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Faculty

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Annalisa Berta, Ph.D., Professor of Biology, Emeritus

Richard W. Bizzoco, Ph.D., Professor of Biology, Emeritus

Andrew J. Bohonak, Ph.D., Professor of Biology, Assistant Dean for Student Services, Policy and Curriculum, Graduate and Research Affairs

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Elizabeth R. Waters, Ph.D., Professor of Biology (Graduate Adviser, Evolutionary Biology Ph.D. program)

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Marina G. Kalyuzhnaya, Ph.D., Associate Professor of Biology

Chun-Ta Lai, Ph.D., Associate Professor of Biology

Jeremy D. Long, Ph.D., Associate Professor of Biology (Graduate Adviser, Ecology, M.S. program)

Ricardo M. Zayas, Ph.D., Associate Professor of Biology (Graduate Adviser, Cell and Molecular Biology Ph.D. program)

Nicholas A. Barber, Ph.D., Assistant Professor of Biology

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Carrie D. House, Ph.D., Assistant Professor of Biology

Robert J. Luallen, Ph.D., Assistant Professor of Biology

Luke P. Miller, Ph.D., Assistant Professor of Biology

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Nicholas J. Shikuma, Ph.D., Assistant Professor of Biology

Jeet Sukumaran, Ph.D., Assistant Professor of Biology

Xiaofeng Xu, Ph.D., Assistant Professor of Biology

Donatella Zona, Ph.D., Assistant Professor of Biology

Associateships and Assistantships

Graduate teaching associateships and graduate assistantships in biology are available to qualified students on a competitive basis. Application and additional information may be secured from the graduate adviser in biology.

General Information

The Department of Biology offers graduate study leading to the degrees of Master of Arts and Master of Science in biology and the Master of Science degree in microbiology. In addition, the Department of Biology offers three doctoral programs leading to the Ph.D. in biology (cell and molecular) with the University of California, San Diego, in ecology with the graduate group in ecology at the University of California, Davis, and in evolutionary biology with the University of California, Riverside. These academic programs can prepare students for careers in research, education, and public service.

Modern life science buildings provide facilities for graduate study in the biological sciences. San Diego State University also operates the Coastal and Marine Institute Laboratory on San Diego Bay, the SDSU Field Stations program with research stations at the Sky Oaks Biological Field Station near Warner Springs, the Santa Margarita Ecological Reserve near Temecula (Riverside County), and a research site at Fortuna Mountain.

Additional facilities and opportunities available in the community include the Tijuana Estuary Reserve, San Diego Zoo and Hospital, the United States Department of Agriculture, Fish and Game Commission, the Hubbs-Sea World Research Institute, the San Diego Natural History Museum, and the Naval Undersea Center.

Admission to Master's or Doctoral Study

Students applying for admission should electronically submit the university application along with the \$55 application fee.

All applicants must submit admissions materials separately to SDSU Graduate Admissions and to the Department of Biology.

Graduate Admissions

The following materials should be submitted as a complete package directly to:

Graduate Admissions
Enrollment Services
San Diego State University
San Diego, CA 92182-7416

1. Official transcripts (in sealed envelopes or electronically submitted) from all postsecondary institutions attended;
 - Students who attended SDSU need only submit transcripts for work completed since last attendance.
 - Students with international coursework must submit both the official transcript and proof of degree. If documents are in a language other than English, they must be accompanied by a certified English translation.
2. GRE scores (<http://www.ets.org> SDSU institution code 4682);
3. English language score, if medium of instruction was in a language other than English (<http://www.ets.org> SDSU institution code 4682).

Master of Arts Degree in Biology

Master of Science Degree in Biology

Master of Science Degree in Microbiology

The following admissions materials must be submitted electronically;

1. Personal statement;
2. Application for teaching assistantship (optional);
3. Three letters of recommendation;
4. Unofficial transcripts;
5. Curriculum vitae or resume.

Complete instructions can be found at <http://www.bio.sdsu.edu/MastersAppIProced.html>.

Biology

Ph.D. Degree in Biology (Cell and Molecular)

Applications to the Ph.D. program in biology (cell and molecular) require an online application through <http://www.calstate.edu/apply>. Applications are due by December 15 (or the preceding weekday if December 15 falls on a weekend or holiday). For additional information visit <http://www.bio.sdsu.edu/cmob/propsinfo.html>.

Ph.D. Degree in Ecology

Application to the Ph.D. program in ecology is a two-step process. The first step requires an online application to the Joint Doctoral Program in Ecology (JDPE) through University of California, Davis at <http://ecology.ucdavis.edu/admissions/jointprogram.html>. A joint SDSU-UCD JDPE admissions committee will evaluate applications. Those selected will be asked to submit an abbreviated application at <http://www.calstate.edu/apply>. All applicants must identify a faculty member at SDSU who has agreed to act as their faculty adviser for the Ph.D. program, if accepted. The person should be listed as the faculty member with whom they have spoken on their SDSU and UCD applications. Applications to UCD are due by December 15 (or the preceding week day if December 15 falls on a weekend or holiday). For additional information, consult the website http://www.bio.sdsu.edu/ecology/ecology_joint_doc_app.php or the coordinator or director for the Ph.D. program in ecology.

Ph.D. Degree in Evolutionary Biology

Application to the Ph.D. in evolutionary biology requires online application to SDSU through <http://www.calstate.edu/apply>.

All applicants must identify a faculty member at SDSU who has agreed to act as their major professor for the Ph.D. program. Applications are due by December 15 (or the preceding week day if December 15 falls on a weekend or holiday). For additional information consult the website: <http://www.bio.sdsu.edu/eb/jdeb.html>.

Section I. Master's Degree Programs

The Master of Science degrees in biology and microbiology are acceptable as preparation for more advanced degree programs. Studies for degrees in biology must be completed in one of the research programs listed below. The Master of Arts degree in biology has a foreign language requirement.

