DIVISION OF BIOLOGICAL SCIENCES

The Division of Biological Sciences provides a unified curriculum for undergraduate majors 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

The Division of Biological Sciences is composed of seven sections: Biochemistry, Molecular and Cell Biology; Ecology and Systematics; Genetics and Development; Microbiology; Neurobiology and Behavior; Physiology; Plant Biology; and, in addition, the L. H. Bailey Hortorium and the Shoals Marine Laboratory.

The offices, research laboratories, and classrooms of biology faculty members are located in many different buildings on the campus, primarily in the Colleges of Agriculture and Life Sciences, Arts and Sciences, and Veterinary Medicine.

Student services are provided by the division's Office for Academic Affairs and the Behrman Biology Center, both located in Stimson Hall, where academic advice, information on biological sciences course offerings, other important information, and counseling are available for undergraduates. The Office for Academic Affairs 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

P. J. Bruns, director; H. T. Stinson, associate director; E. Adkins-Regan, K. K. Adler, C. F. Aquadro, W. J. Arion, R. Barker, A. H. Bass, D. M. Bates, A. Bensadoun, K. W. Beyenbach, A. W. Blackler, S. E. Bloom, R. Booker, A. C. Borror, A. P. Bretscher, W. J. Brown, W. R. Butler, J. M. Calvo, R. R. Capranica, B. F. Chabot, J. L. Cisne, R. A. Corradino, W. L. Crepet, P. J. Davies, J. I. Davis, T. E. Dawson, A. Dobson, J. J. Doyle, S. E. Ealick, T. Eisner, S. T. Emlen, P. P. Feeny, G. W. Feigenson, 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, C. H. Greene, N. G. Hairston, B. P. Halpern, M. R. Hanson, R. G. Harrison, R. M. Harris-Warrick, C. D. Harvell, J. D. Helmann, L. A. Heppel, G. P. Hess, P. C. Hinkle, C. D. Hopkins, K. A. Houpt, T. R. Houpt, R. W. Howarth, S. H. Howell, H. C. Howland, R. R. Hoy, T. C. Huffaker, A. T. Jagendorf, P. A. Karplus, M. N. Kazarinoff, E. B. Keller, K. J. Kemphues, K. A. R. Kennedy, L. V. Kochian, R. P. Korf, T. A. LaRue, R. L. Last, A. C. Leopold, S. A. Levin, J. K. Liebherr, G. E. Likens, J. T. Lis, E. R. Loew, M. A. Luckow, R. E. McCarty, D. K. McClearn, A. R. McCune, J. M. Fessenden MacDonald, R. J. MacIntyre, W. H. Mark, P. L. Marks, J. K. Moffat, R. P. Mortlock, J. B. Nasrallah, M. E. Nasrallah, K. J. Niklas, K. C. Nixon, T. G. Owens, D. J. Paolillo, M. V. Parthasarathy, D. Pimentel, T. R. Podleski, F. H. Pough, A. G. Power, W. B. Provine, A. Quaroni, M. E. Richmond, J. W. Roberts, D. Robertshaw, R. B. Root, M. J. Rossman, J. B. Russell, M. M. Salpeter, A. M. Schneiderman, T. D. Seeley, D. I. Shalloway, J. P. Shapleigh, P. W. Sherman, R. B. Silver, J. Sirois, R. M. Spanswick, D. B. Stern, V. J. Stewart, D. N. Tapper, J. F. Thompson, R. Turgeon, B.-K. Tye, S. Via, V. M. Vogt, C. Walcott, R. H. Wasserman, R. O. Wayne, W. W. Webb, N. F. Weeden, Q. D. Wheeler, D. B. Wilson, S. C. Winans, D. W. Winkler, M. F. Wolfner, J. F. Wootton, R. Wu, S. A. Zahler, S. H. Zinder

Other Teaching Personnel

G. Albrecht, R. R. Alexander, J. E. Blankenship, R. A. Calvo, M. L. Cordts, C. Eberhard, P. R. Ecklund, J. C. Glase, J. M. Griffiths, J. B. Heiser, M. Kusch, C. H. McFadden, S. Merkel, C. M. Rehkugler, H. C. Reiss

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 Biological Sciences 152, 200* (unless permission of associate director is obtained), *202, 205, 206, 208, 209, 301, or 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 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 course (200+) offered by the Division of Biological Sciences *other than Biological Sciences 152, 200* (except by permission of associate director), *202, 205, 206, 208, 209, 301, or 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 courses offered by the Division of Biological Sciences can be used toward fulfillment of the biological distribution requirement except *Biological Sciences 152, 200 (unless permission of the associate director is obtained), 202, 205, 206, 208, 209, 301, or 367.* The following courses are especially suitable for the distribution requirement because they have no prerequisites: Biological Sciences 101–104, 105–106, 107–108, 109–110, 160, 170, 192, 201, 207, 212, 246, 275. *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 Biological Sciences 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: Biological Sciences 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.

THE MAJOR

The Division of Biological Sciences offers a major in biological sciences 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 division's Office for Academic Affairs, 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 associate director for academic affairs, 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): Biological Sciences 101 and 103 plus 102 and 104, or 105–106. Biological Sciences 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 Biological Sciences 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 take to complete the introductory biology requirement. For students in doubt, completion of Biological Sciences 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 215–216,* or 103–104.
3) **College mathematics** (one year): Two semesters of calculus (Mathematics 111–112, 191–192, or their equivalents) or one semester of calculus plus either Mathematics 105 or Statistics and Biometry 102. Education 115 may not be used to fulfill any part of this requirement.
4) **Organic chemistry**: Chemistry 253 and 251, or 253 and 301, 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:** Biological Sciences 281.
7) **Biochemistry:** Biological Sciences 330 or 331.
8) **Evolutionary Biology:** Biological Sciences 378.
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 of the Division of Biological Sciences 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.

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 and Anatomy:* Bio S 311, Introductory Animal Physiology, Lectures; Bio S 313, Histology: The Biology of Tissues; Bio S 316, Cellular Physiology; and Bio S 319, Animal Physiology Experimentation. The Program of Study in Animal Physiology and Anatomy 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.
2) *Biochemistry:* Quantitative Chemistry (Chemistry 300 or completion of Chemistry 215–216 for the general chemistry requirement for the major); a minimum of four credits of organic chemistry laboratory (Chemistry 301–302 or 251–252–302 or 301 or 251–252); a biochemistry laboratory course (Bio S 638 or 430 or 630); and Physical Chemistry (Chemistry 389–390.1 or 287–288 or 287–390.1 or 389–288). Note that Chemistry 288 is designed for biologists. It is recommended that students interested in graduate work in biochemistry take the more rigorous organic chemistry and physics sequences (Chemistry 357–358 or 359–360 and Physics 207–208), six credits of organic chemistry laboratory, and a third semester of calculus in preparation for the more rigorous physical chemistry sequence (Chemistry 389–390). Students interested in biochemistry should complete a year of introductory chemistry other than Chemistry 103–104 before the start of their sophomore year. Students are also urged to complete introductory biology in their freshman year.
3) *Cell Biology:* Chemistry 300 or 215–216, Quantitative Chemistry; Bio S 432, Survey of Cell Biology; Bio S 630, Laboratory in Cell Biology (strongly recommended), or Bio S 638, Intermediate Biochemical Methods, or Bio S 430, Basic Biochemical Methods; and at least 5 additional credits chosen from the following courses: Bio S 222, Neurobiology and Behavior II: Introduction to Neurobiology; Bio S 305, Basic Immunology; Bio S 313, Histology: The Biology of the Tissues; Bio S 345, Plant Anatomy; Bio S 435–436, Undergraduate Biochemistry Seminar; Bio S 437 Oncogenes and Cancer Viruses; Bio S 444, Plant Cell Biology; Bio S 483, Molecular Aspects of Development; Bio S 636, Cell Biology; Bio S 639, The Nucleus; An S 419, Animal Cytogenetics.

   Students interested in cell biology should complete a year of introductory chemistry other than Chemistry 103–104 before the start of their sophomore year. Students are also

urged to complete introductory biology in their freshman year. If graduate work in cell biology is anticipated, students should consider taking a physical chemistry sequence (Chemistry 389–390.1 or 287–288 or 287–390.1 or 389–288).

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

(a) Bio S 241, Introductory Botany; Bio S 274, Functional and Comparative Morphology of Vertebrates; Bio S 373, Biology of the Marine Invertebrates; Bio S 466 and 468, Physiological Plant Ecology, Lectures and Laboratory (formerly Bio S 460); Bio S 467, Physiological Animal Ecology; Bio S 471, Mammalogy; Bio S 472, Herpetology; Bio S 475, Ornithology; Bio S 476, Biology of Fishes; Entom 212, Insect Biology.

(b) Bio S 263, Field Ecology; Bio S 272, Functional Ecology: How Animals Work; Bio S 448, Plant Evolution and the Fossil Record; Bio S 455, Insect Ecology; Bio S 456, Stream Ecology; Bio S 457 and 459, Limnology: Ecology of Lakes, Lectures and Laboratory; Bio S 461, Population and Evolutionary Ecology; Bio S 462, Marine Ecology; Bio S 463 and 465, Plant Ecology and Population Biology, Lectures and Laboratory; Bio S 464, Microevolution and Macroevolution; Bio S 470, Ecological Genetics; Bio S 473, Ecology of Agricultural Systems; Bio S 478, Ecosystem Biology; Bio S 479, Paleobiology; Bio S 481, Population Genetics.

Note: One 400-level, 4-credit course 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.

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 towards requirements 1–8 above. These credits must include one course (200-level or above) from the courses listed for at least three of the eight other programs of study, and must include a course with a laboratory and a minimum of two upper-level (300 and above) courses of two or more credits. Bio S 498 may not be used as one of the upper-level courses. Bio S 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.

6) *Genetics and Development:* A minimum of 13 credits, usually chosen from the following courses: Bio S 385, Developmental Biology; Bio S 389, Embryology; Bio S 423, Neurogenetics; Bio S 433, Molecular Biology; Bio S 470, Ecological Genetics; Bio S 480, Seminar in Developmental Biology; Bio S 481, Population Genetics; Bio S 482, Human Genetics and Society; Bio S 483, Molecular Aspects of Development; Bio S 484, Molecular Evolution; Bio S 485, Microbial Genetics; Bio S 633, Biosynthesis of Macromolecules; Bio S 639, The Nucleus; Bio S 641, Laboratory in Plant Molecular Biology; Bio S 644, Plant Growth and Development; Bio S 652, Plant Molecular Biology II; Bio S 653, Plant Molecular Genetics; Bio S 682, Fertilization and the Early Embryo; Bio S 684, Advanced Topics in Population Genetics; Bio S 686, Mammalian Development; Bio S 687, Developmental Genetics; Bio S 688, Yeast Genetics; Bio S 695, Bacterial Genetics; Pl Br 606, Advanced Plant Genetics.

Up to 3 credits for this program of study may be chosen from other biological sciences courses with approval of the faculty adviser.

7) *Microbiology:* Bio S 290, General Microbiology, Lectures; Bio S 291, General Microbiology, Laboratory; Bio S 300, Seminar in Microbiology; Bio S 391, Advanced Microbiology Laboratory; and at least 5 credits from the following course lists, including at least one course from each group: (a) Bio S 485, Microbial Genetics; or Bio S 416, Microbial Physiology; and (b) Bio S 415, Bacterial Diversity; or Bio S 451, Structure and Function of Bacterial Cells.

8) *Neurobiology and Behavior:* The two-semester introductory course sequence, Neurobiology and Behavior I and II (Bio S 221 and 222) with discussion section (4 credits per term), and 7 additional credits, among which must be a course from the neurobiology and behavior offerings. Bio S 420, 498, 499, and 720 may not be used as this neurobiology and behavior course. However, these readings and independent research courses may form part of the additional credits (beyond those provided by the advanced neurobiology and behavior course) required to complete the Program of Study in Neurobiology and Behavior.

Note: Students who declare the Program of Study in Neurobiology and Behavior after taking Bio S 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 (Bio S 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: Bio S 242 and 244, Plant Physiology, Lectures and Laboratory; Bio S 246, Plants and Civilization; Bio S 248, Taxonomy of Vascular Plants; Bio S 341 and 349, Plant Physiology, Lectures and Laboratory; Bio S 343 and 347, Molecular Biology and Genetic Engineering of Plants, Lectures and Laboratory; Bio S 345, Plant Anatomy; Bio S 359, Biology of Grasses; Bio S 444, Plant Cell Biology; Bio S 445, Photosynthesis; Bio S 447, Molecular Plant Systematics; Bio S 448, Plant Evolution and the Fossil Record; Bio S 463 and 465, Plant Ecology and Population Biology, Lectures and Laboratory; or Bio S 466 and 468, Physiological Plant Ecology, Lectures and Laboratory (formerly Bio S 460).

Option (b) *Plant Biotechnology:* Students are required to take Bio S 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: Bio S 241, Introductory Botany; Bio S 242 and 244, Plant Physiology, Lectures and Laboratory; Bio S 317, Tissue Culture Techniques and Applications; Bio S 341 and 349, Plant Physiology, Lectures and Laboratory; Bio S 346, Algal Physiology; Bio S 433, Molecular Biology; Bio S 434, Biotechnology: Science, Policy, and Values; Bio S 444, Plant Cell Biology; Bio S 648, Plant Biochemistry; Pl Br 401, Plant Cell and Tissue Culture; or Pl Br 402, Plant Tissue Culture Laboratory.

10) *Independent Option:* A special program for students interested in nutrition is available under this option. 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 Division of Biological Sciences Curriculum Committee. Information on independent options and Curriculum Committee petition forms are available in the Office for Academic Affairs, 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 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 the Division of Biological Sciences may act as a supervisor. Faculty supervisors outside the division are acceptable only if a faculty member of the division agrees to take full responsibility for the quality of the work. 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 and anatomy; biochemistry; cell biology; ecology and evolutionary biology; genetics and development; microbiology; plant biology. No more than 4 credits of research may be used in completion of the Program of Study 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 for Academic Affairs, 200 Stimson Hall, and must be submitted to the Honors Program Committee by the deadline announced early in the senior year. Application forms for the honors program are separate from the enrollment forms for Biological Sciences 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 faculty member to supervise their research. Any faculty member in the Division of Biological Sciences may act as a supervisor. Students may also work with faculty supervisors outside the division. Students who select supervisors outside the division must arrange for a faculty member of the division to serve as cosigner of the research. The division cosigner must agree to meet with the student on a regular basis, to 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 Biological Sciences 499 (Undergraduate Research in Biology) under the direction of the faculty member acting as honors supervisor, although it is not necessary to do so. Students choosing to earn credit for honors research must enroll in Biological Sciences 499 (Undergraduate Research in Biology) separate 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 is the responsibility of the Honors Program Committee.

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 the 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 chair of the Honors Program Committee or from the Office for Academic Affairs, 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 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 Curriculum Committee of the division. 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 contact the associate director for academic affairs (200 Stimson Hall).

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

Students interested in the multidisciplinary program 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 middle digits of biological sciences course numbers are used to denote courses in specific areas: 0, general or microbiology; 1, animal physiology and anatomy or microbiology; 2, neurobiology and behavior; 3, biochemistry or cell biology; 4, plant biology; 6 and 7, ecology, systematics, and evolution; 8, genetics and development; 9, microbiology; or neurobiology and behavior. The middle digit 5 is used when all other course numbers in a particular area have already been assigned.

Note: Biological sciences 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.

Current and Former Course Numbers

GENERAL COURSES

Bio S 101–102 Biological Sciences, Lectures

101, fall; 102, spring. 2 credits each term. Prerequisite: concurrent enrollment in Bio S 103 (fall) or 104 (spring). Passing grade (D or better) in 101 is prerequisite to 102 unless written permission is obtained from instructor. S-U grades optional, with permission of instructor. May not be taken for credit after Bio S 105–106 or 109–110.

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. 7. A. W. Blackler.

Designed both for students who intend to specialize in biological sciences and for those specializing in other subjects, such as the social sciences or humanities, who want to obtain a thorough knowledge of biology as part of their general education. Plant and animal materials are considered together rather than in separate units. The fall semester covers the chemical and cellular basis of life, energy transformations, and cell and tissue biology. The spring semester covers genetics, development, evolution, ecology, and the origin of life. Each topic is considered in the light of modern evolutionary theory.

Bio S 103–104 Biological Sciences, Laboratory

103, fall; 104, spring. 2 credits each term. Prerequisite: concurrent enrollment in Bio S 101 (fall) or 102 (spring). 103 is prerequisite to 104 unless written permission is obtained from instructor. S-U grades optional, with permission of instructor. No admittance after second week of classes.

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 S 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, invertebrate diversity, and behavior. In the second semester, laboratory experience is provided in the areas of genetics, biotechnology, immunology, plant biology, population genetics and growth, and ecology. During the first semester, dissection of a doubly-pithed frog is included. Pithing is done by the instructor.

Bio S 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. S-U grades optional, with written permission of instructor. May not be taken for credit after Bio S 101–104 or 109–110. No admittance after first week of classes.

Lec, T 9:05 (1st lec of fall term, R 8/26 9:05); additional study and lab hours to be arranged. Staff.

