methods. Lectures and readings address the major subareas of behavior (communication, orientation, social behavior, foraging, predator avoidance, and sensory mechanisms). Each student engages in short-term behavioral observation and prepares a research proposal for studying a problem within the course subject area.]

[BIOSM 363 Marine Biology for Teachers
Summer. 3 or 4 credits (4-credit option: additional 4 days for individual research). Primarily for teachers, grades 6 through 12, but open to others with teaching experience. Prerequisite: one year of introductory college biology. S-U grades optional. A special 10-day course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Daily lecs, labs, and fieldwork for 10 days. Offered alternate years. Not offered 1999–2000. SML faculty.

Designed to give an overview of living marine organisms (algae, invertebrates, fishes, marine mammals, and shorebirds) and of the environment they inhabit. Fieldwork is emphasized. Occasional lectures and films deal with additional topics such as coastal-zone problems, marine fisheries, economics of marine organisms, and educational resources of the marine environment.]

BIOSM 364 Field Marine Science
Summer. 6 credits. Prerequisite: one year of college biology. S-U grades optional. A special 4-week course offered twice each summer at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML Office, G14 Stimson Hall. Daily lecs, labs, and fieldwork for 4 weeks. 3 core faculty members assisted by up to 15 visiting lecturers, including representatives of governmental agencies. SML faculty.
Designed for the student who desires an initial overview of the marine sciences, this course emphasizes living material in natural habitats. Most of the course work is concerned with the biology of intertidal plants and animals, biological oceanography, ichthyology, and fisheries. Attention is also given to introductory physical and chemical oceanography and marine geology. Marine ecology and the effects of human activity on the marine environment are included. Students apply this knowledge by conducting a transect study toward the end of the course. FMS places additional emphasis on ichthyology, fisheries biology, general oceanography (biological, physical, and chemical) and marine geology. FME places an additional emphasis on ecology, especially in the intertidal zone; ecological, evolutionary and physiological adaptations of marine organisms; and field experiments.

BIOSM 365 Underwater Research
Summer. 4 credits. Prerequisites: one year of college-level biology, recognized scuba certification, and a medical examination. S-U grades optional. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Daily lecs and fieldwork for 2 weeks. Team-taught by three faculty members with occasional guest lecturers. Not for recreational divers.
Course covers the philosophy of research, hypothesis testing and experimental design, sampling methods, various underwater techniques, diving physics and physiology, and use of dive tables. Emphasis is on subtidal ecological research. Requirements include critical evaluation of several journal articles and production of a research proposal.

BIOSM 366–370 SEA Semester
In cooperation with the Sea Education Association (SEA), the Shoals Marine Laboratory offers a semester-length sequence of courses designed to provide college undergraduates with a thorough academic, scientific, and practical understanding of the sea. *This sequence is repeated approximately once every two months throughout the year.* Students spend the first half of SEA Semester (a six-week shore component) in Woods Hole, MA, receiving instruction in oceanography, nautical science, and maritime studies. The second half of SEA Semester (a six-week sea component) is spent at sea aboard the R/V *Westward* or the R/V *Corwith Cramer*. Enrollment is open to both men and women judged capable of benefiting from SEA semester; a student must have successfully completed **at least one college-level laboratory science course** (or its equivalent) in order to be admitted to SEA Semester or SEA Summer Session. **No prior sailing experience is necessary**. Cornell students enrolled in the SEA Semester must take the entire sequence.

For more information, contact the Shoals Marine Laboratory office, G14 Stimson Hall, or call SEA directly at 1–800–552–3633. Program costs are to be paid in place of regular Cornell tuition and fees: tuition for the entire 17-credit SEA Semester, approximately 14,000 which includes room and board at SEA.

Instructors for the SEA Semester include faculty of the Sea Education Association and the Woods Hole Oceanographic Institution and others.

BIOSM 375 Field Marine Ecology
Summer. 6 credits. Prerequisites: one full year of college level biology. S-U grades optional. A 4-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML Office, G-14 Stimson Hall. Daily lecs, labs, and fieldwork for 4 weeks. SML faculty.
Designed for students seeking an introduction to the marine sciences and marine ecology; FME emphasizes field work in natural habitats. Examines aspects of the biology and ecology of marine organisms, including intertidal plants and invertebrates, fishes, marine mammals and birds, biological oceanography, and human impacts on the marine environment. FME places a special emphasis on the ecology of the intertidal zone; ecological, evolutionary and physiological adaptations of marine organisms. Students may not take FME after taking FMS.