Admission to the Degree Curriculum

In addition to the general requirements for admission to the university with classified graduate standing, as described in Part Two of this bulletin, a student must satisfy the following requirements before he/she will be considered for recommendation to enter the masters program.

1. Meet the requirements deemed equivalent to a baccalaureate degree in biology or microbiology at San Diego State University.
2. Have a grade point average of 2.85 or better on work taken for the baccalaureate degree.
3. Have a grade point average of 3.0 or better in upper division courses (at least 24 units) acceptable for the major.
4. Meet biology departmental expectations on the GRE General Test.
5. Be considered as capable of graduate work in the biological sciences by at least two letters of reference submitted to the biology graduate adviser.
6. Be accepted by a research program and be sponsored by a faculty member of the area (required only for programs in ecology and evolutionary biology).

NOTE: Admission to a research program within the biology graduate program will be limited to the number of students for which adequate facilities and faculty sponsorship are available. Students should therefore be as specific as possible in their indication of research interests and career goals. Individual research programs will admit students solely on the basis of merit in relation to space and faculty availability.

Students who do not meet all of the above requirements for admission with classified graduate standing may be admitted

with conditionally classified graduate standing upon the recommendation of the research program. Students so admitted will be advised as to the nature of their deficiency and the time to be allowed to achieve full classified graduate standing.

Biology

Advancement to Candidacy

All students must satisfy the general requirements for advancement to candidacy, including the foreign language requirement for the Master of Arts degree, as stated in Part Four of this bulletin. Presenting a successful thesis proposal (as indicated by submission of a completed thesis proposal form) is required to be advanced to candidacy.

Specific Requirements for the Master of Arts Degree in Biology

(Major Code: 04011) (SIMS Code: 771402)

In addition to meeting the requirements for classified graduate standing and the basic requirements for the master's degree as described in Part Four of this bulletin, the student must complete a graduate program of 30 units of upper division and graduate courses selected, with the approval of the graduate adviser, from the biological sciences as listed below, or from closely related fields. At least 15 of the units selected must be in 600- and 700-numbered courses, including Biology 799A, Thesis. A maximum of six units of the required 30 units may be selected from acceptable courses offered in the College of Education. A reading knowledge of scientific French, German, Russian, or Spanish, and a final oral examination in the field of the thesis and its implications in the broad fields of biology are also required.

Specific Requirements for the Master of Science Degree in Biology

(Major Code: 04011) (SIMS Code: 771401)

In addition to meeting the requirements for classified graduate standing and the basic requirements for the master's degree as described in Part Four of this bulletin, the student must complete a graduate program of 30 units of upper division and graduate courses selected, with the approval of the graduate adviser, from the biological sciences as listed below, or from closely related fields. At least 15 of the units selected must be in 600- and 700-numbered courses, including Biology 799A, Thesis. A maximum of six units of the required 30 units may be selected from acceptable courses offered in the College of Education. A final oral examination in the field of the thesis and its implication in the broad fields of biology is also required.

Master's Degree Research Programs

Ecology (Major Code: 04201) (SIMS Code: M.A. 771416; M.S. 771417): The overall program emphasizes quantitative approaches to ecological research and the framing of problems within the general context of ecological theory. Faculty and student research currently falls into the areas of marine ecology, plant community ecology and primary productivity, physiological plant ecology, animal population ecology and energetics, ecological genetics, ecosystems management, and systems ecology. Program adviser, Long.

Evolutionary Biology (Major Code: 04071) (SIMS Code: M.A. 771488; M.S. 771488): This research program is broadly concerned with the biology and evolution of whole organisms. The student has a wide variety of research areas from which to choose, including morphology, systematics, paleontology, natural history, behavior, comparative physiology, developmental biology, population genetics, coevolution, and evolutionary theory. Many groups of organisms are studied, including marine and terrestrial invertebrates, vertebrates, and plants. Program adviser, Burns.

In addition to the emphases described above, a number of faculty have active research programs in marine biology and accept graduate students in this area.

Microbiology (Major Code: 04111) (SIMS Code: M.S. 771451): A separate graduate degree is offered in microbiology. Program adviser, Segall.

Molecular Biology (Major Code: 04161) (SIMS Code: M.A. 771459; M.S. 771458): The program area is concerned with biology at the molecular level, with particular emphases on the correlation of structure and function of macromolecules, catalysis and control, molecular genetics, regulation of gene expression, and the molecular basis of cellular architecture, cell movement, bioenergetics and membrane function (administered through Molecular Biology Institute). Program adviser, Kelley.

Physiology (Major Code: 04101) (SIMS Code: M.A. 771466; M.S. 771465): Research opportunities are offered by faculty in the cell and molecular biology, ecology, and evolutionary biology program areas. Subareas of interest include cardiovascular, cellular, molecular, physiological plant ecology, and comparative physiology. Requirements for this program vary depending on the program area of the faculty adviser and prospective applicants are encouraged to contact potential faculty advisers or the program adviser before applying. Program adviser, Harris.

Microbiology

Advancement to Candidacy

All students must satisfy the general requirements for advancement to candidacy, as stated in Part Four of this bulletin. Satisfactory progress on the thesis research will be prerequisite to obtaining departmental approval for advancement.

Specific Requirements for the Master of Science Degree in Microbiology

(Major Code: 04111) (SIMS Code: 771451)

In addition to meeting the requirements for classified graduate standing and the basic requirements for the master's degree as described in Part Four of this bulletin, the student must complete a graduate program of 30 units of upper division and graduate courses selected, with the approval of the graduate adviser, from the biological sciences and closely related fields. All students entering the Master of Science program in microbiology will be required to take an advanced course in the molecular biology of microbes.

Not less than 18 units must be selected from courses in the area of microbiology. Among the 600- and 700-numbered courses selected, the student's program must include Biology 799A, Thesis. A maximum of six units of the required 30 units may be selected from acceptable courses offered in other related areas, including the College of Education and the School of Public Health.

A final oral examination on the field of the thesis and its implication in the broad fields of microbiology is required.