Designed primarily for biology majors, preprofessionals, and other students who desire a challenging, broad introduction to fundamental concepts of biology. Physiology, anatomy (accompanied by preserved vertebrate dissection), and biochemistry are strongly emphasized in the fall semester. Subjects of study in the spring semester are genetics, development, ecology, evolution, behavior, and the diversity of organisms. 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. Four formal laboratory sessions are offered each semester. Written reports on experimental work are required in the fall; extensive dissections (both invertebrate and vertebrate) with practical exams constitute spring laboratories. The core units include additional laboratory work. Performance on the core units, the laboratories, and the final examination determine the final grade. Students who object to dissecting live invertebrates may want to take another biology course.

Bio S 107–108 General Biology

Summer (8-week session; 107, weeks 1–4; 108, weeks 5–8). 4 credits each. Prerequisite: Bio S 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 S 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 S 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 S 107 and involves more techniques, a survey of animal organization, and the design and performance of a field study. Bio S 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.

Bio S 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. Letter grades only. May not be taken for credit after Bio S 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 may not always satisfy the prerequisite for second- and third-level courses in biology.*

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. 7. R. Turgeon.

Students who do not plan to major in biology may take this broad introductory course in modern biology. It is not a course in social biology but addresses itself to biological principles with academic rigor. 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 and invertebrate material.

Bio S 152 Special Topics in Biology
Spring. 1 credit. Limited to 30 students. Prerequisites: superior performance in Bio S 109 or equivalent and concurrent enrollment in Bio S 102, 106, or 110, or written permission of instructor. S-U grades only. *This course may not be used in fulfillment of college distribution requirements.*

Lec, T 3:35; occasional field trips to be arranged. R. Turgeon, C. Eberhard, and guest lecturers. Guest lecturers discuss topics in their field of research interest.

This course is designed to complement introductory biology by providing an opportunity for deeper exploration of selected topics of interest. Class involvement and discussion are encouraged.

Bio S 170 Evolution of the Earth and Life (also Geological Sciences 102)
Spring. 3 credits. Recommended: Geol 101. S-U grades optional.

Lecs, T R 9:05 or 11:15; lab, M T W or R 2:00–4:25; field trips to be arranged. 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 charting ancient geography. Fossil collecting on field trips.

Bio S 200 Special Studies in Biology
Fall, spring, or summer. 1–3 credits. Prerequisites: transfer- or special-student status and written permission of instructor and of the associate director of the Division of Biological Sciences. Students must register using a special form available in Stimson 200. 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 of the associate director of the division.

Bio S 201 Biotechnology: The "New" Biology (also Biology and Society 201)
Spring. 3 credits. This course is for students *not* majoring in biological sciences. Students who have taken or are currently enrolled in Bio S 281 or 330 or 331 may not enroll. S-U grades optional.

Lecs, T R 2:30–4:00. J. M. Fessenden MacDonald, J. M. Calvo, S. Howell.

Designed for nonmajors, a general introduction to the application and issues of modern molecular biology in medicine and agriculture. Information on recombinant DNA technology, monoclonal antibodies, plant cell culture techniques, and embryo manipulation methods is presented. Topics include medical diagnostics and treatments; environment, agriculture, and food; and economic, social-policy, regulatory, ethical, and legal issues that surround biotechnology. The course is taught in three modules and the topics vary from year to year. Topics for 1994 are human gene mapping and genetic screening, crop plant biotechnology, immunodiagnostics and therapy, and AIDS and cancer. Recommended for those students who want to understand some new research discoveries, their applications, and social, legal, ethical, and policy issues stemming from them.

[Bio S 202 History of Biology (also Biology and Society 288, History 288, and Society and Technology Studies 288)
Spring. 3 credits. Prerequisite: one year of introductory biology. S-U grades optional. Not offered 1993–94.

Lecs, T R 10:10–11:25. W. B. Provine.

An examination of the history of biology, emphasizing the interaction of biology and culture. Original writings of biologists constitute the bulk of reading assignments. Covers the period from classical antiquity to the present, but primary emphasis is on twentieth-century biology.]

Bio S 205 Ethics and Health Care (also Biology and Society 205 and Philosophy 245)
Fall or summer (6-week session). 4 credits. Limited to 100 students (25 under Bio S 205, 25 under B&Soc 205, and 50 under Phil 245). Registered students not attending during the first week will be dropped from the course. Open to sophomores, juniors, and seniors.

Lecs, T R 8:40–9:55; disc, T or R 10:10 or 1:25. D. Allchin.

This course examines the ethical problems that emerge from cases of health care and search for practical solutions, while also delving deeper into understanding the nature of ethical responsibility and the tools of ethical analysis. This is a lab course in philosophy, with considerable work—both individually and in groups—on specific cases, problems, and fundamental ethical questions. Major sections include life, death, reproduction, and ethics; concepts of health care; health care and society; and research.

Bio S 206 Ethics and the Environment (also Biology and Society 206 and Philosophy 246)
Spring. 4 credits. Limited to 100 students (25 under Bio S 206, 25 under B&Soc 206, and 50 under Phil 246). Permission of instructor required for freshmen.

Lecs, T R 8:40–9:55. Disc, 1 hour each week to be arranged. D. Allchin.

This course addresses how ethical analysis helps shape our responses to environmental problems. Case studies help guide our assessments. This is a lab course in philosophy. The course challenges the student to develop ethical solutions or approaches individually and in groups. Major aims of the course include articulating the relationships between knowledge and values and distinguishing between ethics and economics, ecology, ideology, politics, and prudence or wisdom. A background in basic ecology or environmental issues or ethics is strongly recommended.

Bio S 207 Evolution (also History 287 and Science and Technology Studies 287)
Fall. 3 credits. Intended for students with no background in college biology. May not be taken for credit after Bio S 378. S-U grades optional.

Lecs, T R 10:10; disc, 1 hour each week to be arranged. W. B. Provine.

Evolution is the central concept in biology. This course examines evolution in historical and cultural contexts. Aims of the course include understanding the major issues in the history and current status of evolutionary biology and exploring 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 S 208 Drawing the Human Figure
Summer (6-week session). 3 credits.

Labs, M T W 3–5:15. K. Kucharski.

Human anatomy. Emphasis on learning correct anatomical information relating to the skeletal and muscular systems as approached through observation and drawing practices.

Bio S 209 Introduction to Natural Science Illustration
Summer (6-week session). 2 credits. Limited to 12 students. Prerequisite: free-hand 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 S 301 Biology and Society: The Social Construction of Life (also Biology and Society 301 and Science and Technology Studies 401)
Fall. 4 credits. Prerequisite: one year of introductory biology.

Sems and discs, M W 2:30–4:25. P. J. Taylor.

Controversial issues, past and present, in the life sciences and tools for analysis of the social, historical, and conceptual underpinnings of these issues. Topics include evolution and natural selection, heredity and genetic determinism, biotechnology and reproductive interventions, and ecology and environmental change. Analytic themes include bias, metaphor, historical semantics, styles of explanation, determinism, causality, interest, social construction, and gender. Through discussions and writing assignments, students develop analytic skills and their own responses to current issues.

Bio S 305 Basic Immunology, Lectures (also Veterinary Microbiology 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. Evening prelims: Sept. 23, Oct. 14, and Nov. 11. A. J. Winter.

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

Bio S 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.

Bio S 401 Introduction to Scanning Electron Microscopy

Fall or spring, weeks 1–8. 1 credit. Limited to 8 students (fall), 12 students (spring). Prerequisite: permission of instructor. 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 S 403 Transmission Electron Microscopy for Biologists

Fall. 1, 2, or 3 credits. 3 credits if student takes both sections. Limited to 12 students. Prerequisites: Bio S 313, 345, or 443, or written permission of instructor. 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, 2 credits, weeks 5–8. 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, 2 credits, weeks 5–8, 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, and metal shadowing techniques. Students have two additional weeks to complete laboratory assignments at the end of each section.

Bio S 405 Electron Microscopy in Molecular Biology

Fall, weeks 9–12. 1 credit. Limited to 12 students. Prerequisites: Bio S 403 or proficiency in transmission electron microscopy and written permission of instructor. S-U grades optional.

Lec, T 11:15; labs, M W or T R 1:25–4:25. Fee may be charged. M. V. Parthasarathy, M. Kyle.

An introductory course to electron microscopy (EM) for use as a tool in analyzing molecular structure, interactions, and processes. Methods considered to be most generally applicable to current studies in molecular biology are covered, including visualization of nucleic acids, heteroduplexes, protein molecules and filaments, and EM immunolabelling.

Bio S 407 Advanced Laboratory Techniques

Summer (special programs). 3 credits.

Labs, M–F 9–5. M. Kusch, B. R. Johnson, K. Perry.

Intensive laboratory course taught in three one-week modules, stressing techniques in molecular biology, cell biology and physiology, and neurobiology.

Students who take this course must be accepted into the Hughes Scholars Program. The program begins with an intensive three-and-one-half-week laboratory course. After the laboratory course, students spend the next seven weeks doing independent research in a Cornell biology laboratory. Students receive stipends of $2,400. Students are expected to continue their research projects by enrolling in Bio S 499 and attending a one-credit fall and spring seminar course (Bio S 400) during their senior year. Information about the program and applications are available from the Behrman Biology Center, 216 Stimson Hall, or from Meredith Kusch (255-9405). Application deadline is late February each year.

Bio S 450 Light and Video Microscopy for Biologists (formerly Optical Methods of Biologists)

Spring. 3 credits. Limited to 12 students. Prerequisite: one year of introductory biology and permission of instructor.

Lecs, T R 1:25; lab, R 2:15–4:30. 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 S 469 Food, Agriculture, and Society (also Biology and Society 469 and Science and Technology Studies 469)

Spring. 3 credits. Prerequisite: an introductory ecology course or permission of instructor. S-U grades optional. Possible fee for course reading materials.

Lecs, T R 1:25–2:40. A. G. Power.

A multidisciplinary course dealing with the social and environmental impact of food production in the United States and in 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 S 498 Teaching Experience

Fall or spring. 1–4 credits. Enrollment limited. Prerequisites: previous enrollment in the course to be taught or equivalent, and written permission of instructor. S-U grades optional, with permission of instructor. *Students in the College of Arts and Sciences may not count credits from this course toward the 120 credits required for graduation.*

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 S 105–106, 231, 274, 291, 292, 311, 319, 330, 430, and 475.

Bio S 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 for Academic Affairs in 200 Stimson Hall. Each student must submit an independent study statement describing the proposed research project during course registration. (Special forms for this purpose are available in the college offices and in 200 Stimson Hall.) S-U grades optional. Any faculty member in the Division of Biological Sciences may act as a supervisor. Faculty supervisors outside the division are acceptable only if a faculty member of the division agrees to serve as cosigner, taking full responsibility for the quality of the work.

Hours to be arranged. Staff.

Practice in planning, conducting, and reporting independent laboratory and library research programs. Research credits may *not* be used in completion of the following programs of study: animal physiology and anatomy; biochemistry; cell biology; ecology and evolutionary biology; genetics and development; microbiology; plant biology. No more than 4 credits of research may be used in completion of the program of study in neurobiology and behavior.

Bio S 601 Evolution, Ecology, and Behavior

Summer (special programs). 3 credits.

Lecs and labs, M–F 9–5. A. T. Vawter, R. R. Hoy, W. B. Provine, and staff.

Lecture and laboratory course designed specifically for high-school biology teachers. The lecture covers some aspects of evolution, behavior, and ecology. Includes fieldwork in ecology that is designed to enable participants to lead their own classes in field exercises.

Cornell has received a three-year grant from the National Science Foundation Teacher Enhancement Program to upgrade the information and skills of high-school biology teachers. Twenty teachers from a hundred-mile radius of Ithaca are chosen to participate each summer in a three-week intensive program at Cornell. A major part of the program is a lecture and laboratory course. In addition, there are field trips to various Cornell research facilities and guest lectures by Cornell faculty. Teachers also perform laboratory exercises designed for high school biology classes. There is an important component providing teachers with instruction and practice in the use of computers directed toward enhancing teaching. Each selected participant earns 3 credits and is provided with an Apple Macintosh computer on long-term loan, room, and a stipend.

Bio S 602 Molecular Biology for Teachers

Summer (special programs). 3 credits.

Lecs and labs, M–F 9–5. R. A. Calvo, J. E. Blankenship, and staff.

Lecture and laboratory course in molecular biology designed specifically for high-school biology teachers. The lecture material covers the structure and biosynthesis of macromolecules, recombinant DNA technology, the unexpected complexity of eukaryotic genes, and the application of recombinant DNA technology to human genetics, medicine, and agriculture. The laboratories provide experience with techniques used in modern molecular biology; some techniques are exportable to high-school classrooms. Registration limited to teachers selected to participate in the Cornell Institute for Biology Teachers.

Cornell has received a five-year grant from the Howard Hughes Medical Institute to upgrade the information and skills of high-school biology teachers. Twenty teachers from a 100-mile radius of Ithaca are chosen to participate each summer in a three-week intensive program at Cornell. A major part of the program is a lecture and laboratory course in molecular biology. Also included are field trips to various Cornell research facilities and guest lectures by Cornell faculty. Teachers also perform laboratory exercises designed for high-school biology classes. To enable teachers to implement new laboratory exercises, the grant provides each teacher with about $2,000 worth of equipment and supplies to take home to their biology classes plus an Apple MacIntosh computer on long-term loan. There is an important component providing teachers with instruction and practice in the use of computers directed toward enhancing teaching. Participating teachers receive 3 credits, room, and a stipend. Applicants should not apply directly to the Summer Session Office. More information on the program and the application process is available from Rita Calvo or Stephanie Henkel, Cornell/Hughes Program, 169 Biotechnology Building, (607) 254-4831.

Bio S 606 Freeze-Fracture Technique
Spring, weeks 9–14. 1 credit. Primarily for graduate students. Limited to 8 students. Prerequisites: Bio S 403 or equivalent, and permission of instructor. S-U grades only.
Lec, M 10:10; disc to be arranged; labs, M W 1:25–4:25. Fee may be charged. M. V. Parthasarathy.
Principles of freeze-fracturing and freeze-substitution technique, freezing artifacts, and interpretation of images.

Bio S 608 Advanced Electron Microscopy for Biologists
Spring, weeks 10–14. 1 credit. Primarily for graduate students. Limited to 6 students. Prerequisite: Bio S 403 or equivalent. S-U grades only.
Hours to be arranged. Fee may be charged. M. V. Parthasarathy.
Project in biological ultrastructure.

[Bio S 702 X-Ray Elemental Analysis in Biology
Spring, weeks 7–14. 1 credit. Limited to 6 students. Prerequisites: Bio S 403 or equivalent, and permission of instructor. S-U grades only. Offered alternate years. Not offered 1993–94.
Lec and lab to be arranged. Fee may be charged. M. V. Parthasarathy, C. Daugherty.
Principles of X-ray elemental analysis are discussed, with special reference to the energy-dispersive system. Emphasis is on qualitative elemental analysis of biological specimens and preparation of material for such analysis, including freeze-substitution technique. A brief introduction to quantitative elemental analysis is also given.]

Bio S 705 Advanced Immunology Lectures (also Veterinary Microbiology 705)
Spring. 3 credits. Prerequisite: Bio S 305 or permission of instructor. Offered alternate years.
Lecs, M W F 9:05. Coordinator: A. J. Winter.
Coverage at an advanced level of molecular and cellular immunology.

[Bio S 706 Immunology of Infectious Diseases and Tumors (also Veterinary Microbiology 719)
Spring. 2 credits. Prerequisite: Bio S 305 or permission of instructor. S-U grades with permission of instructor. Offered alternate years. Not offered 1993–94.
Lec, R 10:10–12:05. Coordinator: A. J. Winter.
Coverage at an advanced level of the immunology of diseases caused by selected bacterial, viral, protozoan, and helminthic parasites, and tumor immunology.]

Related Courses in Other Departments

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

Medicine and Civilization (Biology and Society 322)

Pathogenic Bacteriology and Mycology (Biological Sciences 304 and Veterinary Microbiology 318)

Pathogenic Virology (Biological Sciences 308 and Veterinary Microbiology 317)

ANIMAL PHYSIOLOGY AND ANATOMY

Bio S 212 Human Physiology for Non-Biology Majors
Spring. 3 credits. May not be taken for credit after Bio S 311. 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: Mar. 3 and Apr. 19. P. 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.

[Bio S 214 Biological Basis of Sex Differences (also Biology and Society 214 and Women's Studies 214)
Fall. 3 credits. Limited to non-biology majors and freshman and sophomore biology majors. Prerequisite: one year of introductory biology. S-U grades optional. Offered alternate years. Not offered 1993–94.
Lecs, T R 8:30–9:55; occasional discussion to be arranged. 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.]

Bio S 311 Introductory Animal Physiology, Lectures (also Veterinary Physiology 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. 21 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.

Bio S 312 Farm Animal Behavior (also Animal Science 305)
Spring. 2 credits. Prerequisites: introductory courses in animal physiology and genetics. 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 feeding, reproduction, and social interactions of domestic animals, and their physiological basis. Management systems for commercial livestock production and their implications for animal behavior and welfare are stressed.