Shore Component (six weeks)

BIOSM 366 SEA Introduction to Oceanography
3 credits. Prerequisite: concurrent enrollment in BIOSM 367 and 368. A survey of the characteristics and processes of the global ocean. Oceanographic concepts are introduced and developed from their bases in biology, physics, chemistry, and geology. Provides a broad background in oceanography with special attention to areas pertinent to the subsequent cruise. Guest lecturers from the Woods Hole research community interpret current trends and activities in this rapidly evolving field. Students develop individual projects to be carried out at sea.

BIOSM 367 SEA Introduction to Maritime Studies
3 credits. Prerequisite: concurrent enrollment in BIOSM 366 and 368.
An interdisciplinary consideration of our relationship with the marine environment. Covers the elements of maritime history, law, literature, and art necessary to appreciate our marine heritage and to understand the political and economic problems of contemporary maritime affairs.

BIOSM 368 SEA Introduction to Nautical Science
3 credits. Prerequisites: concurrent enrollment in BIOSM 366 and 367.
An introduction to the technologies of operation at sea. The concepts of navigation (piloting, celestial, and electronic), naval architecture, ship construction, marine engineering systems, and the physics of sail are taught from their bases in astronomy, mathematics, and physics. Provides the theoretical foundation for the navigation, seamanship, and engineering that students employ at sea.

Sea Component (six weeks)

Courses 369 and 370 take place aboard the R/V *Westward*, a 125-foot steel auxiliary-powered staysail schooner built in 1961, or the R/V *Corwith Cramer*, a 134-foot steel auxiliary-powered brigantine built in 1987 for SEA. Both ships normally put to sea with a ship's company of thirty-four. The professional staff of nine includes the captain, the chief scientist, three science watch officers, three deck watch officers, an engineer, and a steward. In addition, one or more visiting investigators are frequently aboard. Up to twenty-four students round out the complement.

BIOSM 369 SEA Practical Oceanography I
4 credits. Prerequisite: BIOSM 366.
Theories and problems raised in the shore component are tested in the practice of oceanography at sea. Students are introduced to the tools and techniques of the practicing oceanographer. During lectures and watch standing, students are instructed in the operation of basic oceanographic equipment; in the methodologies involved in the collection, reduction, and analysis of oceanographic data; and in the attendant operations of a sailing oceanographic research vessel.

BIOSM 370 SEA Practical Oceanography II
4 credits. Prerequisites: BIOSM 368 and 369.
Building on the experience of Practical Oceanography I, students assume increasing responsibility for conducting oceanographic research and overseeing operations of the vessel. The individual student is ultimately responsible directly to the chief scientist and the master of the vessel for the safe and orderly conduct of research activities and related operations of the vessel. Each student undertakes an individual research project designed during the shore component.

BIOSM 372 SEA Practical Oceanography III
Summer. 3 credits. Prerequisites: BIOSM 366, 367, and 368.
Theories and problems raised in class are tested in the practice of oceanography at sea. During lectures and watch standing, students are instructed in the operation of basic oceanographic equipment, in the methodologies involved in the collection, analysis, and reduction of oceanographic data, and in the attendant operations of sailing an oceanographic research vessel. Group research projects are completed.

BIOSM 374 Field Ornithology (An Introduction)
Summer. 4 credits. Prerequisite: one year of college-level biology. S-U grades optional. A special two-week course offered at Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Daily lecs and fieldwork for 2 weeks. SML staff.
An introduction to field ornithology focusing on the biology, ecology, and behavior of the avifauna on the Isles of Shoals. The course focuses on field work designed to observe and study many concepts frequently taught in

the classroom setting including territoriality, breeding biology, and survivorship. Students learn and apply numerous ornithological field methods including various census techniques, territory mapping, banding, behavioral observations, and creating a field notebook.

