PH.D. PROGRAMS IN BIOSTATISTICS

The Graduate Program in Biostatistics offers the Ph. D. degree under Plan B. According to this plan the Dissertation Committee consists of three faculty members who guide the student in his or her research and pass upon the merits of the dissertation. The complete degree requirements are listed below:

1. Undergraduate Preparation

An undergraduate major in Mathematics, Statistics, Biostatistics or Biological Sciences with a quantitative orientation is typical for Biostatistics graduate students but is not required. However, because of the mathematical nature of some of the graduate coursework, students should be able to demonstrate good mathematical ability and should have taken coursework in mathematics. Students preferably would have had some exposure to courses in the life sciences (biological, environmental, medical, and agricultural sciences). Students without sufficient coursework in mathematics or life sciences may be admitted on the condition that deficiencies will be corrected during the first year of study. The minimal background for entrance into the program is: a bachelor's degree with 3.0 overall grade-point average; one year of calculus; a course in linear algebra or one year of biological coursework; facility with a programming language; and upper-division work in at least one of the following: Mathematics, Statistics, Biology or Biostatistics. All students whose native language is not English should demonstrate proficiency in English language by taking tests such as Test of English as a Foreign Language (TOEFL) and satisfying the minimum score requirements as set out by the Office of Graduate Studies. The Graduate Record Examination (GRE) General Test is required for all applicants. GRE scores should be greater than 1000 (combined verbal and quantitative) and dated not more than 3 years prior to the quarter of admission.

2. Foreign Language Requirement

None

3. Prerequisites

The Basic Exam covers methodology prerequisites covered in the courses STA 131ABC, STA 106, 108 and an additional elective. The material of these courses (excluding the elective) is prerequisite for the core courses of the Biostatistics program. Therefore, students who do not have such a background must take these courses. Additionally, students who have not taken real analysis or advanced calculus should take Mathematics
127AB; and those with little or no previous exposure to linear algebra should take Mathematics 167. Furthermore, basic biological preparation, if missing, should be attained before the Life Sciences elective courses can be taken, as most of these courses have biological prerequisites. Careful attention needs to be paid to these prerequisites of the Life Sciences elective courses and students should work closely with the Biostatistics graduate adviser to create their study plan. Those students who are sufficiently well prepared for their studies in Biostatistics may petition to the Biostatistics Educational Policy Committee to have their Basic Exam requirement waived.

4. Field of Emphasis:

Students are exposed to the faculty’s research in topics courses and seminars. The faculty’s specific fields of emphasis vary according to their changing research interests and are offered in topics courses such as Biostatistics (BST) 252 and in individual study courses BST 299. Typically, the instructor of BST 252 changes from offering to offering. Students are also exposed to ongoing research in Biostatistics through the Biostatistics seminar, BST 290.

5. Required Courses:

There are no unit requirements other than the Office of Graduate Studies policy that every full time graduate student must register for a minimum of 12 units per quarter. These 12 units can be made up of a combination of required coursework as described below, additional elective coursework if any, and 299’s. Besides the coursework required to pass the prequalifying Basic Exam, the courses below are required.

(a) Biostatistics Core Courses

We note that all of these courses carry a data analysis component and include a computing laboratory. Students will be exposed to projects involving advanced data analyses to address complex life sciences problems.

BST 222: Survival Analysis (4)
BST 223: Generalized Linear Models (4)
BST 224: Analysis of Longitudinal Data (4)

(b) Methodology Core Courses

STA 231ABC: Mathematical Statistics I-III (4,4,4)
STA 232ABC: Linear Statistical Models (4,4,4)
STA 141: Statistical Computing (4)