Section II. Doctoral Programs

Biology (Cell and Molecular)

(Major Code: 04011) (SIMS Code: 771402)

<http://www.bio.sdsu.edu/cmobi/propsinfo.html>

The cooperating faculties of the Departments of Biology at the University of California, San Diego and at San Diego State University offer a joint doctoral program in biology (cell and molecular). The research interests of the participating faculty members cover a wide range of biological problems.

At SDSU, the major areas of research at the graduate level and the participating faculty members include:

Biological structures: Huxford, Love, Sohl.

Cancer biology: House.

Cardiovascular molecular biology: Cripps, Glembotski, Sussman.

Cell and molecular immunology: Luallen, McGuire, Roach, Tsoukas, van der Geer.

Cell and molecular oncology: House.

Gene expression: Cripps, Harris, Luallen, Stumph, Zeller.

DNA recombination and chromosome structure: Segall.

Microbial molecular ecology: Dinsdale, Edwards, Forsberg, Roach, Rohwer.

Molecular biology of viruses and bacteriophage: Feuer, Kalyuzhnaya, Perrault, Roach, Rohwer, Shikuma, Swairjo, Wolkowicz.

Molecular evolution: Kelley, Waters.

Molecular microbiology: Lipson, Luallen, Maloy.

Neurobiology: Zayas, Zeller.

Stem cell biology: Sussman, Zayas.

Substructure and function in motile cells: Bernstein, Bizzoco, Cripps.

Program

Undergraduate Preparation for Admission. Applicants for admission to the doctoral program offered jointly by UCSD and SDSU must present evidence of adequate preparation and capacity for advanced work in biology. There are no inflexible requirements for entrance to graduate study in this program, but a strong background in biology, mathematics, chemistry, and physics is recommended. The applicant must have a bachelor's degree or the equivalent from an accredited institution of higher learning with training comparable to that provided by the University of California's and San Diego State University's undergraduate programs. Admission to the program requires acceptance by each institution on recommendation of the participating departments at UCSD and SDSU. It is understood that acceptance of a student into the joint program by each of the departments will be conditioned by their respective standards for graduate admissions and also by available facilities.

Residency Requirements. After formal admission to the joint doctoral program, the student must spend at least one academic year in full-time residence at each of the two campuses. The definition of residence must be in accord with the regulations of the University of California, San Diego, and San Diego State University.

Course Requirements. There is no specific number of courses required for the doctoral program in biology, except a one-year graduate course including genetics, cellular and molecular biology. Prior to taking the qualifying examination, every student is expected to have a firm understanding of modern biological principles. Usually students will be expected to complete a set of at least three laboratory rotations at SDSU. Coursework may be selected from offerings at either UCSD or SDSU.

Qualifying Examinations

Qualifying Committee. The qualifying committee consists of five faculty members, at least two from UCSD (one of whom must be a full-time faculty member in the Biology Department). The dissertation adviser may be a member of the qualifying committee. The members of the qualifying committee will be selected by the student in consultation with the dissertation adviser. In order to provide continuity between examinations, at least one member of the qualifying committee shall be a member of the SDSU Executive Committee. Final appointment of qualifying committee members will be made jointly by the Graduate Deans of SDSU and UCSD.

The qualifying committee will be responsible for carrying out the qualifying examination, and the chair of this committee will report the outcome of the examination and any related academic recommendations to the Executive Committee. The chair will also provide a written evaluation of the student's performance. The chair of the qualifying committee is responsible for notifying the members of the time and place of the examination, and the student is responsible for obtaining all required documents necessary for the examination four weeks before the scheduled examination time.

Qualifying Examination. The examination consists of two parts, which may be completed at separate times.

First Part: Oral presentation of dissertation research results and proposed dissertation plan (duration is 40-50 minutes, similar to a formal seminar presentation, slides, etc.). The student should come prepared to defend the overall experimental design, including possible outcomes and interpretations, and be thoroughly familiar with the literature in his or her chosen field. A major portion of this examination will be devoted to background information so that a student can demonstrate the context in which the proposed research project lies. A succinctly written version of the proposed dissertation plan (maximum 14 double spaced pages) should be provided to committee members

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at least two weeks before the presentation. Prior written approval by all SDSU Qualifying Committee members stating that the written dissertation proposal is sufficiently developed must be obtained before the oral presentation takes place.

Second Part: In consultation with the Executive Committee or dissertation adviser, the student is required to write and ideally submit a pre-doctoral fellowship application. Examples of the type of fellowship applications a student is expected to write include the National Science Foundation (NSF) Graduate Fellowship Program or the National Institutes of Health (NIH) Predoctoral Individual National Research Service Award. A major goal of this portion of the examination is to help the student become knowledgeable of the literature in their chosen field, understand the existing knowledge gaps, and identify a compelling research question and hypothesis. Students are provided guidance on how to write fellowship applications in the required graduate courses at SDSU and will have the opportunity to fulfill this requirement in the first two years in the program.

The qualifying committee may specify a course of study to strengthen any weaknesses identified during the qualifying examination. Upon successful completion of the qualifying examination the student must make application to the office of Graduate Studies at UCSD for advancement to candidacy. Upon payment of the candidacy fee to UCSD, and after approval by the graduate deans on both campuses, the office of Graduate Studies at UCSD will notify the student of advancement to candidacy.

Joint Dissertation Committee. After a student is admitted to candidacy, a dissertation committee consisting of at least five faculty members is nominated by the student in consultation with dissertation adviser and appointed jointly by the Graduate Deans at SDSU and UCSD. The student's dissertation research adviser will be the chair of this committee. At least one member of this committee must be from SDSU and one member must be a full-time UCSD biology faculty member.

Dissertation. Following successful completion of the qualifying examination, the major remaining requirements for the Ph.D. degree will be satisfactory completion of a narrative evaluation at least once per year during a meeting with the adviser and other faculty committee members and a dissertation consisting of original and significant research carried out under the guidance of a faculty member. Requirements currently in force at UCSD and SDSU must be met for completing and filing the dissertation.