Bio S 313 Histology: The Biology of the Tissues
Fall. 4 credits. Prerequisite: one year of introductory biology. Recommended: Bio S 311, 316, 319, 330 or 331, or their equivalents, and organic chemistry.
Lecs, T R 1:25; labs, T R 2:30–5. R. B. Silver.
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 invertebrate or vertebrate animals.

Bio S 316 Cellular Physiology
Spring. 4 credits. Limited to 100 students, with preference given to students studying in animal physiology and anatomy. Each lab limited to 24 students. Prerequisite: concurrent or previous enrollment in Bio S 330 or 331.

Lecs, M W F 9:05; lab, M T or W 1:25–5 (a R 1:25–5 lab may be added if enrollment exceeds 72 students). Evening prelims: Mar. 1, Apr. 7, and May 3. 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.

Bio S 319 Animal Physiology Experimentation (also Veterinary Physiology 348)
Fall. 3 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 4 afternoon laboratory sections limited to 20 students. Prerequisite: concurrent or previous enrollment in Bio S 311 or permission of instructor based on previous meritorious performance in another introductory animal physiology course.

Lab, M T W or R 1:25–5; disc, F 12:20. R. A. Corradino.

A series of student-conducted *in vitro* and *in vivo* experimental exercises designed to illustrate basic physiological processes in animals and to introduce students to animal physiology research techniques, instrumentation, experimental design, and interpretation of results. Techniques include anesthesia, dissection, vivisection under anesthesia, physiographic recording, and computer analysis. Experiments with living tissues and live animals examine properties of blood, muscle, and nerves; cardiovascular, respiratory, and renal function and control; and endocrine regulation of renal, cardiovascular, and reproductive tissue activity. Experimental resources include live animals of several vertebrate species, including frogs, rats, and rabbits, which are euthanized in conjunction with the laboratory exercises. Written reports of laboratory activities are required. Grading is based on evaluation of these reports, quizzes, and laboratory performance.

Bio S 458 Mammalian Physiology
Spring. 3 credits. Enrollment limited. Graduate student auditors allowed. Prerequisite: Bio S 311 or equivalent with permission of instructor.

Lecs, M W F 10:10. K. W. Beyenbach and staff.

An in-depth treatment of selected topics in mammalian physiology and human physiology. Emphasis is on a conceptual and working knowledge of physiology rather than a factual, memorizing knowledge. Topics selected, in order of presentation, include recurrent themes in physiology; basic functional elements of biological systems; design of multicellular animals; mammalian fluid compartments; homeostasis; cardiovascular, respiratory, gastro-intestinal, and renal physiology; and energy metabolism. The course concludes with a discussion of integrative physiology by considering the multiple, parallel short-term responses of the human body to exercise. Recommended for biological sciences majors, pre-med and pre-vet students, and beginning graduate students in physiology, nutrition, and animal science.

Bio S 615 Nutrition, Physiology, and Biochemistry of Mineral Elements (also Veterinary Physiology 759 and Nutritional Sciences 659)
Spring. 2 credits. Prerequisites: courses in basic physiology, intermediate biochemistry, and general nutrition.

Lec, T 2:30–4:25. R. Schwartz, R. H. Wasserman, D. R. Van Campen, C. C. McCormick.

Lectures on nutritional aspects and physiological, biochemical, and hormonal relationships of the major macroelements and microelements, with emphasis on recent developments. Discussions of methodologies of mineral research and essentiality, transport, function, homeostasis, interrelationships, and toxicity of various mineral elements.

Bio S 618 Biological Membranes and Nutrient Transfer (also Veterinary Physiology 752)
Spring. 2 credits. Prerequisites: courses in animal or plant physiology, quantitative and organic chemistry, and physics. Recommended: a course in cellular physiology. S-U grades optional, with permission of instructor. Offered alternate years.

Lecs, T R 11:15. R. H. Wasserman.

An introduction to elementary biophysical properties of biological membranes; theoretical aspects of permeability and transport; mechanism of transfer of inorganic and organic substances primarily across epithelial membranes; and characteristics and properties of transporting macromolecules and ion channels.

Bio S 619 Lipids (also Nutritional Sciences 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.

Bio S 658 Molecular Mechanisms of Hormone Action (also Veterinary Physiology 758)
Spring. 2 credits. Prerequisite: permission of instructor. Minimum enrollment of 6 required. Offered alternate years.

Lecs, T R 10:10. R. A. Corradino.

An advanced course developed from the current literature on endocrine mechanisms. Primarily a lecture course with student discussion.

Bio S 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.

***Fall 1993:* five topics are offered.**

Bio S 711 Physiological Control of Food and Water Intake: Hunger and Thirst
Fall. 1 credit. Open to undergraduate and graduate students. Offered alternate years.

Lec, 1 hour each week to be arranged. T. R. Houpt.

A variety of species are considered with emphasis on common mammalian species: rat, dog, goat, pig, horse, and human. A mixed lecture/seminar format is used.

Bio S 712 Membrane and Epithelial Transport
Fall. 1 credit. Offered alternate years.

Lec, 1 hour each week to be arranged. K. W. Beyenbach.

The course begins with a series of lectures on the structure and function of membrane pumps, carriers, and channels. Thereafter, the students read and discuss recent review articles on these subjects. When appropriate, there are laboratory demonstrations to illustrate how some of these transport systems are studied experimentally.

Bio S 713 Thermoregulation and Exercise
Fall. 1 credit. Offered alternate years.

Lec, 1 hour each week to be arranged. 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.

Bio S 715 Acid-Base Relations (also Veterinary Physiology 627)
Fall or spring. 2 credits.

Autotutorial. A. Dobson.

Bio S 717 Structure and Function of Joints with Emphasis on Arthritis
Fall. 1 credit. Open to undergraduate and graduate students. Offered alternate years.

Lec, R 3:00. G. Lust.

***Spring 1994:* four topics are offered.**

Bio S 710 Plasma Lipoprotein
Spring. 1 credit.

Sem, 1 hour each week to be arranged. A. Bensadoun.

[Bio S 714 Physiology of Pregnancy
Spring. 2 credits. Offered alternate years. Not offered 1993–94.

Lec, 2 hours each week to be arranged. P. W. Nathanielsz.

Seminar course covering aspects of maternal, placental, and fetal function. Emphasis on fetal growth, respiration, neural and endocrine and cardiovascular function, myometrial activity, parturition, and placental function.]

Bio S 715 Acid-Base Relations (also Veterinary Physiology 627)
Fall or spring. 2 credits.

Autotutorial. A. Dobson.

Bio S 716 Regulation of Mitosis and the Cell Cycle
Spring. 2 credits. Limited to 12 students. Offered alternate years.

Lec, 2 hours each week to be arranged. R. B. Silver.

The course focuses on regulatory mechanism, Ca^{2+} regulation, metabolic pathways that exhibit cell-cycle-related preiodicities, genetic biochemical and cell physiological studies of the cell cycle, and evidence for intracellular clocks and escapements.

Bio S 718 Evolution of Color
Spring. 1 credit. Offered alternate years.
Sem, 1 hour each week to be arranged.
E. R. Loew.

Bio S 719 Graduate Research in Animal Physiology (also Veterinary Physiology 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 725. S-U grades optional.
Hours to be arranged. Staff.
Similar to Bio S 499 but intended for graduate students who are working with faculty members on an individual basis.

Bio S 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. Offered alternate years.
Lec, 2 hours each week to be arranged; disc, 1 hour each week to be arranged.
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.

Bio S 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. Staff. (Coordinator: K. Beyenbach).
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.

Bio S 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. Staff. (Coordinator: K. Beyenbach).
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 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 385)

Embryology (Biological Sciences 389)

Fundamentals of Endocrinology (Animal Science 427)

Insect Morphology (Entomology 322)

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

Neuroanatomy (Veterinary Anatomy 504)

Sensory Function (Biological Sciences 492)

Teaching Experience (Biological Sciences 498)

Undergraduate Research in Biology (Biological Sciences 499)

BIOCHEMISTRY, MOLECULAR AND CELL BIOLOGY

Bio S 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 3 S of semester.
Section chair and staff.
Discussions by six professors about their research and promising areas for research in the future.

Bio S 231 General Biochemistry
Fall. 3 credits. Intended for students who have not studied biochemistry previously and who do not expect to pursue it further. Not recommended for students who have taken organic chemistry. Prerequisite: Chemistry 104 or 208 or equivalent. Preregistration with instructor required (309 Wing Hall). S-U grades optional.
Lecs, M W F 12:20. J. M. Griffiths.
A brief introductory section relating organic chemistry to biochemistry is given, followed by the biochemical material in the usual one-semester introductory courses. Topics of general interest are also included.

Bio S 232 Recombinant DNA Technology and Its Applications (also Biology and Society 232)
Spring. 3 credits. S-U grades optional. Limited to freshmen with AP 4 or 5 in biology. Possible fee for course material.
Lecs and disc, M W F 11:15. J. M. Calvo, J. M. Fessenden MacDonald.
An introduction to molecular approaches to biology. Basic concepts underlying recombinant DNA technology together with strategies for cloning genes are discussed. Much of the course deals with applications of recombinant DNA technology to basic research and to biotechnology. Applications to be discussed include screening for genetic diseases, animal and plant improvement, and production of proteins useful in medicine, agriculture, and industry. Scientific, historical, regulatory, social, and ethical issues are presented and discussed. Recommended especially for students desiring a firm background in recombinant DNA technology in preparation for taking genetics and biochemistry.

Bio S 330–331 Principles of Biochemistry
Introductory biochemistry is offered in two formats: individualized instruction (330) and lectures (331). *Individualized instruction is offered to a maximum of approximately 150 students each semester. Lectures given fall semester only.*

Bio S 330 Principles of Biochemistry, Individualized Instruction
Fall or spring. 4 credits (2 credits if taken after Bio S 231). Prerequisite: Chem 253 or 358 or equivalent. May not be taken for credit after Bio S 331. S-U grades optional for graduate students only.
Hours to be arranged. Evening prelims: fall, Oct. 22; spring, Mar. 16.
J. E. Blankenship, G. Albrecht, R. Wu, P. C. Hinkle.
The core material of the course includes protein structure and function, enzymes, basic metabolic pathways, DNA, RNA, protein synthesis, and an introduction to gene cloning. There are no formal lectures; the course has an autotutorial format. The core material is divided into fourteen units of work that are outlined in a study guide written to accompany the textbook. Students prepare the work on their own, with help from the staff of the Study Center if desired, and must pass a written and an oral quiz on each unit. A midterm and final exam are required.

Each student also participates in four class hours of discussions on research papers, and two hours of discussion on review papers during the semester. A small amount of problems or other supplemental work is also assigned.

Bio S 331 Principles of Biochemistry, Lectures
Fall or summer (6–week session). 4 credits (or 2 credits if taken after Bio S 231). Enrollment may be limited to 400 students in fall. Prerequisite: Chem 253 or 358 or equivalent. May not be taken for credit after Bio S 330. S-U grades optional for graduate students only.
Lecs, M W F S 10:10; recitation, W or R 12:20, 1:25, or 2:30. G. W. Feigenson, R. Barker, B.-K. Tye.
The course is divided into three parts, each with about eighteen lectures, covering protein structure and function; metabolism and bioenergetics; and nucleic acids, protein synthesis, and gene exploration.

Bio S 430 Basic Biochemical Methods
Fall or spring. 4 credits. Enrollment limited. Prerequisites: Bio S 330 or 331, organic chemistry lectures and laboratory, and permission of instructor obtained by preregistering in Wing 312. Concurrent registration in Bio S 330 or 331 may be arranged in the fall term for graduate students.
Lec and disc, F 1:25; labs, M W or T R 12:20–4:25. R. R. Alexander, J. M. Griffiths, and staff.
A laboratory course designed to introduce students to the biochemical techniques commonly used in the study of biological materials. Students work in small groups, and each student may choose some of the experiments after completing a series of

required procedures. Various assay methods, chromatography, electrophoresis, and use of the scintillation counter are taught. Protein isolation, purification, and enzyme characterization methods are included. Techniques used in the clinical laboratory are applied to analyses of blood and urine samples, and some nutritional analyses are done for protein and vitamin contents of foods, or a student may isolate and purify the lipids from a material of his/her choice, perform thin-layer chromatography, and carry out cholesterol and phosphate analyses. In the nucleic acids module, students are introduced to recombinant DNA methodology, isolating DNA, and studying the function of transfer RNA.

Bio S 432 Survey of Cell Biology
Spring. 3 credits. Prerequisite: Bio S 330 or 331 or equivalent. S-U grades optional for graduate students only.

Lecs, M W F 11:15. 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 Bio S 437, 483, 632, 636, and 639.

Bio S 433 Molecular Biology
Fall. 3 credits. Prerequisites: Bio S 281 and 330 or 331.

Lecs, T R 10:10. T. C. Huffaker.
A comprehensive examination of the molecular biology of prokaryotic and eukaryotic cells. Topics include genomic organization; replication, recombination, and rearrangement of DNA; synthesis and processing of RNA; and regulation of gene expression. The principles of recombinant DNA technology are discussed.

Bio S 435–436 Undergraduate Biochemistry Seminar
435, fall; 436, spring. 1 credit each term. May be repeated for credit. Limited to upperclass students. Prerequisite: Bio S 330 or 331 or written permission of instructor. S-U grades only.

Sem 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.

Bio S 437 Oncogenes and Cancer Viruses
Fall. 3 or 4 credits (4 credits for participation in the writing component of the course). Prerequisite: Bio S 330 or 331. Recommended: Bio S 281. S-U grades optional, with permission.

Lecs, T R 12:20–1:35; disc, to be arranged. D. I. Shalloway.
The use of animal cells in culture as an experimental system for studying the cellular mechanisms involved in carcinogenesis through the use of recombinant DNA and biochemical methods. Topics include immortalization of cells, the cell cycle, differences between normal and neoplastically transformed cells, growth factors, molecular biology and biochemistry of cancer viruses, and structure and function of viral and cellular oncogenes. Understanding of relevant experimental techniques, experimental design and comprehension of primary research literature is emphasized. This is *not a survey course*; it is designed primarily for students planning a career in research. A series of exercises to develop scientific writing skills are required for undergraduate students except by special permission. Depending on availability, graduate students may also participate in this writing component. Four credits are given when the writing component is included.

Bio S 630 Laboratory in Cell Biology
Spring. 4 credits. Enrollment limited. Prerequisites: a course in biochemistry or cell biology, and permission of instructor obtained by *registering in 258 Biotechnology Building with J. Gibson*.

Labs, M W 1:25–4:25 or R 9:05–4:25; disc to be arranged. J. Gibson, B. Tyler.
The course emphasizes approaches to experimental design and theory of experimental techniques as well as providing experience in handling and experimenting with cells of different kinds. Limited numbers of vertebrate animals are used for two experiments where no alternative approach exists.

Bio S 631 Protein Structure and Function
Fall. 3 credits. Prerequisites: introductory biochemistry, physical chemistry, and organic chemistry. S-U grades optional.

Lecs, M W F 9:05. P. A. Karplus.
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.

Bio S 632 Membranes and Bioenergetics
Spring. 2 credits. Prerequisite: Bio S 330 or 331 or equivalent. Offered alternate years.

Lecs, T R 11:15. 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.

Bio S 633 Biosynthesis of Macromolecules
Fall. 2 credits. Prerequisite: Bio S 330 or 331. Recommended: Bio S 281.

Lecs, T R 9:05. J. W. Roberts, D. B. Wilson.
Synthesis of DNA, RNA, and proteins, and regulation of gene expression.

[Bio S 635 Enzymes, Coenzymes, and Metabolic Regulation (also Nutritional Sciences 635)
Spring. 2 credits. Prerequisites: Bio S 330 or 331 and Chem 358 or 360, or permission of instructor. Offered alternate years. Not offered 1993–94.

Lecs, T R 9:05. M. N. Kazarinoff.
Lectures on the identification and characterization of regulatory steps in metabolism, considered from both theoretical and practical aspects. The intracellular mechanisms of regulation are emphasized, with specific examples in mammalian metabolism examined in detail.]

Bio S 636 Cell Biology (formerly Current Topics in Cell Biology)
Spring. 2 credits. Prerequisites: Bio S 330 or 331, and 432, or their equivalents.

Lecs, T R 10:10. A. P. Bretscher.
Lectures covering current topics in cell biology, including a detailed discussion of secretion, endocytosis, membrane-bound organelles, membrane recycling, the cytoskeleton, cell motility, junctions, the cell cycle, and related topics. Together with Bio S 632 and 639, this course provides broad coverage of the cell biology subject area.

Bio S 637 Integration and Coordination of Energy Metabolism (also Nutritional Sciences 636)
Fall. 3 credits. Prerequisite: Bio S 330 or 331 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. Emphasis is placed on correlations with physiologic functions. Mechanisms that control energy metabolism within individual tissues and coordinate these processes *in vivo* are analyzed in the contexts of selected physiologic and pathologic stresses.