(c) Life Sciences Core Requirements

Eight units of upper-division or graduate level course work in Biology and Life Sciences are required. Approved Life Sciences courses for this requirement are listed below. The
intention is to provide a base of knowledge in molecular, cellular, organismal, and population biology, epidemiology or environmental sciences. In general, courses that use those on the attached list as prerequisites may serve as substitutions for students entering with more background in biology. To ensure that each student graduating with a degree in Biostatistics will obtain an appropriate depth of training in the life sciences, it is recommended that a "core" topic be chosen from the list and a second course be an advanced treatment of materials in the chosen core topic. At least one course must be taken from the biological/environmental sciences. The combination of courses chosen and any substitutions desired are subject to approval by the Biostatistics Graduate Adviser. Most of the courses listed have lower-division prerequisites, and students are expected to be prepared to meet these prerequisites, which may require additional coursework. Careful planning of the Life Sciences course requirements is recommended to ensure timely completion of coursework.

**Life Sciences Courses:**

*Agricultural Sciences*

- **ANG 107** Genetics and Animal Breeding (4)
- **ASE 105** Concepts in Pest Management (3)
- **ASE 107** Small Fruit Production (2)
- **ASE 110ABC** Crop Production and Management (3,3,4)
- **ASE 112** Forage Crop Ecology (3)
- **ASE 150** Cropping Systems of the World (4)
- **AVS 100** Avian Biology (3)
- **ENH 102** Physiological Principles in Environmental Horticulture (4)

*Biological and Environmental Sciences*

- **BIS 101** Genes and Gene Expression (4)
- **BIS 102** Structure and Function of Biomolecules (3)
- **BIS 103** Bioenergetics and Metabolism (3)
- **ECS 124** Theory and Practice of Bioinformatics (4)
- **ENT 100** General Entomology (3)
- **ENT 102** Insect Physiology (4)
- **EST 100** General Ecology (4)
- **EST 110** Principles of Environmental Science (4)
- **EST 121** Population Ecology (4)
- **EVE 100** Introduction to Evolution (4)
- **EVE 101** Introduction to Ecology (4)
- **EVE 102** Population and Quantitative Genetics (4)
- **EVE 103** Phylogeny and Macroevolution (3)
- **EVE 117** Plant Ecology (4)
- **MCB 150** Embryology (4)
- **FST 104** Food Microbiology (3)
- **NPB 100** Neurobiology (4)
- **NPB 101** Systemic Physiology (5)
- **NPB 102** Animal Behavior (3)
- **NPB 112** Neuroscience (3)
- **NPB 113** Cardiovascular, Respiratory, and Renal Physiology (4)
NPB 114  Gastrointestinal Physiology (3)
NPB 117  Avian Physiology (3)
NPB 121  Physiology of Reproduction (3)
NPB 125  Comparative Physiology: Neurointegrative Mechanisms (3)
NPB 126  Comparative Physiology: Sensory Systems (3)
NPB 127  Comparative Physiology: Circulation (3)
NPB 128  Comparative Physiology: Endocrinology (3)
NPB 129  Comparative Physiology: Respiration (3)
NPB 130  Physiology of the Endocrine Glands (4)
NPB 140  Principles of Environmental Physiology (3)
NUT 110  Principles of Nutrition (5)
NUT 116AB  Clinical Nutrition (3,3)
NUT 118  Community Nutrition (4)
PLB 105  Developmental Plant Anatomy (5)
PLB 111  Plant Physiology (3)
PLB 112  Plant Growth and Development (3)
PLB 116  Plant Morphology and Evolution (5)
PLB 143  Evolution of Crop Plants (4)
PLB 152  Plant Genetics (4)
PLB 154  Plant Breeding (4)
PLB 175  Applied Plant Biology (4)

Epidemiology and Veterinary Medicine

EPI 222  Epidemiological Modeling (3)
EPI 223  Spatial Epidemiology (3)
EPI 206  Epidemiologic Study Design (3)
EPI 208  Analysis and Interpretation of Epidemiologic Data (3)
EPI 220  Problems in Epidemiologic Study Designs (4)
EPI 207  Advanced Study Design (3)
EPI 210AB  Analytic Epidemiology (3,3)
EPI 270  Research Methods in Occupational Epidemiology (3)
EST 126  Environmental and Occupational Epidemiology (4)
VME 217  Evaluation and Diagnostic Tests (3)

