Danielle Harvey, Ph.D., Assistant Adjunct Professor *(Public Health Sciences)*
Fushing Hsieh, Ph.D., Professor *(Statistics)*
Jiming Jiang, Ph.D., Professor *(Statistics)*
Philip H. Kass, Ph.D., Professor *(Population Health and Reproduction)*
Kyoungmi Kim, Ph.D., Assistant Professor *(Public Health Sciences)*
Hans-Georg Müller, Ph.D., Professor *(Statistics)*
Debashis Paul, Ph.D., Assistant Professor *(Statistics)*
Jie Peng, Ph.D., Assistant Professor *(Statistics)*
Katherine Pollard, Ph.D., Assistant Professor *(Statistics)*
Lihong Qi, Ph.D., Assistant Professor *(Public Health Sciences)*
David M. Rocke, Ph.D., Professor *(Applied Science Engineering)*
George G. Roussas, Ph.D., Professor *(Statistics)*
Francisco J. Samaniego, Ph.D., Professor *(Statistics)*
Chih-Ling Tsai, Ph.D., Professor *(Graduate School of Management)*
Jessica M. Utts, Ph.D., Professor *(Statistics)*
Jane-Ling Wang, Ph.D., Professor *(Statistics)*
Xiaowei Yang, Ph.D., Assistant Professor *(Public Health Sciences)*

**Graduate Study.** Biostatistics is a field of science that uses quantitative methods to study life sciences related problems that arise in a broad array of fields. The program provides students with, first, solid training in the biostatistical core disciplines and theory; second, with state-of-the art knowledge and skills for biostatistical data analysis; third, substantial exposure to the biological and epidemiological sciences; and fourth, with a strong background in theoretical modeling, statistical techniques and quantitative as well as computational methods. Programs of study and research are offered leading to the M.S. and Ph.D. degrees. The program prepares students for interdisciplinary careers ranging from bioinformatics, environmental toxicology and stochastic modeling in biology and medicine to clinical trials, drug development, epidemiological and medical statistics. The program draws on the strengths of the Biostatistics faculty at UC Davis.

**Preparation.** Students should have one year of calculus; a course in linear algebra or one year of biological course work; facility with a programming language; and upper-division work in at least one of Mathematics, Statistics and Biology.

**Graduate Adviser.** Prabir Burman *(Statistics)*

## Courses in Biostatistics (BST)

### Graduate Courses

**222. Biostatistics: Survival Analysis (4)**
Lecture—3 hours; discussion/laboratory—1 hour. Prerequisite: Statistics 131C. Incomplete data; life tables; nonparametric methods; parametric methods; accelerated failure time models; proportional hazards models; partial likelihood; advanced topics. (Same course as Statistics 222.)—I.

**223. Biostatistics: Generalized Linear Models (4)**
Lecture—3 hours; discussion/laboratory—1 hour. Prerequisite: Statistics 131C. Likelihood and linear regression; generalized linear model; Binomial regression; case-control studies; dose-response and bioassay; Poisson regression; Gamma regression; quasi-likelihood models; estimating equations; multivariate GLMs. (Same course as Statistics 223.)—II.

**224. Analysis of Longitudinal Data (4)**
Lecture—3 hours; discussion/laboratory—1 hour. Prerequisite: course/Statistics 222, 223, Statistics 232B or consent of instructor. Standard and advanced methodology, theory, algorithms, and applications relevant for analysis of repeated measurements and longitudinal data in biostatistical and statistical settings. (Same course as Statistics 224.)—III. (III.)

**225. Clinical Trials (4)**
Lecture—3 hours; discussion/laboratory—1 hour. Prerequisite: course/Statistics 223 or consent of instructor. Basic statistical principles of clinical designs, including bias, randomization, blocking, and masking. Practical applications of widely-used designs, including dose-finding, comparative and cluster randomization designs. Advanced statistical procedures for analysis of data collected in clinical trials. (Same course as Statistics 225.) Offered in alternate years.—III.