Bio S 638 Intermediate Biochemical Methods
Fall or spring. 4 credits. Primarily for graduate students minoring in the field of Biochemistry, Molecular and Cell Biology, and undergraduates in the biochemistry program of study. Admission to the course is dependent upon the results of a personal interview with the instructor or the teaching support specialist (x5-8072), which must be held before the first day of classes. *There is no admission to the course without the interview*. Undergraduates are urged to interview during preregistration. May not be taken for credit after Bio S 430.

Lab, T 9:05–4:25 (fall); lab, T or R 9:05–4:25 (spring). V. M. Vogt and staff.
Selected experiments on proteins and DNA. The course emphasizes quantitative aspects as well as experimental design in modern biochemical research.

Bio S 639 The Nucleus
Spring. 2 credits. Prerequisite: Bio S 330 or 331 or equivalent. Recommended: Bio S 281.

Lec, M 8–9:55 p.m. 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. Together with Bio S 632 and 636, this course provides broad coverage of the cell biology subject area.

[Bio S 648 Plant Biochemistry
Spring. 3 credits. Prerequisites: organic chemistry, biochemistry, and a course in plant physiology. Offered alternate years. Not offered 1993–94.

Lecs, M W F 9:05. A. T. Jagendorf, R. L. Last, T. G. Owens.
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, 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.]

Bio S 692 Protein-Nucleic Acid Interactions
Spring. 3 credits. Prerequisites: Bio S 330 or 331 and 633.
Lecs, T R 10:10–11:25. 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.

Bio S 732–737 Current Topics in Biochemistry
Fall or spring. 1/2 or 1 credit for each topic. May be repeated for credit. Prerequisite: Bio S 330 or 331 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.

Bio S 738 Macromolecular Crystallography (also Chemistry 788)
Spring. 3 credits. S-U grades optional. Prerequisite: permission of instructor.
Lecs, M W F 10:10. S. A. Ealick, P. A. Karplus, J. C. Clardy.
Lectures briefly cover the fundamentals of crystallography and focus on methods for determining the 3-dimensional structures of macromolecules. These include crystallization, data collection, multiple isomorphous replacement, molecular replacement, model building, refinement, and structure interpretation.

Bio S 750 Cancer Cell Biology (also Veterinary Pathology 750)
Spring. 3 credits. Prerequisite: Bio S 330 or 331 or equivalent.
Lecs to be arranged. D. Shalloway, J. Guan, R. Levine, B. Pauli, A. Yen.
This course focuses on the role of oncogenes, tumor suppressor genes, extracellular matrix and cell surface adhesion receptors in tumorigenesis and tumor progression. The course is taught in large part from the contemporary literature. Course topics include cell proliferation and oncogenes, regulatory effects of cell-substrate and cell-cell interactions, and angiogenesis, invasion, and metastasis.

Bio S 751 Ethical Issues and Professional Responsibilities (also Toxicology 751 and Science and Technology Studies 751)
Fall or spring. 1 credit. Limited to graduate students beyond first year. S-U grades only.
Sem, 2:30–4:15 (ten weeks). Additional sections may be offered. Organizational meeting W 3:35 (Fall: 9/1; spring: 1/26). J. Fessenden MacDonald.
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.

Bio S 830 Biochemistry Seminar
Fall or spring. No credit.
Sem, F 4:30. Staff.
Lectures on current research in biochemistry, presented by distinguished visitors and staff members.

Bio S 831 Advanced Biochemical Methods I
Fall. 6 credits. Limited to graduate students majoring in biochemistry. S-U grades optional.
Labs and discs, 12 hours each week to be arranged. Organizational meeting first R of semester, 10:10. B. Tyler and staff.
This course emphasizes experimental design and the concepts implicit in current approaches to research in biochemistry and cell biology. Students are required to read papers and participate actively in discussions in order to design their own protocols before performing experiments using the techniques most common in the recent literature of these fields.

Bio S 832 Advanced Biochemical Methods II
Spring. 6 credits. Limited to graduate students majoring in biochemistry. S-U grades only.
Lab to be arranged. Staff (coordinator: J. M. Calvo, graduate faculty representative).
Research in the laboratories of two or three different professors chosen by the student. Arrangements are made jointly between the graduate field representative and the research adviser.

Bio S 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, T 5–6:30 p.m. T. C. Huffaker, W. J. Brown, J. T. Lis.
Each student presents one seminar per year on his or her thesis research and then meets with instructors and thesis committee members for evaluation.

Bio S 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: P. A. Karplus; spring: T. C. Huffaker.
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 619 and Nutritional Sciences 602)

Molecular Aspects of Development (Biological Sciences 483)

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

Teaching Experience (Biological Sciences 498)

Undergraduate Research in Biology (Biological Sciences 499)

ECOLOGY AND EVOLUTIONARY BIOLOGY

Bio S 154 The Sea: An Introduction to Oceanography (also Geological Sciences 104)
Spring. 3 credits. S-U grades optional, with permission of either instructor.
Lecs, M W 11:15; lab, W 7:30–10 p.m. or M W R or F 2–4:25. Evening prelims: Feb. 22 and Apr. 7. C. H. Greene, W. M. White.
The oceans remain one of the last frontiers, yet they affect our everyday lives in many subtle ways. This course surveys what is known of the physics, chemistry, geology, and biology of the oceans. Topics include sea-floor spreading and plate tectonics; geology and biology of mid-ocean ridges; biological and geological control on the chemistry of seawater; ocean currents and circulation; the oceans and climate, including El Niño, the greenhouse effect, and the Ice Ages; ecology of open-ocean, ocean-bottom, and near-shore communities; coastal processes; marine pollution and waste disposal; mineral and biological resources of the sea; and Law of the Sea. At the level of *Scientific American*.

Bio S 261 Ecology and the Environment
Fall. 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. Evening prelim: Oct. 7. N. G. Hairston, Jr., P. P. Feeny.
An introduction to principles of ecology concerning the interactions between organisms and their environment. The course deals with both terrestrial and aquatic ecology, drawing examples from both plant and animal studies. Phenomena that occur at the individual population, community, and ecosystem levels of organization are discussed. These principles are extensively applied to current environmental problems and issues.

Bio S 263 Field Ecology
Fall. 2 credits. Limited to 20 students. Prerequisite: concurrent or previous enrollment in Bio S 261.
Lec, R 1:25; lab, F 12:20–5. One weekend field trip to the Hudson Valley. Small fee for field trip. 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, sampling plankton, and use of scientific collections.

Bio S 272 Functional Ecology: How Animals Work
Spring. 4 credits. Enrollment limited to 60 students (15 per laboratory section); preference given to sophomores and juniors. Prerequisite: one year of introductory biology for majors. Offered alternate years.
Lecs, M W F 9:05; lab, M T W or R 1:25–4:25. Fee, $15. F. H. Pough.
An introductory course for students interested in organismal biology. The features of the physical environment that are important to insects and vertebrates are used to illustrate the interaction of physiological, behavioral, and morphological characteristics in organismal activity and homeostasis. Laboratories include a survey of the diversity of endothermal and ectothermal animals,

ecophysiological measurements, and measurements of important environmental parameters in local habitats. This course uses live and preserved vertebrate animals for field observations and laboratory exercises.

[Bio S 274 Functional and Comparative Morphology of Vertebrates
Spring. 4 credits. Prerequisite: one year of introductory biology. Offered alternate years. Not offered 1993–94.
Lecs, M W 12:20; labs, M W or T R 1:25–4:25. Evening prelims to be announced. Fee, $15. D. K. McClearn.
An exploration of the relations between form and function in biological systems with an emphasis on trends in vertebrate evolution. Lectures integrate data from topics such as locomotion, feeding, size, and scaling with issues of historical importance and current interest (e.g., correlation of body parts, adaptationist explanations, developmental constraints, criteria for determining biomechanical and energetic "efficiency"). Laboratories include dissections of preserved vertebrate animals and noninvasive live animal demonstrations (motion analysis, surface electrode, and force-plate recordings).]

Bio S 275 Human Biology and Evolution (also Anthropology 275 and Nutritional Sciences 275)
Fall. 3 credits. S-U grades optional, with permission of either instructor. Offered alternate years.
Lecs, W F 10:10; disc, M 10:10. 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.

Bio S 371 Human Paleontology (also Anthropology 371)
Fall. 4 credits. Prerequisite: one year of introductory biology or Anthr 101 or permission of instructor. Offered alternate years.
Lecs, M W F 2:30; lab, one hour each week to be arranged; occasional field trips. 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.

Bio S 373 Biology of the Marine Invertebrates (formerly The Invertebrates: Form, Function, and Evolution)
Fall. 4 credits. Limited to 30 students. Prerequisite: one year of introductory biology for majors. Offered alternate years.
Lecs, M W F 10:10; lab, W 1:25–4:25; 1 optional weekend field trip to Shoals Marine Laboratory. $60 fee for optional field trip. C. D. Harvell.
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 field trip is an excellent opportunity to study representatives of most of the major phyla in their natural habitat. Laboratory demonstrations on campus involve live marine and freshwater invertebrates.

Bio S 378 Evolutionary Biology
Spring. 4 credits. Enrollment may be limited. Prerequisite: one year of introductory biology or permission of instructor. S-U grades optional.
Lecs, M W F 10:10; disc, 1 hour each week to be arranged. Evening prelims: Mar. 3 and Apr. 14. M. A. Geber, R. G. Harrison.
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.

Bio S 455 Insect Ecology (also Entomology 455)
Fall. 3 credits. Prerequisites: Bio S 261 or equivalent and Entom 212 or knowledge of another taxon. Offered alternate years.
Lecs, W F 11:15; disc, 1 hour each week to be arranged. 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.

Bio S 456 Stream Ecology (also Entomology 456)
Spring. 4 credits. Recommended: Bio S 261. S-U grades optional, with permission of instructor.
Lecs, T R 9:05; labs, T W or R 1:25–4:25. Field project with term paper. B. L. Peckarsky, M. B. Bain.
Lectures address the question: How does flow influence the patterns and processes occurring in stream ecosystems? Patterns include channel structure and formation, chemical suspension and dissolution, watershed influences, and plant, invertebrate, and fish community structure. Processes include nutrient cycling and downstream transport, trophic dynamics, plant and animal colonization and succession, community dynamics, conservation, and the impacts of natural and anthropogenic disturbances. Laboratory: a field project is designed to teach descriptive and experimental techniques and to test hypotheses related to stream environmental assessment.

[Bio S 457 Limnology: Ecology of Lakes, Lectures
Fall. 3 credits. Prerequisite: Bio S 261 or written permission of instructor. Recommended: introductory chemistry. Offered alternate years. Not offered 1993–94.
Lecs, M W F 11:15. N. G. Hairston, Jr.
The study of continental waters, with emphasis on lakes and ponds. Factors regulating nutrients, population and community dynamics of freshwater organisms, and physical and chemical properties of fresh water are considered.]

[Bio S 459 Limnology: Ecology of Lakes, Laboratory
Fall. 2 credits. Prerequisite: concurrent or previous enrollment in Bio S 457. Offered alternate years. Not offered 1993–94.
Lab, T W or R 1:25–4:25; 1 weekend field trip. 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.]

[Bio S 461 Population and Evolutionary Ecology
Fall. 4 credits. Prerequisite: Bio S 261 or 378. S-U grades optional. Offered alternate years. Not offered 1993–94; shortened version offered under Bio S 400, Sec 04.
Lecs, M W F 9:05; lab, M or T 1:25–4:25. D. W. Winkler and staff.
Problems of ecology are viewed from an evolutionary perspective, exploring issues of adaptation and fitness definition 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.]

Bio S 462 Marine Ecology
Spring. 3 credits. Prerequisite: Bio S 261. Offered alternate years.
Lecs and disc, M W F 10:10. 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.

[Bio S 463 Plant Ecology and Population Biology, Lectures
Fall. 3 credits. Prerequisite: Bio S 261 or 378 or equivalents, or permission of instructor. Recommended: some taxonomic familiarity with vascular plants and concurrent enrollment in Bio S 465. Offered alternate years. Not offered 1993–94.
Lecs, M W F 11:15. 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 first. Plant populations are then 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.]

[Bio S 464 Microevolution and Macroevolution (also Entomology 464)
Spring. 4 credits. Limited to 25 students. Prerequisite: Bio S 378 or permission of instructor. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1993–94. Next offered spring 1996, and alternate spring semesters thereafter.
Lecs, T R 10:10–11:30; disc, 1 hour each week to be arranged. A. R. McCune, S. Via.
An advanced course in evolutionary biology integrating macroevolutionary and microevolutionary approaches. Areas of emphasis include patterns and processes of speciation, phylogeny reconstruction in populations and higher taxa, the origins and fate of variation, and causes of major evolutionary transitions. Discussion of these problems involve data and approaches from genetics, morphology, systematics, paleobiology, development, and ecology.]

[Bio S 465 Plant Ecology and Population Biology, Laboratory
Fall. 1 credit. Prerequisite: concurrent enrollment in Bio S 463. Offered alternate years. Not offered 1993–94.
Lab, F 12:05–5. M. A. Geber, P. L. Marks.
Laboratory and field 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 simple data analysis.]

Bio S 466 Physiological Plant Ecology, Lectures (formerly Bio S 460)
Spring. 3 credits. Limited to 35 students. Prerequisite: Bio S 261 or introductory plant physiology. S-U grades optional, with permission of instructor. Offered alternate years.
Lecs, T R 10:10–11:25. T. E. Dawson.
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.

[Bio S 467 Physiological Animal Ecology
Fall. 4 credits. Limited to 25 students. Prerequisite: Bio S 272 or 274. Offered alternate years. Not offered 1993–94.
Lecs, T R 11:15; disc, R 1:25; lab, T 1:25–4:25. Fee $15. Staff.
The course examines how living organisms function in their environment. Classical physiological topics including respiration, circulation, excretion, osmoregulation, metabolism, and integration are addressed in evolutionary and ecological contexts. The theme is organismal adaptation and response to major environmental factors such as temperature, food availability, oxygen, and water. Laboratory exercises demonstrate physiological principles discussed in lectures, cover current experimental physiological methods and techniques, and emphasize experimental design. Some laboratories may run beyond the stated ending time. During the second half of the semester students design and execute an independent research project. Results of this project are presented during the final laboratory section. Live vertebrate animals are used for field observations and laboratory exercises.]

Bio S 468 Physiological Plant Ecology, Laboratory
Spring. 2 credits. Limited to 15 students. Prerequisite: previous or concurrent enrollment in Bio S 466. Offered alternate years.
Lab, T 1:25–4:25, plus additional lab hours to be arranged; 1 weekend field trip required. Fee, $15. T. E. Dawson.
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.

[Bio S 470 Ecological Genetics (also Entomology 470)
Spring. 4 credits. Prerequisite: Bio S 378 or permission of instructor. S-U grades optional. Offered alternate years. Not offered 1993–94.
Lecs, T R 10:10–11:30; disc, 1 hour each week to be arranged. S. Via.
A study of the relationships between genetic and ecological processes in populations. Topics include consequences of genetic variation in age-structured populations; demographic concepts of fitness; evaluation of methods for measuring genetic variation and natural selection on ecologically important traits; genetics of competitive ability and predator avoidance; genetic and ecological aspects of phenotypic plasticity; character displacement; maintenance of genetic variability; limits to selection. How theory can be used to formulate hypotheses about evolutionary mechanisms in natural populations is considered and experiments designed to test such hypotheses are evaluated.]

Bio S 471 Mammalogy
Fall. 4 credits. Recommended: Bio S 274. S-U grades optional, with permission of instructor. Offered alternate years.
Lecs, M W F 9:05; lab, M T or W 1:25–4:25; 1 weekend field trip required. Fee, $15. D. K. McClearn.
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.

[Bio S 472 Herpetology
Spring. 4 credits. Recommended: Bio S 274. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1993–94.
Lecs, T R 12:20; labs, M W or T R 1:25–4:25; occasional field trips and special projects. Fee, $15. F. H. Pough.
Lectures cover various aspects of the biology of amphibians and reptiles, including evolution, zoogeography, ecology, behavior, and physiology. Laboratory includes systematics, functional 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.]

[Bio S 473 Ecology of Agricultural Systems (also Soil, Crop, and Atmospheric Sciences 473)
Fall. 3 credits. Limited to 45 students. Prerequisite: Bio S 261 or permission of instructor. S-U grades optional. Offered alternate years. Not offered 1993–94.
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. A. G. Power, T. W. Scott.
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.]

[Bio S 474 Laboratory and Field Methods in Human Biology (also Anthropology 474)
Spring. 5 credits. Limited to 16 students. Prerequisite: one year of introductory biology or Anthr 101 or permission of instructor. Offered alternate years. Not offered 1993–94.
Lecs and labs, T R 10:10–12:05; additional hours to be arranged. Independent research project required. K. A. R. Kennedy.
Practical exercises and demonstrations of modern approaches to the methodology of physical anthropology. Emphasis on comparative human anatomy, osteology, description of skeletal and living subjects, paleopathology, skeletal maturation, and relevant field techniques for the archaeologist and forensic anthropologist. There is a dissection of a profused (dead) nonhuman primate, usually a macaque or baboon. Students attend demonstrations of the dissection prepared by the presector (a hired graduate student).]

[Bio S 475 Ornithology
Fall. 4 credits. Limited to 30 students, with permission of instructor obtained by preregistering in E241 Corson. Recommended: Bio S 274. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1993–94.
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. 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.]