(d) Required Electives

Three courses selected from the following list:

Biostatistical Electives:

BST 225  Clinical Trials (4)
BST 226  Statistical Methods for Bioinformatics (4)
BST 252  Advanced Topics in Biostatistics (4)

Methodological Electives:

STA 250  Advanced Data Analysis (4)
STA 251  Advanced Statistical Theory (4)
STA 237AB    Time Series Analysis (4,4)
STA 235AB    Probability Theory (3,3)

If Time Series Analysis or Probability Theory is elected, STA 237AB or STA 235AB must both be taken and then count as one elective.

Credit can be accrued for taking topics courses STA 250, 251 or BST 252 repeatedly with permission of the master graduate adviser, as long as these courses are offered under different topics.

(e) Seminars and Professional Courses:

BST 290:         Graduate Group in Biostatistics Seminar
                   (1 unit, every quarter during residence, for five quarters)
STA 390:         Methods of Teaching Statistics (2 units, required once)
STA 401:         Methods in Statistical Consulting (3 units, required twice).

(f) Internship:

Students are strongly encouraged to do a Summer Internship at an appropriate medical or biological facility to broaden their professional experience.

6. Biostatistical Practicum

Students will complete a practicum in the form of an interdisciplinary applied data analysis project. They will work in close collaboration with a UC Davis faculty researcher who conducts studies or experiments which generate data in the medical, biological, veterinary medical, epidemiological, agricultural or environmental sciences, and who will serve as a mentor. The practicum will involve the analysis of original data and the student will prepare or substantially contribute to a project report. The practicum may be conducted as part of employment as a Graduate Student Researcher or as part of the dissertation research.

A report based on an internship of a duration of at least six weeks at a facility, government health office, institute or company outside of UC Davis focusing on biological or medical research can also be used to satisfy this requirement. In this case the mentor will reside at the institution where the internship is carried out.

The practicum (including the internship option) will be conducted under the additional supervision of a Biostatistics faculty member. The student chooses the mentor and the supervising Biostatistics faculty member, who may or may not be identical with the student's dissertation adviser, and notifies the master graduate adviser and graduate administrator of this choice before starting the project or internship. The student will usually enroll in a BST 299 or BST 299D class with the Biostatistics mentor as instructor.

Successful completion of the practicum requires submission of both the report and of an accompanying letter signed by both mentor and supervising Biostatistics faculty member (who might be identical), in which the successful completion of the project is reported.
Criteria for successful completion are that (1) the report requirement has been met; (2) the student has gained an understanding of the underlying biological problem or question, the study or experiment and the nature of the data; (3) the data analysis and methodology is adequate to the problem and data.

The report should have the form of a paper which includes the student as a co-author. Not more than one biostatistics student can be among the co-authors. The report should follow the general format of a manuscript to be submitted to a scientific journal. In the case of an internship-based report, it may alternatively consist of a description of the work completed during the internship. In this case, the report should include an outline of the scientific background and the problem addressed by the student during the internship.

7. Examinations

Basic Examination (pre-qualifying)

All Graduate students except for well prepared students who receive a waiver must pass the **written Basic Examination** on preparatory statistics material covered in the courses STA 131A-131B-131C, 106 and 108 and the material of another one-quarter course (elective), which has STA 131B as a prerequisite. The examination must be taken and passed at the end of the first year. Each student will receive a written evaluation of performance on the entire examination, which will be discussed with the Biostatistics Graduate Adviser. This exam will be given the week after the end of Spring Quarter finals. It can be repeated once. Failure to pass this exam at the second attempt results in the recommendation to the Dean of Graduate Studies that the student be disqualified from the Biostatistics Ph.D. program.