Award of the Degree. The Doctor of Philosophy degree in biology will be awarded jointly by the Regents of the University of California and the Trustees of The California State University in the names of both institutions.

Financial Support. The Department of Biology at SDSU endeavors to provide adequate support for all students so that full time can be devoted to research, training, and study. During 2017-18, support package included tuition, a stipend (approximately \$27,192-\$28,372), health coverage, and funds for research supplies. All students are required to obtain teaching experience, which is normally accomplished by appointment as a graduate teaching associate.

Faculty

The following faculty members of the cooperating institutions participate in the joint doctoral program being available for direction of research and as members of joint doctoral committees.

San Diego State University:

Graduate Adviser: R. Zayas.

Faculty: Bernstein, Bizzoco, Cripps, Dinsdale, Edwards, Feuer, Forsberg (Chemistry and Biochemistry), Glembotski, Harris, House, Huxford (Chemistry and Biochemistry), Kalyuzhnaya, Kelley, Lipson, Love (Chemistry and Biochemistry), Luallen, Maloy, McGuire, Perrault, Roach, Rohwer, Segall, Shikuma, Sohl (Chemistry and Biochemistry), Stumph (Chemistry and Biochemistry), Sussman, Swairjo, (Chemistry and Biochemistry), Tsoukas, van der Geer (Chemistry and Biochemistry), Waters, Wolkowicz, Zayas, Zeller.

University of California, San Diego:

Graduate Adviser: J. Pogliano.

Faculty: Participating UCSD biology faculty

Ecology

(Major Code: 04201) (SIMS Code: 771418)

http://www.bio.sdsu.edu/ecology/prog_phd.php

The cooperating faculties of the Department of Biology, San Diego State University and the Graduate Group in Ecology, University of California, Davis offer a joint program in ecology leading to the Ph.D. The research interests of the participating faculty members cover a wide range of problems and represent the interdisciplinary nature of modern biology.

At SDSU, the research projects are underway concerning:

Coastal and marine ecology: Study of estuarine wetland functions, food webs, effects of natural and human disturbance, and interaction of native and exotic species. Population dynamics of invertebrates and fishes. Community ecology of coral reefs, kelp forests, eelgrass beds, rocky shores, and sandy beaches.

Ecosystem ecology and global change: Effects of global change (elevated CO₂ and climate change) on the structure and functioning of terrestrial and marine ecosystems, including local chaparral, deserts, the Alaskan Arctic and international locations in Baja California including deserts, mangroves, lagoon ecosystems, tropical peatlands of Indonesia, the Mediterranean Basin, and the South Pacific (coastal ecosystems).

Conservation ecology: Application of ecological principles to conserve species, manage populations and genetic diversity, manage fire, and restore disturbed habitats.

A complete list of SDSU faculty and their research interests can be obtained from the graduate adviser of the program.

Program

Undergraduate Preparation for Admission. Applicants for admission to the doctoral program must present evidence of adequate preparation and capacity for advanced work in ecology. Preparation should include a strong background in biology, physics, chemistry, and mathematics. Applicants must have a bachelor's degree from an accredited college or university. Acceptance of a student into the joint program by each institution depends on meeting the standards of admission of the respective institutions and by available facilities for research and instruction.

Residency Requirements. After formal admission to the joint doctoral program, the student must spend at least one academic year in full-time residence on each of the two campuses. The definition of residence must be in accord with the regulations of the University of California, Davis, and San Diego State University.

Advising Committee. The doctoral graduate advisers of the two institutions will establish an advising committee for the student. This committee will consist of three faculty members chosen jointly from the two cooperating institutions. In consultation with the student, the committee will develop the student's course of study and will establish the student's joint qualifying examination topics. At least one member of the advising committee must be from SDSU and one from UCD.

Course Requirements. Upon arrival at SDSU the advising committee works with the student to develop a course of study, which involves coursework at both SDSU and UCD and core requirements at SDSU (Biology 645 and 745), UCD (three quarters of Ecology 296, two to three Ecology 290) seminars. Prior to taking the qualifying examination, students complete the course of study, including the three quarters at UCD, and develop a firm understanding of ecological principles and research methods. The student is expected to complete the qualifying examination and advance to candidacy within six semesters.

Qualifying Examinations

Qualifying Committee. A five-member committee, composed of appropriate numbers of faculty members from each of the cooperating institutions, will be recommended by the advising committee for each student and approved by the Graduate Deans from each institution. The student's dissertation adviser cannot be a member of the qualifying committee.

The qualifying committee will conduct an oral comprehensive qualifying examination, which will evaluate the student's understanding of modern ecological principles. The examination will focus on principles of ecology, research methods, and three areas related to the major research interest of the student. The purpose of this examination is to permit the student to demonstrate competence not only in the major research field but also in related areas of ecology.

Upon successful completion of the qualifying examination, the student must make application to the Graduate Division at UCD for advancement to candidacy. Upon payment of the candidacy fee to UCD, and after approval by the graduate deans on both campuses, the Graduate Division at UCD will notify the student of advancement to candidacy.

Joint Dissertation Committee. After a student is admitted to candidacy, a dissertation committee consisting of at least three faculty members is nominated by the graduate advisers and appointed jointly by the graduate deans at SDSU and UCD. The student's dissertation research adviser will be the chair of this committee. At least one member of this committee must be from SDSU and one member from UCD.

Dissertation. Following successful completion of the qualifying examination, the major remaining requirements for the Ph.D. degree will be publication of papers as agreed by the dissertation committee, satisfactory completion of a dissertation consisting of original and significant research carried out under the guidance of a faculty member, and presentation of an exit seminar at SDSU. Requirements currently in force at UCD and SDSU must be met for completing and filing the dissertation.

Award of the Degree. The Doctor of Philosophy degree in ecology will be awarded jointly by the Trustees of The California State University and the Regents of the University of California in the names of both institutions.