[BIOSM 402 Marine Pollution
Summer. 4 credits. Prerequisites: one year of college-level biology and chemistry or permission of instructor. S-U grades optional. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Daily lecs, labs, and fieldwork for 2 weeks. Offered alternate years. Not offered 1999–2000. SML faculty.
An introduction to marine pollutants; their sources and control/treatment; the effects of marine pollution upon coastal ecosystems; and federal and state water pollution regulatory programs. Laboratory includes training in field collection of water samples, measurement and modeling of effluent plume dispersion, and measurement of microbial indicators of water quality, dissolved nutrients, BOD, dissolved oxygen, and toxicity.]

[BIOSM 409 Ciliophorology
Summer. 2 credits. Prerequisite: permission of instructor. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Daily lecs and lab for 1 week. Offered alternate years. Not offered 1999–2000. SML faculty.
A special course that examines ciliophoran biology in depth through lectures and laboratory exercises. Topics include a detailed look at the ciliate faunules found in such diverse habitats as salt marshes, sandy sediment interstitial spaces, the Gulf Stream and the Sargasso Sea, marine caves, and benthic hydrothermal vents. Laboratory focuses on examining silver stained specimens, and covers staining techniques, as well as back scattered and secondary SEM and TEM methodologies.]

BIOSM 413 Experimental Marine Ecology
Summer. 6 credits. Prerequisite: one year of college level biology; experience in ecology or physiology recommended. S-U grades optional. A special 3-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Daily lecs, labs, and fieldwork for 3 weeks. SML faculty.
An introduction to the physiological ecology and functional morphology of marine plants and animals, with emphasis on selected algal and invertebrate examples from the Gulf of Maine. Topics covered include photosynthesis in the marine environment; respiration in intertidal organisms; carbohydrates, proteins, and lipids as nutrients in the sea; acclimation and tolerance of tide-pool biota; and biological responses to competition and grazing. Field and laboratory exercises explore principles and procedures used to characterize the physical, chemical, and biotic environment of intertidal and shallow subtidal organisms, including determination of temperature, light, salinity, oxygen and nutrient levels, and *in vivo* functional analyses of metabolic phenomena. The process of scientific investigation is the predominant theme of the course.

BIOSM 418 Tropical Marine Science
Summer. 12 credits. Limited to 12 students. Prerequisites: one year college-level biology; recognized SCUBA certification; medical exam; and permission of instructor. Lec/lab, 2 weeks; 6 weeks monitoring study and individual research projects, including data analysis on computers. A special 8-week course offered in Akumal, Mexico. For more details, contact Shoals Marine Laboratory, G-14 Stimson Hall, 255–3717. For competent divers only. D. F. Shapiro.
In addition to lectures and laboratories covering the basic principles of coral reef ecology, students participate in a coral reef monitoring survey. Following two weeks of course work, students engage in independent research projects. This course applies skills learned in the Underwater Research course at Shoals Marine Laboratory.

BIOSM 449 Seaweeds, Plankton and Seagrass: the Ecology and Systematics of Marine Plants
Summer. 4 credits. Prerequisite: BIOSM 364 or one year of introductory biology. S-U grades optional. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Daily lecs, labs, and fieldwork for 2 weeks. SML faculty.
An overview of the major marine algal groups, including aspects of anatomy, morphology, development, life histories, physiology, and use. Laboratories and fieldwork emphasize relationships between distribution and major environmental parameters and involve student projects.

GEOL 475 Special Topics in Oceanography
Summer. 2–5 credits. Prerequisites: GEOL 104 or BIO ES 154 and permission of instructor. C. H. Greene and B. M. Monger.
Undergraduate instruction and participation in advanced areas of oceanographic research. Topics will change from term to term. Contact instructor for further information.

BIOSM 477 Marine Vertebrates
Summer. 6 credits. Prerequisites: a course in vertebrate biology. S-U grades optional. A special 3-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Daily lecs, labs, and fieldwork for 3 weeks. SML faculty.
Topics in marine vertebrate biology emphasizing laboratory studies, field collections or observations, and readings from the current literature. Topics covered include systematics of fishes of the Gulf of Maine, elasmobranch physiology, interpretation of life history and parameters from otolith microstructure, teleost skeletomuscular structure and function, population biology and the contemporary Gulf of Maine fishery, Mesozoic marine reptiles, the biology of sea turtles in cold water, coloniality in sea birds, avian adaptations to life at sea, evolution and systematics of marine mammals, diving physiology, and ecology and conservation of existing marine mammal populations. Dissection of vertebrate animals is a part of one or more laboratory sessions.