Students with sufficient preparation are encouraged to apply to the Biostatistics Educational Policy Committee for a waiver of the requirement to take the Basic Examination in June at the end of the first year. This will allow the student to take the Biostatistics Ph.D. Written Examination after the first year and to finish all course work within the second year and thus put the student on a fast track.

A student applying for such a waiver must agree to take the Ph.D. Written Exam in September following the first year. This is then counted as the first attempt at the Basic Exam and also as the first attempt at the Ph.D. Written Exam. Passing the Ph.D. Written Exam then satisfies the requirement of passing the Basic Exam. In case a student fails to pass the Ph.D. Written Exam in the situation where the Basic Exam was not yet passed, s/he will be required to take the Basic Exam the following June. This will then count as the second attempt at the basic exam.

Biostatistics Ph.D. Written Examination (pre-qualifying)

A Ph.D. student must pass the **Biostatistics Ph.D. Written Examination** given in September. This exam must be attempted in September following the second year, at the latest. It is an exam on the material covered in the following courses: BST 222, BST 223, BST 224 (Session 1) and STA 231ABC (Session 2). The Biostatistics part (Session 1) will include questions on the theory of Biostatistics as well as a data analysis exam at the
discretion of the exam committee. The exam committees in charge may be different for each part of the exam. Pass or Fail is determined separately by the exam committees for BST 222, 223, 224 and for STA 231ABC. If one or both parts of the exam are failed, they must be attempted again at the next offering of the exam. A second failure in any part of the exam results in the recommendation to the Dean of Graduate Studies that the student be disqualified from the Biostatistics Ph.D. program.

*Ph.D. Qualifying Examination*

This is an oral exam and must be attempted as soon as the required coursework is completed, and the pre-qualifying Biostatistics Ph.D. Written Examination has been passed, normally one or two quarters after passing the Biostatistics Ph.D. Written Examination. In preparation for this exam, the student selects a major professor among the regular members of the Biostatistics graduate group. The Exam Committee consists of five faculty members, at least three of whom are members of the Biostatistics graduate group. The chair is not the dissertation adviser and must be a member of the Biostatistics graduate group. The exam consists of three parts: (a) Presentation of an advanced research topic in Biostatistics, or, alternatively, advanced biostatistical data analysis leading into biostatistical research; (b) A period of questions relating to the presented material; (c) Questions relating to biostatistical theory and methodology. The regulations regarding Ph.D. Qualifying Exams as determined by the Graduate Council apply. The Committee will be nominated by the graduate program master adviser, i.e., the Chair of the Committee of Graduate Advisers, after consultation with the student, and will be appointed in accordance with Graduate Council and Graduate Studies policies.

*8. Dissertation*

A topic in Biostatistics will be selected by the student, under the advice and guidance of a Dissertation Committee, which consists of three program members (Plan B according to Academic Senate Regulations). This committee is nominated by the graduate program master adviser after consultation with the student and in accordance with Graduate Council and Graduate Studies policies. The committee is chaired by the dissertation adviser.

The dissertation must contain original contributions to Biostatistics of publishable quality that may expand methodology, theory or the computational tools of Biostatistics, with the aim to solve critical problems in genetics, genomics, medicine, veterinary medicine, biological, environmental or agricultural sciences.

After the dissertation is completed, at the discretion of the Dissertation Committee, the student may be required to be examined in a *Dissertation Defense* with the Dissertation Committee in charge. A public presentation of the dissertation results by the candidate is required of all candidates. This exit seminar may be scheduled as part of the Biostatistics seminar series. The dissertation is accepted and nothing more can be required of the student once the members of the Dissertation Committee approve it unanimously by signing the title page.
9. Ph.D. in Biostatistics Sample Study Plans

Students who need to take prerequisites and plan to take Basic Exam after the first year should follow Sample Plan I listed below. Notice that during the first five quarters in residence, a student will attend the Biostatistics Seminar (BST 290) in addition to the courses listed below. A modified version of this sample program for a well-prepared student is given in Sample Plan 2 listed below. Students can reduce the units taken per quarter by extending their studies for one additional quarter before they take the Ph.D. Qualifying Exam. For such students, participation in the Statistics seminar BST 290 is required for six quarters.