[Bio S 476 Biology of Fishes
Fall. 4 credits. Limited to 24 students. Recommended: Bio S 272 or 274 or equivalent experience in vertebrate zoology. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1993–94.
Lecs, M W F 9:05; lab, M 1:25–4:25. A small lab fee may be required.
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. 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.]

[Bio S 478 Ecosystem Biology
Spring. 4 credits. Prerequisite: Bio S 261 or equivalent. S-U grades optional. Offered alternate years. Not offered 1993–94.
Lecs and discs, T R 10:10–12:05.
R. W. Howarth.
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.]

Bio S 479 Paleobiology (also Geological Sciences 479)
Fall. 3 credits. Prerequisites: one year of introductory biology for majors and either Bio S 272 or 274, Geol 375, Bio S 373, or permission of instructor. Offered alternate years.
Lecs, M W F 12:20. J. L. Cisne and staff.
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.

Bio S 660 Field Studies in Ecology and Systematics
Spring. Variable credit. Prerequisites: Bio S 261, a taxon-oriented course, and permission of instructor. Estimated cost of room and board (exclusive of transportation) to be announced.
Lecs and labs to be arranged. R. B. Root, P. L. Marks.
This course provides students an opportunity to learn techniques and a new biota by participating in an intensive series of field exercises. An extended field trip is scheduled during either intersession or spring break. The region visited, trip objectives, and other details are announced by the instructor in charge in the division's catalog supplement issued at the beginning of the semester. Meetings on campus are devoted to orientation and reports on completed projects.

Bio S 661 Environmental Policy (also ALS 661 and Biology and Society 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 and energy 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*.

[Bio S 662 Mathematical Ecology (also Statistics and Biometry 662)
Spring. 3 credits. Prerequisites: one year of calculus and a course in statistics. Recommended: a general ecology course. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1993–94.
Lecs, M W F 12:20. C. Castillo-Chavez and staff.
Mathematical and statistical analysis of populations and communities: theory and methods. Spatial and temporal pattern analysis. Deterministic and stochastic models of population dynamics. Model formulation, parameter estimation, simulation, and analytical techniques.]

[Bio S 664 Seminar in Insect-Plant Interactions (also Entomology 664)
Spring. 2 credits. Intended for seniors and graduate students. Limited to 15 students. Prerequisites: courses in entomology, ecology, evolution, and organic chemistry and permission of instructor. S-U grades optional. Offered alternate years. Not offered 1993–94.
Sem, 1 evening each week to be arranged. P. P. Feeny.
Presentations and discussions by students on the evolution of patterns of interaction between plants and insects, emphasizing critical evaluation of concepts and evidence.]

[Bio S 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. Offered alternate years. Not offered 1993–94.
Sem to be arranged. N. G. Hairston, Jr.
A seminar course on advanced topics in freshwater ecology.]

Bio S 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. Offered alternate years.
Lecs and discs, T R 10:10–12:05.
R. W. Howarth.
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.

[Bio S 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. Not offered 1993–94.
Sem to be arranged. Staff.
Includes review of current literature, student research, and selected topics of interest to participants.]

[Bio S 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. Not offered 1993–94.
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.]

[Bio S 672 Graduate Seminar in Physiological Ecology
Spring. 2 credits. Limited to 12 students. Prerequisite: a course in plant or animal physiology, especially Bio S 466 or 467. Permission required for undergraduates. May be repeated for credit. S-U grades only. Offered alternate years. Not offered 1993–94.
Sem, 2 hours each week to be arranged.
F. H. Pough, T. E. Dawson.
Discussion of topics on water balance, energetics, and temperature regulation emphasize parallels and contrasts in the relations of animals and plants to their biophysical environments. Each student leads a discussion and prepares a written review of a topic, drawing on the primary literature of his or her own research interests.]

[Bio S 673 Human Evolution: Concepts, History, and Theory (also Anthropology 673)
Fall. 3 credits. Prerequisite: one year of introductory biology, Anthropology 101, or permission of instructor. Offered alternate years. Not offered 1993–94.
Lec, M 2:30; sem and disc, W 7:30–9:30 p.m. K. A. R. Kennedy.
The historical background of present-day concepts of man's evolutionary variations and adaptations in space and time is surveyed. 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.]

[Bio S 674 Principles of Systematics (also Entomology 674)
Spring. 4 credits. Limited to 15 students. Prerequisite: permission of instructor. Recommended: an introductory biological systematics course. Offered alternate years. Not offered 1993–94.
Lecs, discs, and labs, M W 1:25–4:25.
Q. D. Wheeler and staff.
An introduction to modern theory and methods of systematic biology. Lectures are on theoretical systematics and include species concepts, classification, phylogenetics, and biogeography. Laboratories include modern methods of analysis of data, including cladistic hand and computer methods and numerical methods. Laboratory grade is based in part on a final paper.]

Bio S 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.

[Bio S 765 Autecology/Population Ecology
Fall. 4 credits. Prerequisite: Bio S 261 or equivalent. S-U grades optional. Not offered 1993–94.

Lecs and discs, T R 10:10–12:05. Staff.
Comparison of the responses and adaptations of organisms to environments in selected ecosystems. Emphasis on similarities and differences in molecular and organismal mechanisms by which plants and animals cope with their environments. Critical examination of the properties and dynamics of populations. Emphasis on theories of adaptation, population structures, dynamics, and regulation.]

[Bio S 766 Communities and Ecosystems
Spring. 4 credits. Prerequisite: Bio S 261 or equivalent. S-U grades optional. Not offered 1993–94.

Lecs, T R 10:10–12:05. Staff.
Structure, dynamics, and evolution of natural communities; species diversity; niches and gradient relations; and succession, climax, and disturbance. Comparative aspects of terrestrial, marine, and freshwater communities. Analysis of ecosystems in terms of energy flow, biogeochemistry, and model systems. Emphasis on functional and structural properties of communities and ecosystems.]

Bio S 767 Current Topics in Ecology and Evolutionary Biology
Fall. 4 credits. Prerequisites: Bio S 261 and 378 or their equivalents. S-U grades optional.

Lecs and discs, T R 10:10–12:05. One weekend field trip. P. P. Feeny and 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)

Advanced Work in Parasitology (Veterinary Microbiology 737)

Animal Social Behavior (Biological Sciences 427)

Biology of Plant Species (Biological Sciences 442)

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

Evolution of the Earth and Life (Biological Sciences 170, Geological Sciences 102)

Marine Sciences Courses (Biological Sciences 363–370, 477)

Plant Geography (Biological Sciences 440)

Related Courses in Entomology (Entomology 212, 331, 332, 370, 453, 471, 621, 631, 633, 634, 636, 672)

Related Courses in Natural Resources (Natural Resources 270, 302)

Taxonomy of Vascular Plants (Biological Sciences 248)

Teaching Experience (Biological Sciences 498)

Undergraduate Research in Biology (Biological Sciences 499)

Undergraduate Seminar in Biology (Biological Sciences 400)

Veterinary Parasitology (Veterinary Microbiology 510)

GENETICS AND DEVELOPMENT

Bio S 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; written permission of instructor required for students who have taken Bio S 282. 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.
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, genetic aspects of differentiation, genes in populations, breeding systems, 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.*

Bio S 282 Human Genetics
Spring. 2 or 3 credits (2 credits if taken after Bio S 281). Each discussion limited to 25 students. Prerequisite: one year of introductory biology or equivalent; permission of instructor required for students who have taken Bio S 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.

Bio S 385 Developmental Biology
Fall. 3 credits. Prerequisite: Bio S 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.

[Bio S 389 Embryology
Spring. 3 credits. Limited to seniors. Prerequisites: one year of introductory biology and a knowledge of mammalian adult anatomy. Not offered 1993–94.

Lecs, T R 10:10; labs, T 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 level. The laboratory has a strong morphogenetic bias, emphasizing the comparative aspects of developmental anatomy. Preserved materials are used in the laboratory.]

Bio S 480 Seminar in Developmental Biology
Spring. 1 credit. May be repeated for credit. Limited to upperclass students. S-U grades only.

Sem to be arranged. Staff.

Bio S 481 Population Genetics
Fall. 4 credits. Prerequisite: Bio S 281, 378, or equivalents.

Lecs, M W F 10:10; disc, M 2:30 or T 1:25.
C. F. Aquadro.
A study of factors that influence the genetic structure of Mendelian populations and that are involved in race formation and speciation. 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. The interplay between theory and the data from experiments and natural populations are emphasized. Consideration is also given to the population genetic issues involved in DNA fingerprinting.

Bio S 482 Human Genetics and Society
Fall. 3 credits. Enrollment limited to 30 senior biological sciences majors, with preference given to students studying genetics and development. Prerequisites: Bio S 281 and 330 or 331. S-U grades optional.

Disc, T 2:30–4:25 and R 2:30–3:30 or 3:30–4:30. R. A. Calvo, H. T. Stinson.
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 new reproductive strategies, eugenics, genetic counseling, genetic screening (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 most discussions. There is a major writing component in the course.

[Bio S 483 Molecular Aspects of Development
Spring. 3 credits. Prerequisites: Bio S 281, 330 or 331, and 385. Offered alternate years. Not offered 1993–94.

Lecs, T R 10:10–11:25. W. H. Mark.
An examination of the molecular biology of developing systems, with emphasis on the genomic, transcriptional, post-transcriptional, translational, and post-translational mechanisms involved in regulating development. Both prokaryotic and eukaryotic systems are considered, but emphasis is on the latter. Topics to be discussed include changes in chromatin structure, DNA rearrangements, control of RNA synthesis and processing, translational controls, nucleo-cytoplasmic interactions, and genetic responses to hormone treatment. The regulation of selected developmental systems is considered in detail.]

Bio S 484 Molecular Evolution
Spring. 3 credits. Prerequisites: Bio S 281 and organic chemistry. Offered alternate years.

Lecs, T R 11:15. R. J. MacIntyre.
An analysis of evolutionary changes in proteins and nucleic acids. Theories on the evolution of the genetic code and the construction of phylogenetic trees from biochemical data are discussed. The second half of the course concerns the evolution and

the organization of genomes from viruses to higher eukaryotes.

Bio S 485 Microbial Genetics, Lectures
Fall. 2 credits. Limited to upperclass and graduate students. Prerequisite: Bio S 281. Recommended: Bio S 290 and 330 or 331. S-U grades optional.

Lec, W 7:30–9:25 p.m. V. J. Stewart.
Concepts and principles of formal genetic analysis as applied to microorganisms, with emphasis on enterobacteria and their viruses. Topics include mutagenesis and isolation of mutants; genetic exchange, recombination, and mapping; complementation; transposons; suppression, including allele-specificity; epistasis; genome organization and dynamics; and gene expression and regulation.

Bio S 682 Fertilization and the Early Embryo
Fall. 2 credits. Prerequisites: Bio S 281, 330 or 331, and 385. Next offered spring 1995 and alternate spring semesters thereafter.

Lec, R 2:30–4:25. 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, pronuclear fusion, triggering mitosis, cleavage divisions, cytoplasmic determinants, changes in nuclear and cytoplasmic architecture, and midblastula transition.

[Bio S 684 Advanced Topics in Population Genetics
Spring. 2 credits. Limited to 20 students. Prerequisites: Bio S 481 or equivalent and written permission of instructor. S-U grades optional. Offered alternate years. Not offered 1993–94.

Lec, T 2:30–4:25. 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.]

Bio S 686 Mammalian Development
Spring. 3 credits. Limited to 25 students. Prerequisites: Bio S 281, 330 or 331, and 385, or their equivalents. S-U grades optional. Offered alternate years.

Lecs, T R 10:10–11:25. W. H. Mark.
An in-depth study of mammalian development using the mouse as the animal model. The course covers classical embryology beginning with gametogenesis followed by morphogenetic and biochemical analyses of pre- and post-implantation development. Current topics in experimental embryology, including genetic analysis of mutants, study of cell lineage with chimeras, *in vitro* culturing of embryonic stem cells, and molecular approaches to understanding development are examined.

[Bio S 687 Developmental Genetics
Fall. 2 credits. Limited to 20 students. Prerequisites: Bio S 281 and 385 or their equivalents. S-U grades optional. Offered alternate years. Not offered 1993–94.

Lec to be arranged. K. J. Kemphues.
Selected topics focus on the use of genetic analysis in understanding mechanisms of development. Topics are drawn primarily from studies in *Drosophila*, *Caenorhabditis*, and mouse. 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 given the opportunity to discuss each topic in class.]

[Bio S 688 Yeast Genetics
Spring. 2 credits. Prerequisites: Bio S 281 and 330 or 331, or permission of instructor. S-U grades optional. Offered alternate years. Not offered 1993–94.

Lecs, T R 1:25. T. D. Fox.
An advanced overview of genetic studies in yeast, primarily *Saccharomyces cerevisiae*. Both formal genetic and molecular approaches to selected problems of biological interest are discussed.]

Bio S 780 Current Topics in Genetics
Fall or spring. 2 credits. May be repeated for credit. Primarily for graduate students, with preference given to majors in the Field of Genetics; written permission of instructor required for undergraduates. Limited to 20 students. No auditors. S-U grades optional, with permission of instructor.

Sem to be arranged. Staff.
A seminar course with critical presentation and discussion by students of original research papers in a particular area of current interest. Content of the course and staff direction vary each year and are announced a semester in advance.

Bio S 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.

Bio S 782–783 Current Genetics/Development Topics
Fall or 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.

Bio S 786 Research Seminar in Genetics and Development
Fall and spring. 1 credit. 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.

Bio S 787 Seminar in Genetics and Development
Fall or spring. 1 credit. Limited to graduate students in Genetics and Development. S–U grades only.

Sem, M 4–5. Staff.
Seminars in current research in genetics and developmental biology conducted by distinguished visitors and staff.

Related Courses in Other Departments

Animal Development (Veterinary Anatomy 507)

Biosynthesis of Macromolecules (Biological Sciences 633)

Current Topics in Biochemistry (Biological Sciences 731–736)

Evolutionary Biology (Biological Sciences 378)

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

Laboratory in Plant Molecular Biology (Biological Sciences 641)

Molecular Biology (Biological Sciences 433)

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

Neurogenetics (Biological Sciences 423)

Plant Cytogenetics (Plant Breeding 446)

Plant Growth and Development (Biological Sciences 644)

Plant Molecular Biology I (Biological Sciences 653)

Plant Molecular Biology II (Biological Sciences 652)

Protein-Nucleic Acid Interactions (Biological Sciences 692)

The Nucleus (Biological Sciences 639)

Undergraduate Research in Biology (Biological Sciences 499)

MICROBIOLOGY

Bio S 192 Microorganisms on the Planet Earth
Spring. 3 credits. S-U grades optional.

Lecs, M W F 11:15. R. P. Mortlock.
This is a beginning course in microbiology, designed to introduce students who have a limited background in science to the microorganisms. Included among the microorganisms to be studied are the eubacteria, the archaebacteria, some of the microscopic cells, and viruses. This course is not a prerequisite for advanced courses in microbiology.

Bio S 290 General Microbiology, Lectures
Fall, spring, or summer (6-week session). 2 or 3 credits (2 credits if taken after Bio S 192). Prerequisites: one year of introductory biology for majors and Chem 104 or 208, or equivalent. Recommended: concurrent registration in Bio S 291.

Lecs, M W F 11:15. M. L. Cordts, S. M. Merkel.
A comprehensive overview of the biology of microorganisms, with emphasis on bacteria. The biology of eukaryotic microorganisms and viruses is also discussed briefly. 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 immunology and medical microbiology.

Bio S 291 General Microbiology, Laboratory
Fall or spring, 2 credits. Summer (6-week session), 2 or 3 credits. Prerequisite: concurrent or previous enrollment in Bio S 290.

Labs, M W 2–4:25, or T R 11:15–1:45 or 2–4:25. 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.

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

Bio S 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.

[Bio S 304 Pathogenic Bacteriology and Mycology (also Veterinary Microbiology 318)
Spring. 2 or 4 credits (4 credits with lecture and laboratory). Limited to 40 students. Prerequisites: Bio S 290 and 291. Strongly recommended: Bio S 305 and 307. Offered alternate years. Not offered 1993–94.
Lecs, T R 1:25; labs, T R 2:25–5.
T. H. Kawula, L. E. Winter.
The study of the major bacterial and fungal agents of infectious disease, with emphasis on the function of virulence mechanisms and the host-parasite interaction. Lectures cover the significance of normal flora, antibiotic therapy and drug resistance, and vaccine development. Laboratories emphasize techniques for isolation, culture, and identification of infectious agents. Animal models are used to help understand certain pathogenic mechanisms.]

[Bio S 317 Tissue Culture Techniques and Applications
Fall. 2 credits. Prerequisites: Bio S 290 and 291 or permission of instructor. Not offered 1993–94.
Lec, F 1:25–2:30; lab exercises with follow-up work done independently, F 2:30–4:30.
C. M. Rehkugler.
A series of lectures and demonstrations dealing with cell culture methods, especially those required to culture cells of animals from different tissue origins. The application of cell culture to the study of bacterial diseases, virus replication, and the production of biologicals is considered.]