[BIOSM 495 Research Methods in Marine Biology
Summer. 1 credit. Prerequisite: concurrent enrollment in BIOSM 499, or permission of instructor. Primarily for undergraduates. A special 8 week course offered at the Shoals Marine Laboratory (SML). For more details and an application, consult the SML office, G14 Stimson Hall. Weekly seminars for 8 weeks. Offered alternate years. Not offered 1999–2000. J. G. Morin and M. J. Shulman.
Seminar course on research methodology, experimental design, statistical analyses, and scientific writing. The course is designed to assist students in the research they are conducting while enrolled in BIOSM 499.]

BIOSM 499 Research in Biology
Summer. Credits variable (2 credits/7 days on site). For more details and an application, consult the SML Office, G14 Stimson Hall.
Section A: Independent Biological Research: Independent study with a member of the Shoals Marine Laboratory core faculty, based on student faculty interest and available facilities. A short proposal of research must be set with application materials.

[ARKEO 319 Archaeology Underwater
Summer. 2 credits. Prerequisites: recognized scuba certification and a medical examination required for students engaging in underwater research; also open to non-divers. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Daily lecs, labs, and fieldwork for 1 week. Offered alternate years. Not offered 1999–2000. SML faculty.
An introduction to the subject and a review of this contemporary subdiscipline of archaeology. The approach of the course is practical, with a strong potential for actual on-site experience in search, site recognition, survey, and recording. The course also covers the history and development of the subject, the legal aspects of underwater research, and the worldwide potential of the field. Since any archaeological research project involves a great deal more than digging, the course provides ample opportunities for those who are interested in the subject but are not divers or sufficiently experienced in scuba.]

GEOL 213 Marine and Coastal Geology
Summer. 2 credits. Prerequisite: an introductory course in geology or permission of instructor. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board), $1,100. Daily lecs, labs, and fieldwork for 1 week. SML faculty.
This course examines the complete history of the Isles of Shoals from Paleozoic intrusion, deformation and metamorphism to recent glaciation, sea-level change and wave erosion. Students will learn basic surveying and mapping techniques using the Brunton compass, poplevel/stadia rod, autolevel and

GPS. Sea kayaks will be used for inter-island travel and explorations of the islands. No previous kayak experience is required. Field efforts will focus on creating a series of thematic maps depicting island characteristics such as topography, bedrock geology and structure, vegetation and land use patterns.

NTRES 306 Coastal and Oceanic Law and Policy

Summer. 2 credits. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Daily lecs and disc for 1 week. SML faculty.

Intended for persons interested in careers in management of marine or coastal resources or in the natural sciences. Subjects include law and policy related to ocean dumping, marine sanctuaries, environmental impact statements, water and air pollution, fisheries management, offshore gas and oil production, and territorial jurisdiction. Lectures on the status and history of law are accompanied by discussion of relevant policy and analysis of the efficacy of various legal techniques. A case study that requires extensive use of the laboratory's library and personnel is assigned. The week concludes with a mock hearing.

NTRES 417 Wetland Resources

Summer. 2 credits. Prerequisite: one year of college-level biology. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML), on an island off Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Daily lecs, labs, and fieldwork. SML faculty.

An examination of coastal and adjacent freshwater wetlands from historic, destruction, and preservation perspectives, including fresh- and salt-marsh ecology and management. Field trips to selected examples of the wetlands under discussion and follow-up laboratories emphasize successional features, plant identification and classification, and examination of the dominant insect and vertebrate associations.

BIOES 373 Biology of the Marine Invertebrates

Fall (but taken in the previous summer at the Shoals Marine Laboratory [SML]). 4 credits. Limited to 30 students. Prerequisite: one year of introductory biology for majors. Permission of faculty required for 1999 because it will be off campus. Two week, full-time course. Daily and evening lectures, laboratories, and field work. Offered alternate years. C. D. Harvell, J. G. Morin, SML faculty.

An introduction to the biology and evolution of the major invertebrate phyla, concentrating on marine representatives. In addition to the evolution of form and function, lectures cover aspects of ecology, behavior, physiology, chemical ecology, and natural history of invertebrates. By being taught at the Shoals Marine Laboratory, students are exposed to a wealth of marine and terrestrial invertebrates in their natural habitats. Regular field excursions allow an excellent opportunity to study freshly collected and *in situ* representatives of most of the major phyla.