**226. Statistical Methods for Bioinformatics (4)**
Lecture—3 hours; discussion/laboratory—1 hour. Prerequisite: course 131C or consent of instructor; data analysis experience recommended. Standard and advanced statistical methodology, theory, algorithms, and applications relevant to the analysis of -omics data. (Same course as Statistics 226.) Offered in alternate years.—(II.)

**252. Advanced Topics in Biostatistics (4)**
Lecture—3 hours; discussion/laboratory—1 hour. Prerequisite: course 222, 223. Biostatistical methods and models selected from the following: genetics, bioinformatics and genomics; longitudinal or functional data; clinical trials and experimental design; analysis of environmental data; dose-response, nutrition and toxicology; survival analysis; observational studies and epidemiology; computer-intensive or Bayesian methods in biostatistics. May be repeated for credit with consent of adviser when topic differs. (Same course as Statistics 252.) Offered in alternate years.—III.

**290. Seminar in Biostatistics (1)**
Seminar—1 hour. Seminar on advanced topics in the field of biostatistics. Presented by members of the Biostatistics Graduate Group and other guest speakers. May be repeated for up to 12 units of credit. (S/U grading only.)—I, II, III.

**298. Directed Group Study (1-5)**
Prerequisite: consent of instructor.

**299. Special Study for Biostatistics Graduate Students (1-12)**
Prerequisite: consent of instructor. (S/U grading only.)

**299D. Dissertation Research (1-12)**
Prerequisite: advancement to Candidacy for Ph.D. and consent of instructor. Research in biostatistics under the supervision of major professor. (S/U grading only.)

# Biotechnology

(College of Agricultural and Environmental Sciences)

**Faculty.** Faculty includes members of the Departments of Animal Science, on page 141; Engineering: Chemical Engineering and Materials Science, on page 235; Computer Science, on page 196; Engineering: Biological and Agricultural, on page 227; Food Science and Technology, on page 295; Land, Air, and Water Resources, on page 342; Plant Pathology, on page 446; Plant Sciences, on page 448; Viticulture and Enology, on page 513; and the College of Biological Sciences, on page 166.

## The Major Program

Every living organism, from the smallest and most primitive bacteria to every plant, insect, animal or human being, contains DNA as the primary genetic material. DNA directs all cellular processes, creating the incredible variety and diversity of living organisms in the biosphere. Biotechnology focuses on the mechanics of life processes and their application. Biotechnology means "life technology" and represents an integrated, multidisciplinary field, with a profound impact today on almost every aspect of human endeavor.

**Preparatory Requirements.** UC Davis students who wish to change their major to Biotechnology must complete the following preparatory courses with a combined grade point average of at least 2.500. All of these courses must be taken for a letter grade:

| | UNITS |
|---|---|
| Plant Sciences 120 or Statistics 100 | 4 |
| Biotechnology 1 | 4 |
| Biological Sciences 1A, 1B, 1C or 2A, 2B, 2C | 14-15 |
| Chemistry 2A, 2B, 2C | 15 |
| Organic Chemistry, one of the following groups | 6-12 |
| Chemistry 8A, 8B; or Chemistry 118A, 118B, 118C; or Chemistry 128A, 128B, 128C, 129A | |
| Math, one of the following groups | 6-8 |
| Math 16A, 16B; or Math 17A, 17B; or Math 21A, 21B Physics 7A, 7B | 8 |

**The Program.** In the first two years, students develop a strong and general background in biological science with an emphasis on fundamental concepts and basic principles of genetics, molecular biology and cell biology. Four options, Animal Biotechnology, Plant Biotechnology, Fermentation/Microbial Biotechnology, and Bioinformatics, provide in-depth training and specialized knowledge in an aspect of biotechnology. Each option has a strong laboratory component to reinforce the theoretical concepts. Students also do an internship in a biotechnology company or university or government laboratory.