Bio S 391 Advanced Microbiology Laboratory
Fall. 3 credits. Prerequisites: Bio S 290, 291, and 330 or 331. Preference given to biological sciences students in the microbiology program of study.
Lab, M W or T R 1:25–4:25; disc, F 1:25.
J. B. Russell and staff.
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 select a topic from one of the modules and conduct a two-week independent experiment at the end of the semester.

[Bio S 398 Environmental Microbiology (also Soil, Crop, and Atmospheric Sciences 398)
Spring. 3 credits. Prerequisite: Bio S 261 or 290 or Soil, Crop, and Atmospheric Sciences 260 or permission of instructor. Offered alternate years. Not offered 1993–94.
Lecs, M W F 10:10. M. Alexander, W. C. Ghiorse.
Behavior and function of microorganisms in natural environments and the role of microorganisms in transformation of pollutants.]

Bio S 406 Clinical Microbiology
Fall and spring. 15 credits each semester. Prerequisite: permission of instructor.
Hours to be arranged. 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.

Bio S 415 Bacterial Diversity, Lectures
Fall. 3 credits. Prerequisites: Bio S 290, 291, and 330 or 331.
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.

Bio S 416 Microbial Physiology, Lectures
Spring. 3 credits. Prerequisites: Bio S 290, 291, and 330 or 331, or their equivalents. Recommended: Bio S 415. S-U grades optional for students not specializing in the microbiology program of study.
Lecs, M W F 11:15. R. P. Mortlock.
The concern is with the physiological and metabolic functions of microorganisms. Consideration is given to chemical structure, regulation, growth, and the energy metabolism of prokaryotic organisms. Special attention is given to those aspects of microbial metabolism and carbohydrate catabolism not normally studied closely in biochemistry courses.

[Bio S 451 Structure and Function of Bacterial Cells
Fall. 3 credits. Prerequisites: Bio S 290 and 330 or 331 or permission of instructor. Recommended. Bio S 415. S-U grades optional. Offered alternate years. Not offered 1993–94.
Lecs, M W F 10:10. W. C. Ghiorse.
Morphology, ultrastructure, macromolecular organization, and life cycles of bacterial cells are considered with regard to chemical composition and physiological and ecological function of cellular components.]

Bio S 485 Microbial Genetics
Fall. 2 credits. Limited to upper-class and graduate students. Prerequisite: Bio S 281. Recommended: Bio S 290 and 330 or 331. S-U grades optional.
Lecs, W 7:30–9:25 p.m. V. J. Stewart.
Concepts and principles of formal genetic analysis as applied to microorganisms, with emphasis on enterobacteria and their viruses. Topics include mutagenesis and isolation of mutants; genetic exchange, recombination and mapping; complementation; transposons; suppression, including allele-specificity; epistasis; genome organization and dynamics; and gene expression and regulation.

Bio S 652 (Section 04) Molecular Plant-Microbe Interactions
Spring. 1 credit. Prerequisites: Bio S 281, 330 or 331, and 653 (section 01) or their equivalents. S-U grades optional.
Lecs, M W F 10:10 (12 lecs) Mar. 31–Apr. 26. S. C. Winans, T. A. LaRue.
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.

Bio S 692 Protein-Nucleic Acid Interactions
Spring. 3 credits. Prerequisites: Bio S 330 or 331 and 633.
Lecs, T R 10:10–11:25. 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.

Bio S 694 Genetic Aspects of Bacterial Diversity
Spring. 3 credits. Prerequisite: Bio S 485 or equivalent.
Lecs, M W 2:30–3:45. S. C. Winans.
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.

Bio S 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.

Bio S 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.

Bio S 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 Bio S 797 series requirement are required to present a seminar concerning their research interests and activities at least once each year.

Bio S 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 Animal Virology, Lectures (Veterinary Microbiology 708)

Advanced Food Microbiology (Food Science 607)

Advanced Immunology Lectures (Biological Sciences 705 and Veterinary Microbiology 705)

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

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

Algal Physiology (Biological Sciences 346)

Bacterial Plant Diseases (Plant Pathology 647)

Basic Immunology, Lectures (Biological Sciences 305 and Veterinary Microbiology 315)

Bioprocessing Applications in Agriculture (Agricultural and Biological Engineering 467)

Ciliophorology (Biological Sciences 409)

Comparative Biogeochemistry (Biological Sciences 668)

Controlled Cultivation of Microbial Cells (Chemical Engineering 646)

Ecology of Soil-Borne Pathogens (Plant Pathology 644)

Food Microbiology, Laboratory (Food Science 395)

Food Microbiology, Lectures (Food Science 394)

Food Mycology (Food Science 411)

Immunology of Infectious Diseases and Tumors (Biological Sciences 706 and Veterinary Microbiology 719)

Insect Pathology (Entomology 453)

Intermediate Soil Science: Chemistry and Microbiology (Soil, Crop, and Atmospheric Sciences 364)

Introduction to Bioprocess Engineering (Chemical Engineering 643)

Introduction to Scanning Electron Microscopy (Biological Sciences 401)

Introductory Mycology (Plant Pathology 309)

Limnology: Ecology Lakes, Lectures (Biological Sciences 457)

Magical Mushrooms, Mischievous Molds (Plant Pathology 201)

Marine Microbial and Plankton Ecology (Biological Sciences 454)

Marine Plankton Ecology (Biological Sciences 468)

Microbiology of Water and Wastewater (Civil and Environmental Engineering 651)

Optical Methods of Biologists (Biological Sciences 450)

Plant Virology (Plant Pathology 645)

NEUROBIOLOGY AND BEHAVIOR

Bio S 221 Neurobiology and Behavior I: Introduction to Behavior
Fall. 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. Prerequisite: one year of introductory biology for majors. May be taken independently of Bio S 222. S-U grades optional.
Lecs, M W F 12:20; disc to be arranged. P. W. Sherman 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.

Bio S 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 Bio S 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.

Bio S 322 Hormones and Behavior (also Psychology 322)
Spring. 3 or 4 credits; the 4-credit option involves a one-hour section once a week, in which students are expected to participate in discussion and read original papers in the field. Limited to juniors and seniors; open to sophomores only by permission. Prerequisites: one year of introductory biology plus a course in psychology or Bio S 221 or 222. S-U grades optional.
Lecs, M W F 11:15; disc to be arranged. D. Gudermuth.
Following a review of the neural and endocrine systems, this course connects endocrine physiology to specific behaviors observed in various species, including humans. Although the relationship between sexual physiology and behavior is strongly emphasized, the lectures also describe hormonal contributions to parental behavior, aggression, stress, learning and memory, homeostasis, and biology rhythms. Topics for the discussion sections are chosen by the students within the context of hormonal influences on behavior.

Bio S 324 Biopsychology Laboratory (also Psychology 324)
Fall. 4 credits. Limited to 20 upperclass students. Prerequisites: laboratory experience in biology or psychology, Bio S 221 and 222 or Psych 123 and 222; and permission of instructor.
Labs, T R 1:25–4:25. T. J. 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.

Bio S 326 The Visual System
Spring. 4 credits. Prerequisite: Bio S 222 or 311, or permission of instructor. S-U grades optional. Offered alternate years.
Lecs, M W F 10:10; disc, 1 hour each week to be arranged. H. C. Howland.
The visual systems of vertebrates and invertebrates 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.

Bio S 328 Biopsychology of Learning and Memory (also Psychology 332)
Spring. 3 credits. Prerequisites: one year of biology and either a course in biopsychology or Bio S 222.
Lecs, M W F 11:15. T. J. DeVoogd.
This course surveys the approaches that have been or are currently being used 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.

Bio S 396 Introduction to Sensory Systems (also Psychology 396)
Spring. 3 or 4 credits (4 credits with term paper). Registration for the 4-credit option requires permission of instructor. No auditors. Prerequisites: an introductory course in biology or biopsychology, and 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. Offered alternate years.
Lecs, M W F 10:10. B. P. Halpern.
This course employs 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. There are two preliminary exams and a final exam. 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*, 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.

Bio S 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.

[Bio S 422 Computer Interfacing for Neurobiologists
Spring. 3 credits. Limited to 20 students. Prerequisites: Bio S 222 and 426, or permission of instructor. S-U grades optional. Offered alternate years. Not offered 1993–94.
Lecs, T R 9:05; lab, 4 hours each week to be arranged. Staff.
Lectures and laboratories deal with interfacing a computer with an experiment and doing data acquisition and computer control of the experiment. Topics include introduction to digital electronics, data acquisition and monitoring of an experiment (A/D conversions and digital input), some data analysis and decision making, computer control of an experiment (D/A conversions and digital output), communication (RS-232 and IEEE), sampling theory and Fourier analysis and feedback control using computers. A Mac II computer is used in this course.]

Bio S 423 Neurogenetics
Fall. 3 credits. Limited to junior, senior, and graduate students. Prerequisites: Permission of instructor, one year of introductory biology or equivalent, and Bio S 222 and 281. S-U grades optional. Offered alternate years.
Lecs, T R 2:30; disc, R 3:35.
A. M. Schneiderman.
Lectures, discussions, and student presentations focus on the uses of genetics for the study of the nervous system. Emphasis is on recent advances in genetic and molecular biological techniques and their application to the study of neural development and behavior. Both invertebrate and vertebrate systems are discussed, and main consideration is given to the fruit fly and the mouse. Readings are taken primarily from original journal articles.

Bio S 424 Neuroethology (Psychology 424)
Spring. 3 credits. Prerequisites: Bio S 221 and 222. Offered alternate years.
Lecs, M W F 9:05; disc to be arranged.
C. D. Hopkins.
This course presents an integrated study of neurobiology and classical ethology with emphasis on the cellular and mechanistic basis of behavior. After a brief survey of the history of ethology and basic neurobiology principles, the course emphasizes a research-oriented approach to recent neuroethological themes including acoustic communication in insects and amphibians; vocal mechanisms and plasticity in song birds; vertebrate hearing mechanisms and their role in social communication; bat echolocation, prey detection and sound localization in birds; electric fish and electroreception; olfaction and chemical communication; visual processing and visual signaling; fundamentals of neural circuit analysis and modeling; lateral inhibition; parallel sensory processing; time and amplitude pathways in auditory and electroreceptive systems; command neurons and decision-making neurons; locomotion and motor pattern generation; escape behavior; and neural correlates of learning. Assigned readings come from original research articles and reviews. A term paper is required.

[Bio S 426 Electronics for Neurobiology
Spring. 3 credits. Limited to 20 students. Prerequisites: Bio S 222 and one year of introductory physics. Offered alternate years. Not offered 1993–94.
Lecs, T R 9:05; lab, 4 hours each week to be arranged. Staff.
The course deals with electronics as applied to neurobiology and behavior. Analog circuits centered around operational amplifiers are emphasized. Topics include a review of basic electrical concepts; the cell as circuit, voltage, and current amplifiers; transducers (temperature, light, pressure, etc.); filtering; timing circuits; radiotelemetry; basic trouble shooting; and reading schematics. In the last third of the term, students design and construct a circuit (both circuit board and housing box) of their own choosing relative to their research and/or interests.]

[Bio S 427 Animal Social Behavior
Fall. 4 credits. Limited to 30 students. Prerequisites: Bio S 221 and 261 or 378, and permission of instructor. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1993–94.
Lecs and discs, T R 2:30–4:25.
P. W. Sherman.
An intensive course for upper-division students interested in the adaptive bases of social behavior. Lectures, discussions, and student presentations examine topics including adaptation, spacing systems, mating systems, sexual selection, sex ratios, senescence, mate choice, conflict and cooperation in animal societies, and the evolution of deceit, honesty, and altruism.]

[Bio S 428 Topics in Behavior
Fall or spring. Variable credit. (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. Not offered 1993–94.
Sem to be arranged. Staff.
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.]

Bio S 429 Olfaction and Taste: Structure and Function (also Psychology 429)
Fall. 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. S-U grades optional for graduate students only. Offered alternate years.
Lecs, T R 9:05. 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.

Bio S 491 Principles of Neurophysiology
Fall. 4 credits. Limited to 20 students. Prerequisite: Bio S 222 or written permission of instructor. S-U grades optional for graduate students.
Lecs, M W 10:10; lab, M or W 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 present laboratory exercise results, to supplement laboratory topics, and for discussion of primary research papers. Intracellular and extracellular recording techniques are used to analyze neuronal properties such as resting potentials, electrical and chemical synaptic transmission, ionic currents under voltage-clamp, and functional expression of foreign membrane proteins in *Xenopus oocytes*. A variety of preparations are used as model systems. Computer acquisition and analysis of laboratory results are emphasized.

[Bio S 492 Sensory Function (also Psychology 492)
Spring. 3 or 4 credits. (The 4-credit option involves a one-hour section once a week, in which students are expected to participate in discussion. The 4-credit option is not always offered.) Prerequisite: a 300-level course in biopsychology or Bio S 222 or 311, or permission of instructors. Students are expected to have a knowledge of elementary physics, chemistry, and behavior. S-U grades optional. Offered alternate years. Not offered 1993–94.
Lecs, M W F 10:10; disc, hours to be arranged. 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, 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. At the level of *The Senses*, edited by Barlow and Mollon, and *An Introduction to the Physiology of Hearing, 2nd edition*, by Pickles.]

[Bio S 493 Developmental Neurobiology
Fall. 3 credits. Prerequisite: Bio S 222 or permission of instructor. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1993–94.
Lecs, M W F 11:15. 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.]

[Bio S 494 Comparative Vertebrate Neuroanatomy
Spring. 3 credits. Intended for juniors, seniors, and graduate students. Prerequisite: Bio S 222 or equivalent. S-U grades optional. Offered alternate years. Not offered 1993–94.
Lecs, T R 10:10–11:30. 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 vertebrate brain evolution.]

[Bio S 495 Membrane Ion Channels
Spring. 3 credits. Limited to 15 students. Prerequisites: Bio S 222, college introductory physics, and calculus, or permission of instructor. S-U grades optional. Offered alternate years. Not offered 1993–94.
Lecs, M W F 10:10. Staff.
The functional and mechanistic aspects of membrane ion channels, beginning with basic concepts and model systems. Theories of ion permeation and channel gating are discussed. Development of membrane ion channels during neuron differentiation and the role of membrane channels in disease states are also considered.]

[Bio S 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. Offered alternate years. Not offered 1993–94.
Lecs, M W 9:05; lab to be arranged.
C. 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.]

[Bio S 497 Neurochemistry and Molecular Neurobiology
Fall. 3 credits. Limited to 30 students. Prerequisites: Bio S 222 and either 330 or 331, or permission of instructor. S-U grades optional. Offered alternate years. Not offered 1993–94.
Lecs, T R 9:05; disc, T 2:25. T. R. Podleski.
This course focuses primarily on the biochemistry/molecular biology of neurons. Emphasis is on the molecular properties of these cells that account for their unique function. The presynaptic regulation of release and postsynaptic mechanism of action of the major classes of neurotransmitters are discussed, as well as selected neuromodulators and hormones. Readings are selected primarily from research journals.]

[Bio S 623 Chemical Communication (also Chemistry 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. Offered alternate years. Not offered 1993–94.
Lecs, M W 1:25; disc, F 1:25. Coordinator: 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. The discussion sessions focus on readings from the recent literature and involve student-led discussions of contemporary topics.]

[Bio S 626 Sex Differences in Brain and Behavior (also Psychology 524)
Spring. 2 credits. Limited to 12 students. Prerequisite: Bio S 322 or permission of instructor. Not offered 1993–94.
Discs and sems, M W 3:35–5:30.
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.]

Bio S 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.

Bio S 721 Introductory Graduate Survey in Neurobiology and Behavior
Fall. 2 credits each term. Required of graduate students majoring in neurobiology and behavior. Concurrent registration in Bio S 221 and 222 not required. S-U grades only.
Lecs and discs, T R 10:10–12:05, alternate weeks. Staff.
Lectures by faculty and student-led discussions on topics of current importance in neurobiology and behavior. Topics are linked to the materials presented in Bio S 221 and 222. Class meets twice a week, every other week. Students are required to write four term papers, over the two semesters, on selected topics in two of three sub-areas: (1) cellular and molecular neurobiology; (2) integrative neurobiology; (3) behavior.

Bio S 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. 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.

Bio S 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. 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.

Bio S 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: Bio S 222. S-U grades optional.
Lecs and sem to be arranged. 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.

Bio S 792 Advanced Laboratory in Cellular and Molecular Neurobiology
Fall or spring. 2 credits. May be repeated for credit. Primarily for graduate students. Prerequisites: Bio S 330 or 331 or equivalent, 491 or equivalent, and written permission of instructor. S-U grades optional.
Lab to be arranged. 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.

Bio S 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. 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.