FACULTY ROSTER

New York State College of Agriculture and Life Sciences

Adler, Kraig K., Ph.D., U. of Michigan. Prof., Neurobiology and Behavior

Alani, Eric E., Ph.D., Harvard U. Asst. Prof., Genetics and Development

Anderson, John M., Ph.D., New York U. Prof. Emeritus, Genetics and Development

Bates, David M., Ph.D., U. of California at Los Angeles. Prof., Bailey Hortorium

Beyenbach, Klaus W., Ph.D., Washington State U. Prof., Physiology/Veterinary Physiology†

Bruns, Peter J., Ph.D., U. of Illinois. Prof., Genetics and Development

Cade, Thomas J., Ph.D., U. of California at Los Angeles. Prof. Emeritus, Ecology and Systematics

Calvo, Joseph M., Ph.D., Washington State U. William T. Keeton Professor in Biological Sciences, Biochemistry, Molecular and Cell Biology

Chabot, Brian F., Ph.D., Duke U. Prof., Ecology and Systematics

Clayton, Roderick K., Ph.D., California Inst. of Technology. Prof. Emeritus, Plant Biology

Corradino, Robert A., Ph.D., Cornell U. Prof., Physiology/Veterinary Physiology†

Crepet, William L., Ph.D., Yale U. Prof., Bailey Hortorium*

Daniel, Louise J., Ph.D., Cornell U. Prof. Emeritus, Biochemistry, Molecular and Cell Biology

Davies, Peter J., Ph.D., U. of Reading (England). Prof., Plant Biology

Davis, Jerrold I., Ph.D., U. of Washington. Assoc. Prof., Bailey Hortorium

Dhondt, André A., Ph.D., Ghent State U. (Belgium). Edwin H. Morgens Professor of Ornithology, Ecology and Systematics/ Laboratory of Ornithology

Dondero, Norman C., Ph.D., Cornell U. Prof. Emeritus, Microbiology

Doyle, Jeffrey J., Ph.D., Indiana U. Prof., Bailey Hortorium

Dress, William J., Ph.D., Cornell U. Prof. Emeritus, Bailey Hortorium

Eisner, Thomas, Ph.D., Harvard U. Jacob Gould Schurman Professor, Neurobiology and Behavior*

Emlen, Stephen T., Ph.D., U. of Michigan. Jacob Gould Schurman Professor, Neurobiology and Behavior

Feeny, Paul P., Ph.D., Oxford U. (England). Prof., Ecology and Systematics/Entomology

Fitzpatrick, John W., Ph.D., Princeton U. Prof., Ecology and Systematics/Laboratory of Ornithology

Flecker, Alexander, S., Ph.D., U. of Maryland. Asst. Prof., Ecology and Systematics

Fox, Thomas D., Ph.D., Harvard U. Prof., Genetics and Development

Ghiorse, William C., Ph.D. Rensselaer Polytechnic Inst. Prof., Microbiology

Gibson, Jane, Ph.D., U. of London (England). Prof. Emeritus, Biochemistry, Molecular and Cell Biology

Goldberg, Michael L., Ph.D., Stanford U. Prof., Genetics and Development

Hanson, Maureen R., Ph.D., Harvard U. Prof., Genetics and Development

Harrison, Richard G., Ph.D., Cornell U. Prof., Ecology and Systematics*

Harris-Warrick, Ronald M., Ph.D., Stanford U. Prof., Neurobiology and Behavior

Harvell, C. Drew, Ph.D., U. of Washington. Assoc. Prof., Ecology and Systematics

Helmann, John D., Ph.D., U. of California at Berkeley. Assoc. Prof., Microbiology

Hopkins, Carl D., Ph.D., Rockefeller U. Prof., Neurobiology and Behavior

Howarth, Robert W., Ph.D., Massachusetts Inst. of Technology/Woods Hole Oceanographic Institution. David R. Atkinson Professor in Ecology and Environmental Biology, Ecology and Systematics/Soil, Crop, and Atmospheric Sciences

Ingram, John W., Ph.D., U. of California at Berkeley. Prof. Emeritus, Bailey Hortorium