**Internships and Career Opportunities.** In the last decade, more industries are turning to biotechnology to solve problems and improve products, creating a growing job market for individuals trained in biotechnology in the agricultural, food and beverage, health care, chemical, pharmaceutical and biochemical, and environmental and bioremediation industries.

Graduates trained in the technologies designed for biotechnology will find their training applicable to advanced research in molecular biology, genetics, biochemistry, and the plant and animal sciences.

## B.S. Major Requirements:

| | UNITS |
|---|---|
| **English Composition Requirement** | **8** |
| See College requirement. select at least one course from: University Writing Program 101, 102A, 102B, 102C, 102D, 102E, 102F, 102G, 104A, 104B, 104C, 104D, 104E or 104F | |
| **Preparatory Subject Matter** | **57-66** |
| Biological Sciences 1A, 1B, 1C or 2A, 2B, 2C | 14-15 |
| Chemistry 2A, 2B, 2C | 15 |
| Chemistry 8A, 8B or 118A, 118B, 118C or 128A, 128B, 128C, 129A | 6-12 |
| Mathematics 16A, 16B, or 17A, 17B or 21A, 21B | 6-8 |
| Physics 7A, 7B | 8 |
| Plant Sciences 120 or Statistics 100 | 4 |
| Biotechnology 1 | 4 |
| **Breadth/General Education** | **24** |
| **Depth Subject Matter** | **26-32** |
| Biological Sciences 101 | 4 |
| Microbiology 102 | 4 |
| Animal Biology 102 or Biological Sciences 102 | 3-5 |
| Animal Biology 103 or Biological Sciences 103 | 3-5 |
| Biological Sciences 104 | 3 |
| Molecular and Cellular Biology 161 | 3 |
| Biotechnology 171 | 3 |
| Internship or independent research; course 192 or 199 or Biotechnology189L | 3 |
| Undergraduate research proposal: Biotechnology 188 (optional) | 3 |
| Honors undergraduate thesis (optional) | 1 |
| **Areas of Specialization (choose one)** | |
| **Fermentation/Microbiology Biotechnology Option** | **31-34** |
| Engineering: Chemical 160; Microbiology 140 and 150, or Plant Pathology 130 and Microbiology 170; Microbiology 102L or Food Science and Technology 104L; Molecular and Cellular Biology 160L or Biotechnology 161A | 16-19 |
| Restricted Electives | 15 |

Select from:
Biotechnology 150, 161B, Chemistry 107A, 107B, Engineering: Biological Systems 160, Engineering: Chemical 161C, 161L, Evolution and Ecology 100, Food Science and Technology 102A, 102B, 104, 104L, 110A, 110B, 123, 123L, Microbiology 105, 105L, 140, 150, 155L, 162, 170, Molecular and Cellular Biology 120L, 164, Plant Pathology 130, 140, Viticulture and Enology 124, 124L, 128, 135, 186.

**Plant Biotechnology Option ..... 34**

Biotechnology 160, 161A, 161B, Molecular and Cellular Biology 126, Plant Sciences 152..... 22
Restricted Electives ..... 12
Select at least one course from each of the following areas:
*(a) Pests, Pathogens and Production:* Biotechnology 150, Entomology 110, Evolution and Ecology 100, Microbiology 162, Molecular and Cellular Biology 120L, 164, Nematology 100 or 110, Plant Pathology 120, 123, 130, 140, Plant Biology 143, Plant Sciences 146, 151, 153, 154, 172, 173
*(b) Growth and Development:* Biotechnology 150, Evolution and Ecology 100, Molecular and Cellular Biology 120L, Plant Biology 105, 111, 112, Plant Pathology 140, Plant Sciences 157, 158