Bio S 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. 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 of Human Behavior (Psychology 326)

Human Behavior: A Sociobiological Perspective (Anthropology 476)

Insect Behavior Seminar (Entomology 662)

Neurobiology of Animal Behavior (Biological Sciences 327)

Primates and Evolution (Anthropology 490)

Primate Behavior and Ecology (Anthropology 390)

Teaching Experience (Biological Sciences 498)

Undergraduate Research in Biology (Biological Sciences 499)

PLANT BIOLOGY

Bio S 241 Introductory Botany
Fall. 3 credits. Prerequisite: one year of introductory biology or permission of instructor.
Lecs, T R 9:05; lab, M T W R or F 1:25–4:25, or M or W 7:30–10:30 p.m.
K. J. Niklas.
Introductory botany for those who plan to specialize in or use some aspect of 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.*

Bio S 242 Plant Physiology, Lectures
Spring. 3 credits. 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 introductory chemistry. Concurrent enrollment in Bio S 244 required of undergraduates except those majoring in the social sciences or humanities, for whom it is recommended. May not be taken for credit after Bio S 341 except by written permission of instructor.
Lecs, M W F 10:10. H. C. Reiss.
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, flowering, fruiting, dormancy, and abscission; stress; tissue culture; and genetic engineering.

[Bio S 243 Taxonomy of Cultivated Plants
Fall. 4 credits. Prerequisite: one year of introductory biology or written permission of instructor. May not be taken for credit after Bio S 248. Not offered 1993–94.
Lecs, M W 10:10; labs, M W 2–4:25.
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.]

Bio S 244 Plant Physiology, Laboratory
Spring. 2 credits. Prerequisite: concurrent enrollment in Bio S 242. May not be taken for credit after Bio S 349.
Disc and lab, M T W or R 12:20–4:25.
H. C. Reiss.
Experiments exemplify concepts covered in Bio S 242 and offer experience in a variety of biological and biochemical techniques, including use of small amounts of radioisotopes.

Bio S 245 Plant Biology
Summer (6–week session). 3 credits. Limited to 24 students.
Lecs, M–F 11:30–12:45; labs, M W 1:45–3:45. S. Williams.
Introductory botany, including plant identification. Emphasizes structure, reproduction, and classification of angiosperms. Seventy-five percent of the laboratory work is conducted outdoors in an area that surpasses most biological stations. Those who lack college-level biology are expected to work more closely with the instructor on supplemental instructional materials.

Bio S 246 Plants and Civilization
Spring. 3 credits.
Lecs, T R 11:15; disc, T or W 1:25 or W or R 12:20. D. M. Bates.
A consideration of the role that plants have played and continue to play in the evolution of human cultures. Emphasis is on the interactions between humans and the plant environment, the nature of plants and manner in which humans use and integrate them into their cultures, and the problems and concerns related to contemporary and future use of plant resources.

Bio S 248 Taxonomy of Vascular Plants
Spring. 4 credits. Prerequisite: one year of introductory biology. May not be taken for credit after Bio S 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.

Bio S 341 Plant Physiology, Lectures
Fall. 3 credits. Prerequisites: one year of introductory biology, organic chemistry, and either concurrent enrollment in Bio S 349 or written permission of instructor. May not be taken for credit after Bio S 242 unless written permission is obtained from instructor.
Lecs, T R 10:10–11:25. A. T. Jagendorf.
The behavior, growth, transport processes, and environmental response of plants. Topics include membrane properties, solute and water transport, and function of osmotic forces; mineral and organic nutrition; stress resistance; growth and development controls; metabolism, including photosynthesis and respiration; and responses to environmental influences.

Bio S 343 Molecular Biology and Genetic Engineering of Plants
Fall. 2 credits. S-U grades optional. Prerequisite: Bio S 281 or Pl Br 225.
Lecs, T R 11:15. M. E. Nasrallah.
An introduction to current studies involving recombinant DNA technology and its application to the analysis of basic plant processes. The course emphasizes genetic transformation methodology, molecular genetic approaches to the study of selected plant systems, and prospects for plant improvement using biotechnology. The course is directed at undergraduates who wish to become familiar with plants as experimental organisms. Selected topics attempt to illustrate the uniqueness of plant life and how it differs from other systems.

Bio S 345 Plant Anatomy
Fall. 4 credits. Limited to 15 students. Prerequisite: one year of introductory biology or a semester of botany. Offered alternate years.
Lecs, M W 9:05; labs, M W 2–4:25.
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.

Bio S 346 Algal Physiology
Fall. 3 credits. Prerequisites: one year of introductory biology for majors and Bio S 242 or 341, or permission of instructor. S-U grades optional. Offered alternate years.
Lecs, T R 8:30–9:55. T. G. Owens.
This course takes an interdisciplinary approach to the study of algae with an emphasis on the physiology, biochemistry, and ecology of this diverse group of organisms. The algal classes are briefly described with consideration of traditional and emerging criteria for classification of the algae. The majority of the course focuses on interactions

of algae with the physical/chemical environment, uptake of inorganic compounds, algal photosynthesis, metabolic strategies, and population dynamics of planktonic algae and benthic macrophytes. There is no laboratory section with this course.

Bio S 347 Laboratory in Molecular Biology and Genetic Engineering of Plants
Fall. 2 credits. Limited to 24 students. S-U grades optional. Prerequisite: Bio S 343.
Lab, W 12:25–4:25. M. E. Nasrallah.
The laboratory provides experience in handling and experimenting with the plant *Arabidopsis thaliana*. Selected experiments include the preparation and analysis of nucleic acids, methods used in the detection and isolation of plant genes, analysis of gene expression using antibody and nucleic acid probes, mutant isolation, and methods of gene transfer to plants.

Bio S 349 Plant Physiology, Laboratory
Fall. 2 credits. Prerequisite: concurrent enrollment in Bio S 341. May not be taken for credit after Bio S 244.
Lab-disc, W 12:20–4:25. H. C. Reiss.
Experiments exemplify concepts covered in Bio S 341 and offer experience in a variety of biological and biochemical techniques, including use of small amounts of radioisotopes.

[Bio S 359 Biology of Grasses
Fall. 3 credits. Limited to 24 students. Prerequisite: one year of introductory biology or an introductory plant taxonomy course, or permission of instructor. S-U grades optional. Offered alternate years. Not offered 1993–94.
Lecs, T R 10:10; lab, T 1:25–4:25.
J. I. Davis.
Systematics and ecology of the graminoid plant families (grasses, sedges, and rushes), with principal emphasis on grasses. Major topics include taxonomy, phylogenetics, physiology, reproductive biology, ecotypic variation, speciation, biogeography, and population biology. The role of graminoids as ecosystem dominants, weeds, and the origins of cultivated species are discussed. Laboratory concentrates on the diversity of grasses.]

[Bio S 441 Crop Plant Evolution
Fall. 2 credits. Prerequisite: an advanced-level course in the plant sciences with taxonomic content or permission of instructor. Offered alternate years. Not offered 1993–94.
Lecs, T R 11:15. 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.]

Bio S 443 Research Methods in Systematic Botany
Fall or spring. 2 credits. Limited to 10 students. Prerequisite: Bio S 248 or equivalent. Offered alternate years.
Lab, F 1:25–4:25; additional hours to be arranged. Bailey Hortorium staff.
An introduction to the methodology of plant systematic research: field studies; sampling and collecting methods; preparation of taxonomic revisions and monographs; numerical methods of data analysis; and laboratory methods in cytogenetics, comparative anatomy, and comparative chemistry, as applied to problems in plant systematics.

Bio S 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.

[Bio S 445 Photosynthesis
Fall. 3 credits. Prerequisites: Chem 104 or 208, Math 106 or 111, and either Phy 102 or 208 or permission of instructor. Offered alternate years. Not offered 1993–94.
Lecs, M W F 10:10. T. G. Owens.
A detailed study of the processes by which plants use light energy to grow. Structure of the photosynthetic apparatus, light absorption and antenna processes, photochemistry, and electron transport are emphasized. The course incorporates biophysical, biochemical, physiological, and molecular aspects of photosynthesis. Photosynthetic carbon metabolism is not covered in detail. Discussions include relevant material in bacterial, algal, and higher-plant photosynthesis.]

Bio S 447 Molecular Plant Systematics
Fall. 3 credits. Prerequisites: Bio S 248, 281, and 330 or 331, or written permission of instructor. Offered alternate years.
Lecs, T R 10:10–11:30. J. J. Doyle.
The study of variation at the molecular level and its application to the taxonomy and evolution of plants, particularly angiosperms. Emphasis is on the use of molecular evidence, particularly DNA data, for reconstructing phylogenies. Theory and methods of phylogenetic reconstruction are discussed. The organization and evolution of nuclear, mitochondrial, and chloroplast genomes, genes, and gene products are described from the standpoint of their utility for addressing a diversity of evolutionary questions. These questions span the entire taxonomic spectrum, and include such issues as the origin of angiosperms, evolution of species related to important crop plants, and population studies of hybridization.

[Bio S 448 Plant Evolution and the Fossil Record
Spring. 3 credits. Prerequisite: Bio S 241 or equivalent, or permission of instructor. Offered alternate years. Not offered 1993–94.
Lecs, T R 9:05; lab, R 12:20–2:15.
K. J. Niklas.
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.]

Bio S 453 Principles and Practice of Historical Biogeography (also Entomology 453)
Fall. 3 credits. S-U grades optional. Prerequisite: a course in systematics or permission of instructor.
Lecs, T R 10:10; lab/disc, R 2:30–4:25.
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.

Bio S 641 Laboratory in Plant Molecular Biology
Spring. 4 credits. Prerequisites: Bio S 281 or equivalent, 330 or 331 or equivalent, and permission of instructor. S-U grades optional.
Lab, T 9:05–4:30. J. B. Nasrallah, M. R. Hanson, S. D. Tanksley, P. F. Palukaitis.
Selected experiments on genome organization, gene expression, and gene transfer in plants. The course emphasizes the application of molecular biology methodology to plant systems. Students may have additional lab time to complete assignments.

[Bio S 642 Plant Mineral Nutrition (also Soil, Crop, and Atmospheric Sciences 642)
Spring. 3 credits. Prerequisite: Bio S 341 or equivalent. Offered alternate years. Not offered 1993–94.
Lecs, M W F 10:10. 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.]

Bio S 643 Plant Physiology, Advanced Laboratory Techniques
Fall. 4 credits. Prerequisites: organic chemistry, biochemistry, and a course in plant physiology. S-U grades only.
Lab, T or W 8–5; disc, M 4:30–5:30.
A. T. Jagendorf and 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.

Bio S 644 Plant Growth and Development
Spring. 3 credits. Prerequisites: Bio S 345 and either 242 or 341 or their equivalents, or written permission of instructor. Offered alternate years.
Lecs, M W F 9:05. P. J. Davies, D. J. Paolillo.
Explores the changes that occur during plant growth and development and their control: morphological and anatomical changes in apices, tissue differentiation, organ formation, embryo development, gene regulation, hormone action and interaction, the influence of light in development, flowering, fruiting, dormancy, abscission, and senescence.

[Bio S 645 Families of Tropical Flowering Plants
Fall. 1 credit. Prerequisite: written permission of instructor. S-U grades only. Offered alternate years. Not offered 1993–94.
Lec and disc, F 11:15. 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.]

[Bio S 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: Bio S 243 or 248 or equivalent. Recommended: Bio S 645. S-U grades only. For more details and application, contact the L. H. Bailey Hortorium, 467 Mann Library. Offered alternate years. Not offered 1993–94.
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.]

Bio S 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.

[Bio S 648 Plant Biochemistry
Spring. 3 credits. Prerequisites: organic chemistry, biochemistry, and a course in plant physiology. Offered alternate years. Not offered 1993–94.
Lecs, M W F 9:05. A. T. Jagendorf 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.]

Bio S 649 Transport of Solutes and Water in Plants
Fall. 3 credits. Prerequisite: Bio S 341 or equivalent. Offered alternate years.
Lecs, T R 10:10–11:30. R. M. Spanswick.
Transport of ions, water, and organic materials in plants; mechanisms of ion transport; relationships between ion transport and metabolism; ion uptake and transport in higher plants; phloem transport; and water relations of single cells and whole plants.

[Bio S 651 Quantitative Whole-Plant Physiology
Fall. 3 credits. Prerequisites: introductory physics, calculus, and plant physiology. S-U grades only. Offered alternate years. Not offered 1993–94.
Lecs, T R 10:10–11:30. 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.]

Bio S 652 Plant Molecular Biology II
Spring. 1–4 credits (1 credit per section). Prerequisites: Bio S 281, 330 or 331, and 653 (Section 01), or their equivalents. S-U grades optional.
A series of four-week modules on specialized topics. Coordinator: S. H. Howell.

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

Section 02 Molecular Biology of Plant Organelles
1 credit. S-U grades optional.
Lecs, M W F 1:25 (12 lecs) Jan. 26–Feb. 21. M. R. Hanson (even years), D. B. Stern (odd years).
An in-depth examination of the molecular biology of plant mitochondria (even years) and plastids (odd 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 03 Molecular Aspects of Plant Development II
1 credit. S-U grades optional.
Lecs, M W F 10:10 (12 lecs) Feb. 23–Mar. 28. S. H. Howell.
A systems approach to the study of plant development from a molecular perspective. Topics include molecular genetics of flowering, embryogenesis, meristem function, vascular formation, root development; consideration of cell lineages and positional information.

Section 04 Molecular Plant-Microbe Interactions
1 credit. S-U grades optional.
Lecs, M W F 10:10 (12 lecs) Mar. 30–Apr. 25. 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 05 Plant Gene Evolution
1 credit.
Lecs, M W F 1:25 (12 lecs) Mar. 30–Apr. 25. 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.

Bio S 653 Plant Molecular Biology I
Fall. 1–4 credits (1 credit per section). Prerequisites: Bio S 281 and 330 or 331, or their equivalents. S-U grades optional.
A series of four-week modules on specialized topics. Coordinator: S. H. Howell.

Section 01 Concepts and Techniques in Plant Molecular Biology
1 credit.
Lecs, M W F 10:10 (12 lecs) Sept. 1–Sept. 27. R. L. Last, R. Wu.
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, mutant production, DNA-protein interactions, and use of antibodies.

Section 02 Plant Biotechnology (also Plant Breeding 653 and Plant Pathology 663)
1 credit.
Lecs, M W F 10:10 (12 lecs) Sept. 1–Sept. 27. M. Zaitlin, E. D. Earle.
Applications of molecular biology and tissue culture to plant biotechnology are studied. Topics covered include gene introduction and tissue culture technologies; use of somaclonal variation; and use of cultured plant materials and transgenic plants to obtain resistance to insects, plant diseases, and herbicides, and to improve nutritional and food processing qualities. Regulatory and social issues relating to plant biotechnology are discussed.

Section 03 Plant Genome Organization and Function (also Plant Breeding 653)
1 credit.
Lecs, M W F 10:10 (12 lecs) Oct. 4–Nov. 1. S. D. Tanksley.
Molecular structure and evolution of plant nuclear genomes are explored. Topics covered include mechanisms for packaging DNA into chromosomes, molecular structure of telomeres and centromeres, DNA replication and methylation, and molecular biology of plant transposons. Methods for genetic and physical mapping of plant genomes are discussed as well as applications of mapping tools for gene isolation and plant breeding.

Section 04 Molecular Aspects of Plant Development I
1 credit.
Lecs, M W F 10:10 (12 lecs) Nov. 3–Dec. 3. J. B. Nasrallah.
The regulation of plant nuclear gene expression during development and in

response to environmental stimuli is explored. Topics include the use of classical and molecular genetics, transposable elements, and transgenic plants to identify and characterize *cis*- and trans-acting elements responsible for the regulation of selected genes.

Bio S 654 Botanical Nomenclature (formerly Plant Nomenclature)
Spring. 1 credit. Prerequisite: written permission of instructor. S-U grades only. Offered alternate years.
Lec and disc to be arranged. R. P. Korf.
An analysis of the International Code of Botanical Nomenclature and its application to various plant groups.

Bio S 655 Seminar in Ethnobotany (also Anthropology 627)
Fall. 2 or 4 credits (4 credits with independent tutorial). Prerequisite: written permission of instructor for undergraduates.
Lec, W 1:25; disc, W 2:30. D. M. Bates, C. R. Franquemont.
An exploration of ethnobotany, the study of the interrelationships of people and plants viewed from anthropological and botanical perspectives. Contemporary issues, theory, and methodology are considered. Topics include subsistence systems, crop domestication, traditional medicine, indigenous resource management, and preceptions of nature, among others.

Bio S 656 Topics in Paleobotany
Spring. 1 credit. Prerequisite: Bio S 448 or equivalent background in evolution, or written permission of instructor.
Lab and disc to be arranged. 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.

Bio S 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.

Bio S 742 Current Topics in Plant Molecular Biology
Fall or spring. 1 credit. Limited to 20 students. 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. Staff.
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.

Bio S 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 S 499 but intended for graduate students who are working with faculty members on an individual basis.

Bio S 840 Current Topics in Plant Physiology
Fall or spring. 2 credits. May be repeated for credit. S-U grades only.
Sem to be arranged. Staff.
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 449)

Mycology Conferences (Plant Pathology 649)

Phytomycology (Plant Pathology 709)

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

Plant Ecology Seminar (Biological Sciences 669)

Plant Cytogenetics Laboratory (Plant Breeding 446)

Teaching Experience (Biological Sciences 498)

Undergraduate Research in Biology (Biological Sciences 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 and Oceanography offered through the Division of Biological Sciences and the summer program of courses offered by the Shoals Marine Laboratory. Further information on both 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 areas of marine biology and oceanography. In addition to fulfilling the major and the ecology and evolutionary biology program of study requirements, students in marine biology and oceanography are encouraged to enroll in the following courses:

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

Students in this specialization 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

John B. Heiser, director
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.