Jagendorf, André T., Ph.D., Yale U. Liberty Hyde Bailey Professor of Plant Physiology Emeritus, Plant Biology

Kemphues, Kenneth J., Ph.D., Indiana U. Prof., Genetics and Development

Kingsbury, John M., Ph.D., Harvard U. Prof. Emeritus, Plant Biology

Kraus, Lee, Ph.D., U. of Illinois. Asst. Prof., Biochemistry, Molecular and Cell Biology

Lis, John T., Ph.D., Brandeis U. Prof., Biochemistry, Molecular and Cell Biology

Loew, Ellis R., Ph.D., U. of California at Los Angeles. Assoc. Prof., Physiology/ Veterinary Physiology†

Luckow, Melissa A., Ph.D., U. of Texas at Austin. Assoc. Prof., Bailey Hortorium

MacDonald, Russell E., Ph.D., U. of Michigan. Prof. Emeritus, Biochemistry, Molecular and Cell Biology

MacIntyre, Ross J., Ph.D., Johns Hopkins U. Prof., Genetics and Development

Madsen, Eugene L., Ph.D., Cornell U. Asst. Prof., Microbiology

Marks, Peter L., Ph.D., Yale U. Prof., Ecology and Systematics

McCune, Amy R., Ph.D., Yale U. Assoc. Prof., Ecology and Systematics

Morin, James G., Ph.D., Harvard U. Prof., Ecology and Systematics

Mortlock, Robert P., Ph.D., U. of Illinois. Prof., Microbiology

Nasrallah, June B., Ph.D., Cornell U. Prof., Plant Biology

Nasrallah, Mikhail E., Ph.D., Cornell U. Prof., Plant Biology

Naylor, Harry B., Ph.D., Cornell U. Prof. Emeritus, Microbiology

Niklas, Karl J., Ph.D., U. of Illinois. Prof., Plant Biology

Nixon, Kevin C., Ph.D., U. of Texas at Austin. Assoc. Prof., Bailey Hortorium

Owens, Thomas G., Ph.D., Cornell U. Assoc. Prof., Plant Biology

Paolillo, Dominick J., Jr., Ph.D., U. of California at Davis. Prof., Plant Biology

Parthasarathy, Mandayam V., Ph.D., Cornell U. Prof., Plant Biology†

Quaroni, Andrea, Ph.D., U. of Pavia (Italy). Prof., Physiology/Veterinary Physiology†

Reeve, H. Kern, Ph.D., Cornell U. Assoc. Prof., Neurobiology and Behavior

Roberts, Jeffrey W., Ph.D., Harvard U. Robert J. Appel Professor of Cellular and Molecular Biology, Biochemistry, Molecular and Cell Biology

Rodriguez, Eloy, Ph.D., U. of Texas. Prof., Bailey Hortorium/Plant Biology

Root, Richard B., Ph.D., U. of California at Berkeley. Prof., Ecology and Systematics/ Entomology

Russell, James B., Ph.D., U. of California at Davis. Prof., Microbiology

Seeley, Jr., Harry W., Ph.D., Cornell U. Prof. Emeritus, Microbiology

Shalloway, David I., Ph.D., Massachusetts Inst. of Technology. Greater Philadelphia Prof., Biochemistry, Molecular and Cell Biology

Shapleigh, James P., Ph.D., U. of Georgia. Asst. Prof., Microbiology
Spanswick, Roger M., Ph.D., U. of Edinburgh (Scotland). Prof., Plant Biology
Tye, Bik-Kwoon, Ph.D., Massachusetts Inst. of Technology. Prof., Biochemistry, Molecular and Cell Biology
Uhl, Charles H., Ph.D., Cornell U. Prof. Emeritus, Plant Biology
Uhl, Natalie W., Ph.D., Cornell U. Prof. Emeritus, Bailey Hortorium
Vogt, Volker M., Ph.D., Harvard U. Prof., Biochemistry, Molecular and Cell Biology
Walcott, Charles, Ph.D., Cornell U. Prof., Neurobiology and Behavior
Wayne, Randy O., Ph.D., U. of Massachusetts. Assoc. Prof., Plant Biology
Winans, Stephen C., Ph.D., Massachusetts Inst. of Technology. Assoc. Prof., Microbiology
Winkler, David W., Ph.D., U. of California at Berkeley. Assoc. Prof., Ecology and Systematics
Wu, Ray, Ph.D., U. of Pennsylvania. Prof., Biochemistry, Molecular and Cell Biology
Zahler, Stanley A., Ph.D., U. of Chicago. Prof. Emeritus, Genetics and Development
Zinder, Stephen H., Ph.D., U. of Wisconsin. Prof., Microbiology