Financial Support. The Department of Biology at SDSU endeavors to provide adequate support for all students in good standing so that full time can be devoted to research, training, and study. Support includes tuition, a stipend, and funds for research supplies. All students are required to obtain teaching experience, which is normally accomplished by appointment as a graduate teaching associate.

Faculty

Graduate Advisers:

San Diego State University: W. Oechel
University of California, Davis: E. Grosholz

SDSU Faculty: Anderson, Bohonak, Clark, Dinsdale, Edwards, Hentschel, Hovel, Lai, Lewison, Lipson, Long, Oechel, Reeder, Xu, Zona

Evolutionary Biology

(Major Code: 04016) (SIMS Code: 771485)

<http://www.bio.sdsu.edu/eb/jdeb.html>

The cooperating faculties of the Department of Biology, San Diego State University (SDSU) and the Graduate program in Evolution, Ecology, and Organismal Biology (EEOG) at the University of California, Riverside (UCR) offer a joint program in evolutionary biology leading to the Ph.D. The research interests of the participating faculty cover a wide range of topics in evolutionary biology.

Program

Undergraduate Preparation for Admission. Applicants for admission to the doctoral program must present evidence of adequate preparation and capacity for advanced work in evolutionary biology. Preparation should include a strong background in biology. Applicants must have a bachelor's degree from an accredited college or university. Acceptance of a student into the joint program by each institution depends on meeting the standards of admission of the respective institutions and by available facilities for research and instruction.

Residency Requirements. After formal admission to the joint doctoral program, the student must spend at least one academic year in full time residence on each of the two campuses. The definition of residence must be in accord with the regulations of the University of California, Riverside, and San Diego State University.

Advising Committee. At the start of the student's first year in the program, the student will form a Guidance Committee. This committee will consist of four faculty members, two chosen from each institution. From SDSU, the committee must include the student's prospective dissertation adviser and an additional, programmatically appropriate, member. From UCR, the committee members will be drawn from faculty within the EEOB graduate program. In consultation with the student, the Guidance Committee plans the student's program through Advancement to Candidacy.

Course Requirements. The Guidance Committee works with the student to develop an individualized course of study and identify potential deficiencies. Students in the joint doctoral program will have similar requirements as students in UCR's EEOB graduate program. Specifically, the joint doctoral students will take the Theory of Evolution (UCR Biol 216) and at least two disciplinary courses (see below; the two required disciplinary courses must cover different disciplines; at least one disciplinary course must be taken at UCR). In addition, the students will enroll in a current research topics seminar course during each UCR quarter or SDSU semester of residence. The majority of required course work should be completed prior to the Written Qualifying Examination, which is taken at the end of the second year. All required disciplinary courses (see below) must be completed before taking the Oral Qualifying Examination. An example of the required coursework and anticipated schedule for completion is presented below:

Year One at SDSU

Each semester:	Units
BIOL 795 Seminar in Ecology and Evolutionary Biology	3 (Cr/NC)

At least one of the following courses:

BIOL 624 Population Genetics	3
BIOL 740 Phylogenetic Systematics	3

Year Two at UCR

UCR BIOL 216 The Theory of Evolution	
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Each quarter of residence:

UCR BIOL 252 General Colloquium in Biology (or another disciplinary colloquium)	
UCR BIOL 265 Advances in Population and Evolutionary Biology	

At least one of the following courses:

UCR BIOL 211 Ecology: Genes to Ecosystems	
UCR BIOL 212 Ecological Systems in Space and Time	
UCR BIOL 213 Behavioral Ecology	
UCR BIOL 214 Evolutionary Genetics	
UCR BIOL 217 Population and Community Ecology	
UCR BIOL 219 Theory of Systematics	
UCR BIOL 220 Evolutionary Physiology	

Qualifying Examinations

Qualifying Committee. By the end of the second year, students are expected to have taken a written qualifying examination. The written examination is evaluated by an ad hoc committee of faculty participating in the JDPEB program. The committee will have a minimum of four faculty, at least two from SDSU EB and two from UCR EEOB. Upon passing the written examination, the student (in consultation with their SDSU and UCR co-advisers) selects an Oral Examination Committee. This committee normally consists of five faculty members: a minimum of two SDSU EB faculty and a minimum of two UCR EEOB faculty, and a UCR outside committee member. The student writes a detailed research proposal and schedules an oral examination. During the examination, the candidate must defend the research proposal and may be questioned on other topics by the Oral Examination Committee.

Joint Dissertation Committee. After passing the Written and Oral Examinations, students file for Advancement to Candidacy with the Graduate Divisions at SDSU and UCR. On the petition, students state the dissertation topic and selects the members of the Dissertation Committee, to be approved by the Graduate Division. This committee will consist of at least four faculty members, including the major adviser. At least two members must be from

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at least two members must be from the evolutionary biology faculty of SDSU and the EEOB faculty of UCR (with approval from the Graduate Division at UCR).

Dissertation. Following successful completion of the qualifying examination, the final requirement of the Ph. D. degree will be satisfactory completion of a dissertation consisting of original and significant research carried out under the guidance of the joint dissertation committee. Requirements currently in force at SDSU and UCR must be met for completing and filing the dissertation.

Award of the Degree. The Doctor of Philosophy degree in Evolutionary Biology will be awarded jointly by the Regents of the University of California and the Trustees of the California State University in the names of both institutions.

Financial Support. The Department of Biology at SDSU endeavors to provide adequate support for all students so that full time can be devoted to research training and study. Support includes tuition, a stipend, and funds for research supplies. All students are required to obtain teaching experience, which is normally accomplished by appointment as graduate teaching associate.

Faculty

Graduate Advisers:

San Diego State University: E. Waters
University of California, Riverside: T. Higham
SDSU Faculty: Bohonak, Burns, Clark, Flores Renteria, Hedin, Kelley, Reeder, Renner, Rohwer, Waters, Zayas, Zeller.