**Animal Biotechnology Option ..... 33**

Animal Genetics 111, Neurobiology, Physiology, and Behavior 101, Molecular and Cellular Biology 150, 150L, 182, Animal Science 170..... 21
Restricted Electives ..... 12
Select at least one course from each of the following areas:
*(a) Animal cell biology/microbiology/immunology:* Animal Genetics 101, Biotechnology 150, 161A, 161B, Evolution and Ecology 100, Medical Microbiology 188 or Pathology, Microbiology, and Immunology 126, Microbiology 102L, 162, Molecular and Cellular Biology 120L, 160L, Pathology, Microbiology, and Immunology 126L, 127, 128, Physiology, Molecular, Cellular, and Integrative Physiology 200L, Neurology, Physiology, and Behavior 131, Plant Pathology 140

**Bioinformatics Option ..... 31**

Biotechnology 150, Engineering: Computer Science 20, 30, 124, Molecular and Cellular Biology 182 or Neurobiology, Physiology, and Behavior 131..... 19
Restricted Electives ..... 12
Select from:
Animal Genetics 120, 212, Biological Sciences 132, Engineering: Applied Science 289, Engineering: Computer Science 40, 50, 60, 122A, 140A, 150, 154A, 189K, Evolution and Ecology 100, 102, 103, Mathematics 124, Statistics 130A or 131A, 130B or 131B, 141

**Unrestricted Electives ..... 14-34**

**Total Units for the Major ..... 180**

**Major Adviser:** J.I. Yoder *(Plant Sciences)* in 101 Asmundson Hall

**Advising Center** for the major is located in 1220 Plant and Environmental Sciences (530) 752-1715.

## Courses in Biotechnology (BIT)

### Lower Division Courses

**1. Introduction to Biotechnology (4)**
Lecture—3 hours; discussion—1 hour. Principles and applications of biotechnology. Topics include microbial biotechnology, agricultural biotechnology, biofuels, cloning, bioremediation, medical biotechnology, DNA fingerprinting and forensics. GE Credit: SciEng.—III. (III.) Dandekar, Yoder

**92. Internship in Biotechnology (1-12)**
Internship—3-36 hours. Prerequisite: consent of instructor. Work experience on or off campus in subject area pertaining to biotechnology or in a business, industry or agency associated with biotechnology. Internship supervised by faculty member in the animal or plant sciences. (P/NP grading only.)

**99. Special Study for Undergraduates (1-5)**
Prerequisite: consent of instructor. (P/NP grading only.)

### Upper Division Courses

**150. Applied Bioinformatics (4)**
Lecture—2 hours; laboratory/discussion—2 hours. Prerequisite: Computer Science Engineering 10 or 15 or Plant Sciences 21; Biological Sciences 101 and 104; Plant Sciences 120 or Statistics 13 or Statistics 100. Concepts and programs needed to apply bioinformatics in biotechnology research. Sequence analysis and annotation and use of plant and animal databases for students in biological and agricultural sciences. Limited enrollment. Two units of credit for students who have completed Computer Science Engineering 124.—I. (I.) Dubcovsky, Neale

**160. Principles of Plant Biotechnology (3)**
Lecture—3 hours. Prerequisite: Biological Sciences 1A or 2A; Biological Sciences 101 or Plant Sciences 152. Principles and concepts of plant biotechnology including recombinant DNA technology, molecular biology, genomics, cell and tissue culture, gene transfer and crop improvement strategies using transgenic crops. Not open for credit to students who have completed Plant Biology 160. (Former course Plant Biology 160.)—II. (II.) Dandekar

**161A. Genetics and Biotechnology Laboratory (6)**
Lecture—3 hours; laboratory—9 hours. Prerequisite: Plant Sciences 152 or Biological Sciences 101. Techniques of genetic analysis at the molecular level including recombinant DNA, gene mapping and basic computational biology. Not open for credit to students who have completed Plant Biology 161A. (Former course Plant Biology 161A.)—II. (II.) Beckles

**161B. Plant Genetics and Biotechnology Laboratory (6)**
Lecture—3 hours; laboratory—9 hours. Prerequisite: Plant Sciences 152 or Biological Sciences 101. Advanced techniques of genetic analysis at the molecular and organismal levels, including transformation, gene expression, analysis of transgenic plants and QTL analysis. Not open for credit to students who have taken Plant Biology 161B. (Former course Plant Biology 161B.)—III. (III.) Bennett, Blumwald