Other Teaching Personnel

Blankenship, James E., M.S., Cornell U. Sr. Lecturer, Biochemistry, Molecular and Cell Biology
Calvo, Rita A., Ph.D., Cornell U. Sr. Lecturer, Genetics and Development
Ecklund, P. Richard, Ph.D., Oregon State U. Sr. Lecturer, Neurobiology and Behavior
Ely, Susan, Ph.D., Tufts U. Lecturer, Biochemistry, Molecular and Cell Biology
Glase, Jon C., Ph.D., Cornell U. Sr. Lecturer, Neurobiology and Behavior
Land, Bruce, Ph.D., Cornell U. Sr. Lecturer, Neurobiology and Behavior
McFadden, Carol H., Ph.D., Cornell U. Sr. Lecturer, Physiology
Merkel, Susan, M.S., Cornell U. Lecturer, Microbiology
Nivison, Helen T., Ph.D., U. of California at Davis. Lecturer, Biochemistry, Molecular and Cell Biology
Rehkugler, Carole M., M.S., Cornell U. Sr. Lecturer, Microbiology
Shulman, Myra J., Ph.D., U. of Washington. Sr. Res. Assoc., Ecology and Systematics
Silva, Thomas, M.S., U. of Rhode Island. Lecturer, Plant Biology

Joint Appointees

Bloom, Stephen E., Assoc. Prof., Poultry and Avian Sciences/Biological Sciences
Borror, Arthur C., Adjunct Prof., U. of New Hampshire/Biological Sciences
Bradfield, Jack, Prof. Neurobiology and Behavior/Library of Natural Sounds
Comstock, Jonathan P., Adjunct Asst. Prof., Boyce Thompson Institute/Ecology and Systematics
Foote, Robert H., Jacob Gould Schurman Prof. Emeritus, Animal Science/Physiology
Hodge, Kathie, Asst. Prof. Plant Pathology/Bailey Hortorium
Holmes, Susan, Assoc. Prof., Biometrics/Biological Sciences
Howell, Stephen H., Adjunct Prof., Boyce Thompson Institute/Plant Biology
Kochian, Leon V., Adjunct Prof., USDA Science and Education Administration/Plant Biology
Korf, Richard P., Prof. Emeritus, Plant Pathology/Bailey Hortorium
Last, Robert L., Adjunct Prof., Boyce Thompson Institute/Genetics and Development
Liebherr, James K., Assoc. Prof., Entomology/Bailey Hortorium
Mason, Hugh S., Adjunct Asst. Prof., Boyce Thompson Institute/Plant Biology
May, Gregory D., Adjunct Asst. Prof., Boyce Thompson Institute/Plant Biology
Richmond, Milo E., Assoc. Prof., USDI Fish and Wildlife Service/Natural Resources/Ecology and Systematics
Rossman, Michael J., Adjunct Prof., Purdue U./Biochemistry, Molecular and Cell Biology
Stern, David B., Adjunct Prof., Boyce Thompson Institute/Plant Biology
Thompson, John F., Adjunct Prof., USDA Science and Education Administration/Plant Biology
Vehrencamp, Sandra, Prof. Neurobiology and Behavior/Library of Natural Sounds
Weeden, Norman F., Assoc. Prof., Horticultural Sciences/Bailey Hortorium
Wheeler, Quentin D., Prof., Entomology/Bailey Hortorium