Courses Acceptable for Master's and Doctoral Degree Programs in Biology (BIOL)

Refer to Courses and Curricula and Regulations of the Division of Graduate Affairs sections of this bulletin for explanation of the course numbering system, unit or credit hour, prerequisites, and related information.

UPPER DIVISION COURSES

Writing Requirement: Completion of the Graduation Writing Assessment Requirement or the eligibility to enroll in an upper division writing course is a prerequisite for all upper division biology courses numbered 450 and above.

BIOL 509. Evolutionary Biology (3)

Two lectures and two hours of activity.
Prerequisite: Biology 352.

Evolutionary biology including genetics of populations, speciation, systematic biology, adaptation, role of development in evolution, evolution of behavior, and comparative biology. Evolutionary biology as the central organizing principle of biology.

BIOL 510. Molecular Evolution (3)

Prerequisites: Biology 352 and 366 or graduate standing.

Molecular evolution including concepts of homology and convergence, the nearly neutral theory of evolution, evolution of new protein function, detecting selection, multi-gene family evolution and evolutionary genomics.

BIOL 512. Evolution and Ecology of Marine Mammals (3)

Two lectures and three hours of laboratory.
Prerequisites: Biology 352 and 354.

Biology of marine mammals including pinniped, cetacean and sirenian evolution, diet and foraging strategies, social organization, reproductive strategies, echolocation, diving physiology, and conservation.

BIOL 514. Biology of the Algae (4)

Three lectures and three hours of laboratory.
Prerequisites: Biology 203, 203L, 204, 204L and six units of upper division coursework in the major.

Evolution, life histories, morphology, physiology, and ecology of micro and macro algae, with attention to both marine and freshwater taxa, and of sea-grasses.

BIOL 515. Marine Invertebrate Biology (4)

Two lectures and six hours of laboratory.

Prerequisites: Biology 203, 203L, 204, 204L. Strongly recommended: Completion of three to six upper division units in the major.

Structure and function, ecology, behavior, physiology and phylogenetic relationships of marine invertebrate animals.

BIOL 516A. Marine Larval Ecology Research Part 1 (4)

Three lectures and three hours of laboratory.

Prerequisites: Biology 203, 203L, 204, 204L, 215.

Biology of marine invertebrate larvae. Biodiversity, evolution of complex life cycles, larval culture techniques, physiological and ecological consequences of environmental variability during larval development. Designing and peer reviewing original research proposals related to larval ecology.

BIOL 516B. Marine Larval Ecology Research Part 2 (4)

Three lectures and three hours of laboratory.

Prerequisites: Biology 516A and consent of instructor.

Research experience investigating marine invertebrate larval ecology.

BIOL 517. Marine Ecology (4)

Two lectures and six hours of laboratory.

Prerequisite: Biology 354.

Ecological concepts as applied to pelagic and benthic marine organisms and their environment. Field and laboratory experience in oceanographic techniques, particularly the coastal environment.

BIOL 518. Biology of Fishes (4)

Three lectures and three hours of laboratory.

Prerequisite: Biology 354.

Ecology, anatomy, physiology, evolution, taxonomy, environmental constraints, habitats, feeding, behavior, growth, reproduction, biotic interactions, population dynamics, and assemblage structure. Fisheries biology concepts to include stock-recruitment models, density dependence and population regulation, management of fisheries, and conservation. Not open to students with credit in Biology 520 and 541.

BIOL 523. Herpetology (4)

Two lectures and six hours of laboratory.

Prerequisites: Biology 203, 203L, 204, 204L. Recommended: Biology 352.

Evolution, systematics, distribution, and ecology of amphibians and reptiles of the world.

BIOL 524. Ornithology (4)

Two lectures, six hours of laboratory or field excursions, and a field project.

Prerequisites: Biology 203, 203L, 204, 204L. Strongly recommended: Completion of three to six upper division units in the major.

Study and identification of birds, especially those of the Pacific Coast and the San Diego region.

BIOL 525. Mammalogy (4)

Two lectures and six hours of laboratory.

Prerequisites: Biology 203, 203L, 204, 204L. Strongly recommended: Completion of three to six upper division units in the major.

Evolution, systematics, distribution and ecology of mammals of the world.

BIOL 526. Terrestrial Arthropod Biology (4)

Two lectures and six hours of laboratory.

Prerequisites: Biology 203, 203L, 204, 204L. Strongly recommended: Biology 352 and completion of three to six upper division units in the major.

Structure, function, behavior, ecology, evolution, and relationships of major groups of terrestrial arthropods, including insects, arachnids, and myriapods. Identification and natural history of southern California diversity.

BIOL 527. Animal Behavior (3)

Prerequisites: Biology 203, 203L, 204, 204L, 215; Psychology 211 and 260 for psychology majors.

Biological bases of animal behavior with emphasis on ethological approach, including evolution and adaptive significance of behavior.

BIOL 527L. Animal Behavior Laboratory (1)

Three hours of laboratory.

Prerequisite: Credit or concurrent registration in Biology 527.

Animal behavior with emphasis on ethological approach to include evolution and adaptive significance of behavior, data collection and analysis, scientific writing and results.

BIOL 528. Microbial Ecology (3)

Two lectures and three hours of laboratory.

Prerequisites: Biology 203, 203L, 204, 204L. Recommended: Biology 350 and 354.

Roles of microorganisms in soil, aquatic and marine ecosystems, microbial adaptations to the environment, and interactions within microbial communities and between microbes and multicellular organisms. Laboratory techniques to isolate and study microbes.

BIOL 530. Plant Systematics (4)

Two lectures and six hours of laboratory, field trips.

Prerequisites: Biology 203, 203L, 204, 204L. Strongly recommended: Completion of three to six upper division units in the major.

Plant description, identification, classification, and nomenclature with emphasis on evolutionary patterns, interdisciplinary data acquisition, and phylogenetic analysis.

BIOL 531. Taxonomy of California Plants (4)

Two lectures and six hours of laboratory.

Prerequisites: Biology 203, 203L, 204, 204L.