**171. Professionalism and Ethics in Genomics and Biotechnology (3)**
lecture—1 hour; discussion—2 hours. Prerequisite: upper division standing in a natural science major. Real and hypothetical case studies to illustrate ethical issues in genomics and biotechnology. Training and practice in difficult ethical situations and evaluating personal and social consequences.—I, II, III. (I, II, III.) Yoder, Bradford

**188. Undergraduate Research Proposal (3)**
Lecture/discussion—3 hours. Prerequisite: upper division standing. Preparation and review of a scientific proposal. Problem definition, identification of objectives, literature survey, hypothesis generation, design of experiments, data analysis planning, proposal outline and preparation. (Same course as Plant Sciences 188.) GE Credit: Wri.—III. (III.)

**189L. Laboratory Research in Genomics and Biotechnology (2-5)**
Laboratory—3-12 hours; discussion—1 hour. Prerequisite: course 188 and consent of instructor. Formulating experimental approaches to current questions in biotechnology; performance of proposed experiments. May be repeated for credit up to 12 units. (P/NP grading only.)—I, II, III. (I, II, III.)

**192. Internship in Biotechnology (1-12)**
Internship—3-36 hours. Prerequisite: consent of instructor. Work experience on or off campus in a subject area pertaining to biotechnology or in a business, industry or agency associated with biotechnology. Internship supervised by faculty member in the animal or plant sciences. (P/NP grading only.)

**194H. Honors Thesis in Biotechnology (1-5)**
Independent Study—3-15 hours. Prerequisite: senior standing in Biotechnology with 3.250 GPA or higher and completion of courses 188 and 189L. Independent study of selected topics under the direction of a member or members of the staff. Completion will involve the writing of a senior thesis. (Deferred grading only, pending completion of sequence.) (P/NP grading only.)

**199. Special Study for Advanced Undergraduates (1-5)**
Prerequisite: consent of instructor. (P/NP grading only.)

# Bodega Marine Laboratory Program

*http://www.bml.ucdavis.edu/*

See also Biological Sciences, Bodega Marine Laboratory Program, on page 169.

## Spring Quarter Program

A full quarter of undergraduate course work in marine biology is available each spring quarter at the Bodega Marine Laboratory, located in Bodega Bay, California. Course offerings include lecture and laboratory instruction in the developmental biology and physiological adaptation of marine organisms, and population biology and ecology; a weekly colloquium; and an intensive individual research experience under the direction of laboratory faculty (Biological Sciences courses 120, 120P, 122, 122P, 123; Neurobiology, Physiology, and Behavior 141, 141P). This is a 15 unit program and course offerings and instructors may vary from year to year. Applications are due January 31.

For more course detail, see full description under appropriate academic department listing or *http://www.bml.ucdavis.edu/*.

## Summer Special Session Courses

This integrated program offers students a multidisciplinary understanding of coastal ecosystems through intensive, hands on courses taught at BML. The program offers students three sequences of instruction with up to 10 units in each. Two sequences occur during the first Summer Session dates and one sequence in the second Summer Session dates. Applications are due May 1.

For more course detail, see full description under appropriate academic department listing or *http://www.bml.ucdavis.edu/*.

Sequences are:

*Marine Organisms and Ecology of the California Coast.* Evolution and Ecology 106, 114, 111, 110; Biological Sciences 124
Effects of Coastal Pollution on Marine *Organisms.* Environmental Toxicology/Nutrition 127
*Oceanography.* Environmental Science and Policy 152; Geology/Environmental Science and Policy 150C; Biological Sciences 124

Course offerings, sequence structure and instructors may vary from year to year.

Bodega Marine Laboratory spring and summer programs are residential, with students housed on the laboratory grounds. Participants are assessed a room and board fee in addition to standard campus registration fees. Applications and consent of instructors are required.