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

Bio S 160 The Oceanography of the Gulf of Maine
Summer. 4 credits. S–U grades optional. Limited to 24 students. A special 3-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, consult the SML office, G14 Stimson Hall or the Sea Education Association office at P.O. Box 6, Woods Hole, MA 02543. Estimated cost (includes tuition, room and board aboard ship and on the island, and ferry transportation), $2,100.
Daily lecs, labs, and fieldwork for 3 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, Mass., 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.

Bio S 161 Introduction to Field Marine Science
Summer. 4 credits. 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. Estimated cost (includes tuition, room and board, and ferry transportation), $1,700.

Daily lecs, labs, and fieldwork for 2 weeks. SML faculty.

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.

Bio S 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. Estimated cost (includes tuition, room and board, supplies, and ferry transportation), $800.

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.

Bio S 309 Coastal Ecology and Bioclimates
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. Estimated cost (includes tuition, room and board, and ferry transportation), $1,500.

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. In-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.

Bio S 327 Neurobiology of Animal Behavior
Summer. 4 credits. Prerequisite: permission of instructor and successful performance in college-level introductory biology and chemistry courses with laboratories. Recommended: course work in neurobiology, psychology, and animal behavior. S–U grades optional. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off the coast of Portsmouth, N.H. For more details and an application, consult the SML office, G14 Stimson Hall. Estimated cost (includes tuition, room and board, and ferry transportation), $1,500.

Daily lecs, labs, and fieldwork for 2 weeks. SML faculty.

Neural mechanisms underlie all behaviors, from simple reflexes to complex social interactions. The functional elements of those mechanisms often are common to both vertebrate and invertebrate nervous systems. The course focuses on neural mechanisms of behavior in marine organisms, a topic that has produced significant biomedical discoveries. Students gain hands-on experience with a spectrum of modern research techniques for behavioral, systems, cellular, and molecular approaches. A visiting scientist program allows student interaction with research scientists.

Bio S 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. Estimated cost (includes tuition, room and board, and ferry transportation), $1,500.

Daily lecs and fieldwork for 2 weeks. 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.

Bio S 363 Marine Biology for Teachers
Summer. 3 credits. 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. Estimated cost (includes tuition, room and board, and ferry transportation), $1,100.

Daily lecs, labs, and fieldwork for 10 days. 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.

Bio S 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. Estimated cost (includes tuition, room and board, and ferry transportation), $2,500.

Daily lecs, labs, and fieldwork for 4 weeks. 3 core faculty members assisted by up to 15 visiting lecturers, including representatives of governmental agencies and commercial fishermen. 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.

Bio S 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. Estimated cost (includes tuition, room and board, and ferry transportation), $1,600.

Daily lecs and fieldwork for 2 weeks. Team-taught by a diving-safety officer, two faculty members, and guest lecturers.

For competent divers only. Covers special problems of underwater research, including random sampling, use of dive tables, underwater instrumentation, special diving equipment, photographic techniques, integration with boat and shore facilities, and emergency procedures. Students are required to conduct a transect study on both soft and hard substrates.

Bio S 366–370 SEA Semester
In cooperation with the Sea Education Association (SEA), the Shoals Marine Laboratory office 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 (the six-week shore component) in Woods Hole, Mass., receiving instruction in oceanography, nautical science, and maritime studies. The second half of SEA Semester (the six-week sea component) is spent at sea aboard the R/V *Westward* or the R/V *Corwith Cramer.* Enrollment is open to men and women judged capable of benefiting from SEA Semester; no specific prior training or study is required. Cornell students enrolled in the SEA Semester must take the entire sequence.

For more information, consult 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 entire 17-credit

SEA Semester, about $8,300; room and board about $2,500.

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

Shore Component (six weeks)

Bio S 366 SEA Introduction to Oceanography
3 credits. Prerequisite: concurrent enrollment in Bio S 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.

Bio S 367 SEA Introduction to Maritime Studies
3 credits. Prerequisite: concurrent enrollment in Bio S 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.

Bio S 368 SEA Introduction to Nautical Science
3 credits. Prerequisites: concurrent enrollment in Bio S 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-five students round out the complement.

Bio S 369 SEA Practical Oceanography I
4 credits. Prerequisite: Bio S 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.

Bio S 370 SEA Practical Oceanography II
4 credits. Prerequisites: Bio S 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.

Bio S 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. Estimated cost (includes tuition, room and board, and ferry transportation), $1,500.

Daily lecs, labs, and fieldwork for 2 weeks. SML faculty.

Dispersion modeling and the effects of pollutants (including oil, outfalls, solid wastes, sludge and dredge spoils, and radioactive wastes) are discussed from the perspectives of elementary physical oceanography and biological processes. Laboratories include basic methods for targeting and tracing wastewater, organic carbon determinations, and practical field projects.

Bio S 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. Estimated cost (includes tuition, room and board, and ferry transportation), $800.

Daily lecs and labs for 1 week. 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 saltmarshes, 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.

Bio S 413 Adaptations of Marine Organisms
Summer. 6 credits. Prerequisite: Bio S 364 or a course in physiological ecology. 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. Estimated cost (includes tuition, room and board, and ferry transportation), $2,100.

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.

Bio S 449 Marine Botany: Ecology of Marine Plants
Summer. 4 credits. Prerequisite: Bio S 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. Estimated cost (includes tuition, room and board, and ferry transportation), $1,500.

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.

Bio S 477 Marine Vertebrates
Summer. 6 credits. Prerequisites: permission of instructor and 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. Estimated cost (includes tuition, room and board, and ferry transportation), $2,100.

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.

AGEC The History and Economics of Whaling in North America (Agricultural Economics 454 and History 413)
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. Estimated cost (includes tuition, room and board, and ferry transportation), $800.

Daily lecs, labs, and fieldwork for 1 week. D. H. Usner, J. M. Conrad.

The whaling industry of nineteenth-century America presents a rich tapestry for studying the people, resources, and technology that contributed to the economic development of the United States. This course examines the species of whales on which that industry was based, aboriginal and colonial whaling, the golden era of the American fishery, whaling in the western Arctic, and the decline and demise of the industry in the early twentieth century. Social relationships, cross-cultural influences, markets, resource dynamics, and technical change are all evident in the rise and fall of this unique American industry.

ARKEO Archaeology of Maritime Communities (Archaeology 300: Individual Study in Archaeology)
Summer. 2 credits. Prerequisite: a strong interest in history 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, and ferry transportation), $800.

Daily lecs, labs, and fieldwork for 1 week. SML faculty.

Fieldwork on various land sites and their adjacent offshore marine environments. Artifact analysis, preliminary conservation, and the proper recording of finds are emphasized. Methods of archaeological research, including the use of archives and historical materials, and publication methodologies as well as the larger questions in the discipline are discussed.

ARKEO Archaeology Underwater (Archaeology 319)
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. Estimated cost (includes tuition, room and board, and ferry transportation), $900.

Daily lecs, labs, and fieldwork for 1 week. 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 Marine and Coastal Geology (Geological Sciences 213)
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, and ferry transportation), $800.

Daily lecs, labs, and fieldwork for 1 week. SML faculty.

With "the New England coast" defined as beginning at the -200 meter isobath and proceeding westward, this course examines specific geological events and processes important in shaping the area's bedrock and surficial sediments. Petrology, geophysics, and the Pleistocene geology of the region are investigated. Consideration of the geologic history of New England within the plate tectonic model is emphasized. Examination of insular geology is used to integrate micro-, meso-, and macroscale geological evolution of continental margins in general. Marine geology is approached through basic geophysical exploration and bottom-sediment collection followed by data analysis and interpretation. Experience aboard a coastal research vessel is an integral part of the course.

NTRES Coastal and Oceanic Law and Policy (Natural Resources 306)
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. Estimated cost (includes tuition, room and board, and ferry transportation), $800.

Daily lecs and discs 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 Wetland Resources (Natural Resources 417)
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. Estimated cost (includes tuition, room and board, and ferry transportation), $800.

Daily lecs, labs, and fieldwork for 1 week. 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.

COURSES IN BIOPHYSICS

Biophysics is an interdisciplinary undergraduate and graduate program. Information on this independent option is available in the Office for Academic Affairs, 200 Stimson Hall. Graduate study and research in biophysics are available through several Graduate Fields.

Students interested in graduate study in any of the fields offering biophysics can inquire of the Biophysics Program in the Applied Physics Office, 210 Clark Hall. There is a concentration in biophysics available through the Field of Biochemistry, Molecular and Cell Biology. The following courses are available for students interested in biophysics:

Advanced Concepts in Biological Engineering (Chemical Engineering 645)

Biomedical Engineering (Chemical Engineering 481)

Biomechanical Systems—Analysis and Design (Mechanical and Aerospace Engineering 465)

Chemistry of Nucleic Acids (Chemistry 677)

Computer Interfacing for Neurobiologists (Biological Sciences 422)

Electron Microscopy for Biologists (Biological Sciences 401, 403, 405, 606, 608)

Electronics for Neurobiology (Biological Sciences 426)

Enzyme Catalysis and Regulation (Chemistry 672)

Introduction to Bioprocess Engineering (Chemical Engineering 643)

Molecular Biophysics of Cellular Dynamics (Applied and Engineering Physics 615)

Membranes and Bioenergetics (Biological Sciences 632)

Membrane Ion Channels (Biological Sciences 495)

Neurochemistry and Molecular Neurobiology (Biological Sciences 497)

Neuroethology (Biological Sciences 424)

Photosynthesis (Biological Sciences 445)

Physical Chemistry of Proteins (Chemistry 686)

Principles of Neurophysiology (Biological Sciences 491)

Protein Structure and Function (Biological Sciences 631)

Special Topics in Biophysical and Bioorganic Chemistry (Chemistry 782)

Transport of Solutes and Water in Plants (Biological Sciences 649)

FACULTY ROSTER

New York State College of Agriculture and Life Sciences

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

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

Banks, Harlan P., Ph.D., Cornell U. Liberty Hyde Bailey Prof. of Botany Emeritus, Plant Biology

Barker, Robert, Ph.D., U. of California at Berkeley. Prof., Biochemistry, Molecular and Cell Biology/Center for the Environment

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
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. Asst. Prof., Bailey Hortorium
Delwiche, Eugene A., Ph.D., Cornell U. Prof. Emeritus, Microbiology
Dondero, Norman C., Ph.D., Cornell U. Prof. Emeritus, Microbiology
Doyle, Jeffrey J., Ph.D., Indiana U. Assoc. Prof., Bailey Hortorium
Dress, William J., Ph.D., Cornell U. Prof. Emeritus, Bailey Hortorium
Ealick, Steven E., Ph.D., U. of Oklahoma. Prof., Biochemistry, Molecular and Cell Biology
Eisner, Thomas, Ph.D., Harvard U. Jacob Gould Schurman Professor, Neurobiology and Behavior
Emlen, Stephen T., Ph.D., U. of Michigan. Prof., Neurobiology and Behavior
Feeny, Paul P., Ph.D., Oxford U. (England). Prof., Ecology and Systematics/Entomology
Fox, Thomas D., Ph.D., Harvard U. Assoc. Prof., Genetics and Development
Ghiorse, William C., Ph.D. Rensselaer Polytechnic Inst. Prof., Microbiology
Gibson, Jane, Ph.D., U. of London (England). Prof., Biochemistry, Molecular and Cell Biology
Goldberg, Michael L., Ph.D., Stanford U. Assoc. 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. Asst. 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/Center for the Environment
Ingram, John W., Ph.D., U. of California at Berkeley. Prof. Emeritus, Bailey Hortorium
Jagendorf, Andre T., Ph.D., Yale U. Liberty Hyde Bailey Professor of Plant Physiology, Plant Biology
Keller, Elizabeth B., Ph.D., Cornell U. Prof. Emeritus, Biochemistry, Molecular and Cell Biology
Kemphues, Kenneth J., Ph.D., Indiana U. Assoc. Prof., Genetics and Development
Kingsbury, John M., Ph.D., Harvard U. Prof. Emeritus, Plant 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. Asst. 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
Marks, Peter L., Ph.D., Yale U. Prof., Ecology and Systematics*
McCune, Amy R., Ph.D., Yale U. Assoc. Prof., Ecology and Systematics
Mortlock, Robert P., Ph.D., U. of Illinois. Prof., Microbiology
Nasrallah, June B., Ph.D., Cornell U. Assoc. 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
Pough, F. Harvey, Ph.D., U. of California at Los Angeles. Prof., Ecology and Systematics/Physiology
Quaroni, Andrea, Ph.D., U. of Pavia (Italy). Assoc. Prof., Physiology
Roberts, Jeffrey W., Ph.D., Harvard U. Robert J. Appel Professor of Molecular and Cell Biology, Biochemistry, Molecular and Cell 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
Srb, Adrian M., Ph.D., Stanford U. Jacob Gould Schurman Prof. Emeritus, Genetics and Development
Steward, Frederick C., Ph.D., U. of Leeds (England). Charles A. Alexander Prof. Emeritus, Biological Sciences
Stewart, Valley J., Ph.D., U. of Virginia. Assoc. Prof., Microbiology/Genetics and Development
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/Laboratory of Ornithology
Wayne, Randy O., Ph.D., U. of Massachusetts. Asst. Prof., Plant Biology
Winans, Stephen C., Ph.D., Massachusetts Inst. of Technology. Asst. Prof., Microbiology
Winkler, David W., Ph.D., U. of California at Berkeley. Asst. 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., Genetics and Development*
Zinder, Stephen H., Ph.D., U. of Wisconsin. Assoc. Prof., Microbiology

Other Teaching Personnel

Alexander, Renee R., Ph.D., Cornell U. Sr. Lecturer, Biochemistry, Molecular and Cell Biology
Blankenship, James E., M.S., Cornell U. Lecturer, Biochemistry, Molecular and Cell Biology
Cordts, Marcia L., Ph.D., Cornell U. Sr. Lecturer, Microbiology
Ecklund, P. Richard, Ph.D., Oregon State U. Lecturer, Neurobiology and Behavior
Glase, Jon C., Ph.D., Cornell U. Sr. Lecturer, Neurobiology and Behavior
Griffiths, Joan M., Ph.D., Cornell U. Lecturer, Biochemistry, Molecular and Cell Biology
Heiser, John B., Ph.D., Cornell U. Sr. Lecturer, Ecology and Systematics
McFadden, Carol H., Ph.D., Cornell U. Sr. Lecturer, Physiology
Merkel, Susan, M.S., Cornell U. Lecturer, Microbiology
Rehkugler, Carole M., M.S., Cornell U. Sr. Lecturer, Microbiology
Reiss, H. Carol, M.S., Cornell U. Sr. 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
Butler, Walter R., Assoc. Prof., Animal Science/Physiology
Edelstein, Stuart M., Adjunct Prof., U. of Geneva (Switzerland)/Biochemistry, Molecular and Cell Biology
Foote, Robert H., Jacob Gould Schurman Professor, Animal Science/Physiology
Greene, Charles H., Adjunct Asst. Prof., Center for the Environment/Ecology and Systematics
Howell, Stephen H., Adjunct Prof., Boyce Thompson Institute/Plant Biology
Kochian, Leon V., Adjunct Assoc. Prof., USDA Science and Education Administration/Plant Biology
Korf, Richard P., Prof., Plant Pathology/Bailey Hortorium
LaRue, Thomas A., Adjunct Prof., Boyce Thompson Institute/Plant Biology
Last, Robert L., Adjunct Asst. Prof., Boyce Thompson Institute/Genetics and Development
Leopold, A. Carl, Adjunct Prof., Boyce Thompson Institute/Plant Biology
Liebherr, James K., Assoc. Prof., Entomology/Bailey Hortorium
McCarty, Richard E., Adjunct Prof., Johns Hopkins U./Biochemistry, Molecular and Cell Biology
Moffat, J. Keith, Adjunct Prof., U. of Chicago/Biochemistry, Molecular and Cell Biology
Pimentel, David, Prof., Entomology/Ecology and Systematics
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 Asst. Prof., Boyce Thompson Institute/Plant Biology
Thompson, John F., Adjunct Prof., USDA Science and Education Administration/Plant Biology
van Tienhoven, Ari, Ph.D., U. of Illinois. Prof. Emeritus, Physiology
Via, Sara, Assoc. Prof., Entomology/Ecology and Systematics
Weeden, Norman F., Assoc. Prof., Horticultural Sciences/Bailey Hortorium
Wheeler, Quentin D., Assoc. Prof., Entomology/Bailey Hortorium

College of Arts and Sciences

Aquadro, Charles F., Ph.D., U. of Georgia. Assoc. Prof., Genetics and Development/Ecology and Systematics
Bass, Andrew H., Ph.D., U. of Michigan. Assoc. Prof., Neurobiology and Behavior
Blackler, Antonie W., Ph.D., U. of London (England). Prof., Genetics and Development
Booker, Ronald, Ph.D., Princeton U. Asst. Prof., Neurobiology and Behavior
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