Fundamentals of plant taxonomy with emphasis on identification of plants native and naturalized to California. Plant collecting techniques. Field trips are required.

BIOL 535. Plant Ecology (4)

Three lectures and three hours of laboratory.

Prerequisites: Biology 203, 203L, 204, 204L. Strongly recommended: Biology 354.

Plant adaptation and response to living and non-living environment including aspects of plant evolution, demography, ecophysiology community and ecosystem dynamics and soil-plant relationships. Terrestrial systems emphasized.

BIOL 538. Environmental Policy and Regulations (3)

(Same course as Environmental Science 538)

Prerequisite: Biology 354.

History of biological conservation and environmental laws; regulations governing biological resources; role of biologists; environmental impact analysis, operation of regulatory and resource agencies; biologists as expert witnesses; wetland protection and mitigation, state heritage programs, role of nongovernmental agencies.

BIOL 540. Conservation Ecology (3)

Two lectures and three hours of laboratory.

Prerequisite: Biology 354.

Human impacts on ecosystems, the resultant endangerment and extinction of plant and animal species, and strategies for the protection and recovery of threatened forms.

BIOL 542. Ecological Signaling in the Environment (3)

Prerequisites: Biology 354 and Chemistry 201.

Ecological consequences of species interactions mediated by signals in terrestrial and aquatic ecosystems. Evaluating primary literature and conveying science to a broad audience.

BIOL 544. Terrestrial Ecosystems and Climate Change (3)

(Same course as Environmental Science 544)

Prerequisite: Biology 354.

Controls on fluxes and stocks of nutrients within terrestrial ecosystems, ecosystem responses, feedbacks to climate change. Climate systems, water transport, production and decomposition, nutrient cycling, stable isotopes, spatial and temporal integration.

BIOL 549. Microbial Genetics and Physiology (3)

Prerequisite: Biology 350 or 366.

Physiology of microbial growth, bacterial structure and function, genetics of bacteriophages and bacteria.

BIOL 554. Molecular Virology (3)

Prerequisites: Biology 366 and Chemistry 365.

Molecular aspects of structure, genetics, and replication of viruses, virus-host interactions, pathogenesis of virus infections, diagnostic virology, and antiviral vaccines and drugs; emphasis on human pathogens.

BIOL 556. Scanning Electron Microscopy Laboratory (2)

Six hours of laboratory.

Prerequisites: Biology 204, 204L, and Physics 180B.

Biological specimen preparation and operation of scanning electron microscope.

BIOL 557. Transmission Electron Microscopy Laboratory (3)

One lecture and six hours of laboratory.

Prerequisites: Biology 204, 204L, and Physics 180B.

Biological sample preparation and operation of transmission electron microscope.

BIOL 560. Animal Physiology (3)

Prerequisites: Biology 203, 203L, 204, 204L; Chemistry 365; Physics 180B, 182A, and 182B.

Physiology of vertebrate and invertebrate animals with emphasis on diversity of solutions to physiological problems and on functional integration of organ systems.

BIOL 562. Ecological Metagenomics (3)

Two lectures and three hours of laboratory.

Prerequisites: Credit or concurrent registration in Biology 354 and 366.

Next generation DNA sequencing technology with emphasis on ecological applications in microbial communities. Metagenomic analysis of taxonomic identification, physiological function, and the ecological role of the microbial community in the broader ecosystem.

BIOL 567. Advanced Biochemistry, Cellular, and Molecular Biology (4)

Prerequisites: Biology 366 and Chemistry 365.

Advanced concepts of cellular biology, molecular biology, and biochemistry.

BIOL 567L. Biochemistry, Cellular, and Molecular Biology Laboratory II (2)

Six hours of laboratory.

Prerequisites: Biology 366 and 366L. Recommended: Biology 350.

Intermediate laboratory approaches to biochemistry, cellular biology, and molecular biology at a level appropriate for both advanced undergraduate and graduate students.

BIOL 568. Bioinformatics (3)

(Same course as Bioinformatics and Medical Informatics 568)

Two lectures and three hours of laboratory.

Prerequisite: Biology 366.

Bioinformatics analysis methods and programming skills. Practical bioinformatic software for sequence analysis, bioinformatic algorithms and programming fundamentals.

BIOL 570. Neurobiology (3)

Prerequisite: Biology 366 or 590 or Psychology 360 for psychology majors.

Structure and function of the nervous system to include cellular and molecular mechanisms underlying neuronal excitability and synaptic function, nervous system development, cellular and systems analysis of sensory, motor and higher brain functions. Emphasis on experimental approaches.

BIOL 575. Molecular Basis of Heart Disease (3)

Prerequisite: Biology 366 or 590.

Current literature on the molecular basis of disordered physiology leading to heart disease.

Biology

BIOL 576. Developmental Biology (3)

Prerequisite: Biology 366. Strongly recommended: Biology 567.

Fundamental processes of development from fertilized egg to organism. Emphasis on cellular and molecular mechanisms common to development of metazoan organisms.

BIOL 584. Medical Microbiology (3)

Prerequisites: Biology 350 and 366.

Major bacterial and viral pathogens; molecular mechanisms of pathogenesis, microbial toxins and antimicrobial agents; immune response to microbial infections; biochemical and molecular diagnostics.

BIOL 585. Cellular and Molecular Immunology (3)

Prerequisite: Biology 366. Recommended: Credit or concurrent registration in Biology 567 and 567L.

Cellular and molecular aspects of the immune response. Genetics of immunoglobulins, major histocompatibility complex, lymphocyte development and their manifestations on immune responsiveness, lymphokines immunopathologies including AIDS, and contemporary immunological techniques. Not open to students with credit in Biology 485.

BIOL 589. Stem Cell and Regenerative Biology (3)

Prerequisites: Biology 366 and credit or concurrent registration in Biology 366L.

Stem cell basics, cloning, tissue engineering, research on animal models of regeneration, political and ethical issues surrounding stem cell debate.

BIOL 590. Physiology of Human Systems (4)

Three lectures and one hour of discussion.