College of Arts and Sciences

Adkins-Regan, Elizabeth, Ph.D., U. of Pennsylvania. Prof., Neurobiology and Behavior/Psychology
Aquadro, Charles F., Ph.D., U. of Georgia. Prof., Genetics and Development/Ecology and Systematics
Bass, Andrew H., Ph.D., U. of Michigan. Prof., Neurobiology and Behavior
Blackler, Antonie W., Ph.D., U. of London (England). Prof., Genetics and Development
Booker, Ronald, Ph.D., Princeton U. Assoc. Prof., Neurobiology and Behavior
Bretscher, Anthony P., Ph.D., Leeds U. (England). Prof., Biochemistry, Molecular and Cell Biology
Brown, William J., Ph.D., U. of Texas Health Science Center at Dallas. Assoc. Prof., Biochemistry, Molecular and Cell Biology
Capranica, Robert R., Sc.D., Massachusetts Inst. of Technology. Prof. Emeritus, Neurobiology and Behavior
Chen, Rey-Huei, Ph.D., Harvard U. Asst. Prof., Biochemistry, Molecular and Cell Biology
Deitcher, David, Ph.D., Harvard Med. School. Asst. Prof., Neurobiology and Behavior
Feigenson, Gerald W., Ph.D., California Inst. of Technology. Prof., Biochemistry, Molecular and Cell Biology
Finlay, Barbara, Ph.D., Massachusetts Inst. of Tech. Prof., Neurobiology and Behavior/Psychology
Geber, Monica A., Ph.D., U. of Utah. Assoc. Prof., Ecology and Systematics
Gibson, Quentin H., Ph.D./D.Sc., Queen's U. (Northern Ireland). Greater Philadelphia Professor Emeritus in Biological Sciences, Biochemistry, Molecular and Cell Biology
Gilbert, Perry W., Ph.D., Cornell U. Prof. Emeritus, Neurobiology and Behavior
Greene, Harry W., Ph.D., U. of Tennessee. Prof., Ecology and Systematics
Hairston, Nelson G., Jr., Ph.D., U. of Washington. Frank H. T. Rhodes Professor of Environmental Science, Ecology and Systematics
Halpern, Bruce P., Ph.D., Brown U. Prof., Neurobiology and Behavior/Psychology
Hedin, Lars O., Ph.D., Yale U. Assoc. Prof., Ecology and Systematics
Heppel, Leon A., Ph.D., U. of California at Berkeley. Prof. Emeritus, Biochemistry, Molecular and Cell Biology
Hess, George P., Ph.D., U. of California at Berkeley. Prof., Biochemistry, Molecular and Cell Biology
Hinkle, Peter C., Ph.D., New York U. Prof., Biochemistry, Molecular and Cell Biology
Howland, Howard C., Ph.D., Cornell U. Prof., Neurobiology and Behavior/Physiology
Hoy, Ronald R., Ph.D., Stanford U. Prof., Neurobiology and Behavior
Huffaker, Tim C., Ph.D., Massachusetts Inst. of Technology. Assoc. Prof., Biochemistry, Molecular and Cell Biology
Kennedy, Kenneth A. R., Ph.D., U. of California at Berkeley. Prof., Ecology and Systematics
Kondrashov, Alexey S., Ph.D., Res. Computer Center and Inst. of Developmental Biology (Russia). Assoc. Prof., Ecology and Systematics
Leonard, Samuel L., Ph.D., U. of Wisconsin. Prof. Emeritus, Genetics and Development
McCobb, David, Ph.D., U. of Iowa. Asst. Prof., Neurobiology and Behavior
MacDonald, June M. Fessenden, Ph.D., Tufts U. Assoc. Prof., Biochemistry, Molecular and Cell Biology/Program on Science, Technology, and Society
McFarland, William N., Ph.D., U. of California at Los Angeles. Prof. Emeritus, Ecology and Systematics
Nicholson, Linda, Ph.D., Florida State U. Asst. Prof., Biochemistry, Molecular and Cell Biology
Podleski, Thomas R., Ph.D., Columbia U. Prof., Neurobiology and Behavior
Power, Alison G., Ph.D., U. of Washington. Prof., Ecology and Systematics/Science and Technology Studies
Provine, William B., Ph.D., U. of Chicago. Charles A. Alexander Professor of Biological Sciences, Ecology and Systematics/History
Salpeter, Miriam M., Ph.D., Cornell U. Prof., Neurobiology and Behavior/Applied and Engineering Physics§
Seeley, Thomas D., Ph.D., Harvard U. Prof., Neurobiology and Behavior
Sherman, Paul W., Ph.D., U. of Michigan. Prof., Neurobiology and Behavior
Turgeon, Robert, Ph.D., Carleton U. (Canada). Prof., Plant Biology
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