Prerequisites: Biology 366, Chemistry 365, Physics 180B, 182B.

Human physiology presented at both cellular and organ system levels; neurophysiology, muscle physiology, cardiovascular physiology and respiration, kidney function, hormone function and reproduction. For students majoring in a natural science or pre-professional studies.

BIOL 596. Special Topics in Biology (1-4)

Prerequisite: Consent of instructor.

Advanced selected topics in modern biology. May be repeated with new content. See *Class Schedule* for specific content. Limit of nine units of any combination of 296, 496, 596 courses applicable to a bachelor's degree. Credit for 596 and 696 applicable to a master's degree with approval of the graduate adviser.

BIOL 597A. Univariate Statistical Methods in Biology (3)

Two lectures and three hours of laboratory.

Prerequisite: Biology 352 or 354 or 366.

Application of univariate statistical techniques in biological sciences.

GRADUATE COURSES

BIOL 600. Seminar (1-3)

Prerequisite: Consent of instructor.

An intensive study in advanced biology. May be repeated with new content. See *Class Schedule* for specific content. Maximum credit six units applicable to a master's degree.

BIOL 606. Biological Data (3)

Two lectures and three hours of laboratory.

Prerequisite: Biology 597A or equivalent graduate course in biostatistics.

Concepts and applications of advanced statistical techniques in the biological sciences to include multivariate statistics, analysis of discrete data, spatial statistics, time series analysis, and Monte Carlo methods (e.g. bootstrapping and randomization tests).

BIOL 624. Population Genetics (3)

Two lectures and two hours of activity.

Prerequisite: Biology 352.

Theoretical and applied population genetics to include genetic diversity in natural populations, random drift, mutation, gene flow, natural selection, nucleotide variation, and quantitative genetics. Emphasis on data analysis and interpretation.

BIOL 645. Theory and Principles of Ecology I (3)

Prerequisites: Admission to graduate program in biology and approval of ecology graduate adviser.

Major theoretical concepts in ecology, topics of current interest, and historical context of central ideas in ecology, with emphasis on use of primary literature.

BIOL 677. Seminar in Marine Conservation Biology (3)

Prerequisite: Graduate standing.

Threats to marine biodiversity and marine populations.

BIOL 688. Seminar in Terrestrial Ecology (2)

Prerequisite: Biology 354.

Ecological concepts as applied to the terrestrial environment. May be repeated with new content. See *Class Schedule* for specific content. Maximum credit four units applicable to a master's degree.

BIOL 696. Advanced Topics in Biology (1-3)

Prerequisite: Consent of instructor.

Intensive study in specific areas of biology. May be repeated with new content. See *Class Schedule* for specific content. Credit for 596 and 696 applicable to a master's degree with approval of the graduate adviser.

BIOL 725. Clinical Anatomy I (4)

(Same course as Doctor of Physical Therapy 725)

Three lectures and three hours of laboratory.

Prerequisite: Admission to the DPT program.

Applied anatomy of upper and lower extremities of the human body; joint anatomy and mechanics, anatomical structures to produce articular movement to include muscles, arterial, peripheral nervous systems, and articular and extremity movement patterns.

BIOL 726. Clinical Anatomy II (4)

(Same course as Doctor of Physical Therapy 726)

Three lectures and three hours of laboratory.

Prerequisite: Biology 725 [or Doctor of Physical Therapy 725].

Axial portion of the human body; biomechanics of the spinal column to include head and neck, thorax, related viscera, and abdomino-pelvic region.

BIOL 740. Phylogenetic Systematics (3)

Two lectures and three hours of laboratory.

Prerequisite: Biology 354.

Theory and methodology of phylogenetic systematics. Includes use of computer algorithms, survey of literature and preparation of a project in phylogenetic systematics. Not open to students with credit in Biology 740 (Seminar in Phylogenetic Systematics).

BIOL 745. Theory and Principles of Ecology II (3)

Prerequisites: Admission to graduate program in biology and Biology 645.

Community and ecosystem ecology to include foodwebs, landscapes, ecosystems, biogeochemistry. Conservation and applied ecology to include climate change, anthropogenic impacts on natural systems.

BIOL 770. Seminar in Systematics and Evolution (2-3)

Prerequisite: Consent of instructor.

Selected topics in systematics and evolution. May be repeated with new content. See *Class Schedule* for specific content. Maximum credit four units applicable to a master's degree.

BIOL 795. Seminar in Ecology and Evolutionary**Biology (1) Cr/NC**

Prerequisite: Graduate standing.

Recent research advances in ecology and evolutionary biology. May be repeated with new content. Maximum credit six units applicable to a graduate degree.

BIOL 797. Research (1-3) Cr/NC/RP

Research in one of the fields of biology. Maximum credit six units of 797 and 798 applicable to a master's degree.

BIOL 798. Special Study (1-3) Cr/NC/RP

Prerequisite: Consent of staff; to be arranged with department chair and instructor.

Individual study. Maximum credit six units of 797 and 798 applicable to a master's degree.

BIOL 799A. Thesis or Project (3) Cr/NC/RP

Prerequisites: An officially appointed thesis committee and advancement to candidacy.

Preparation of a project or thesis for the master's degree.

BIOL 799B. Thesis or Project Extension (0) Cr/NC

Prerequisite: Prior registration in Thesis or Project 799A with an assigned grade symbol of RP.

Registration required in any semester or term following assignment of RP in Course 799A in which the student expects to use the facilities and resources of the university; also student must be registered in the course when the completed thesis or project is granted final approval.

DOCTORAL COURSES**BIOL 897. Doctoral Research (1-15) Cr/NC/RP**

Prerequisite: Admission to the doctoral program.

Independent investigation in the general field of the dissertation.

BIOL 899. Doctoral Dissertation (1-15) Cr/NC/RP

Prerequisites: An officially constituted dissertation committee and advancement to candidacy.

Preparation of the dissertation for the doctoral degree. Enrollment is required during the term in which the student plans to graduate.