SAMPLE PLAN 1

For a student who needs to train in prerequisites and is preparing to take the Basic Exam after the first year.

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Basic Exam (pre-qualifying)

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Written Ph.D. Exam (pre-qualifying) Ph.D. Qualifying Exam

Year 4, 5

Research, BST 299D (Dissertation Research), Elective Coursework, Summer Internships, Biostatistical Practicum, Dissertation, Presentation or Defense. Note that even after passing the qualifying examination all full time students must register for 12 units per quarter as per the Office of Graduate Studies regulations. These 12 units can be made up of elective coursework and 299s.
SAMPLE PLAN 2

This plan applies for a student who already has completed the prerequisites of the program and who will therefore not take the prequalifying Basic Exam. This fast track plan allows a student to graduate with the Ph.D. degree approximately one year earlier as compared to Sample Plan 1.

Year 1

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Year 2

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<tr>
<td>Ph.D. Written</td>
<td>Ph.D. Qualifying Exam (pre-qualifying)</td>
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Year 3, 4

Research, BST 299D (Dissertation Research), Elective Coursework, Summer Internship, Biostatistical Practicum, Dissertation, Presentation or Defense. Note that even after passing the qualifying examination all full time students must register for 12 units per quarter as per the Office of Graduate Studies regulations. These 12 units can be made of up elective coursework and 299s.

10. Normative Time

The normative time for the Ph.D. in the Biostatistics program is 5 years. Normative time to candidacy is 2.5 years. These normative times are for full-time students. The program does not provide for part-time enrollment. Incentives for timely progress toward completion will be instituted by offering support primarily for those students who are making good progress, by encouraging the recruitment of "fast track" Plan 2 students, by efficient advising and mentoring of students, and by annual offerings of required courses.

11. Relation to M.S. in Biostatistics Program and Change of Degree Objective

The first year of study is very similar, and courses STA 232AB are shared by both the M.S. and Ph.D. programs in the second year. The prequalifying Basic Exam is the same for both programs. An M.S. student can easily apply to transfer into the Ph.D. program in the second year. Students’ change of degree objective from the Biostatistics M.S. to the Ph.D. program and also admission as double-major requires the endorsement by the
Biostatistics Admissions and Awards Committee and is subject to approval by Graduate Studies. A Ph.D. student with a change in plan and the intention to obtain a terminal M.S. degree instead of the Ph.D. degree can do so easily with some adjustments in the coursework for the second year.

**MASTER'S PROGRAM IN BIOSTATISTICS (M.S.)**

The Graduate Program in Biostatistics offers the M.S. degree under Plan II (the Comprehensive Examination option). The degree requirements are listed below.

1. **Undergraduate preparation**

An undergraduate major in Mathematics, Statistics or Biostatistics is typical for Biostatistics graduate students, but is not required. However, because of the mathematical nature of some of the graduate coursework, students should be able to demonstrate good mathematical ability. Students should also demonstrate some exposure to courses in the life sciences (biological, environmental, medical, and agricultural sciences). Students without sufficient coursework in mathematics or life sciences may be admitted on the condition that deficiencies will be corrected during the first year of study. The minimal background for entrance into the program is: a bachelor's degree with 3.0 overall grade-point average; one year of calculus; a course in linear algebra or one year of biological coursework; facility with a programming language; and upper-division work in at least one of the following: Mathematics, Statistics, Biology or Biostatistics. All students whose native language is not English should demonstrate proficiency in English language by taking tests such as Test of English as a Foreign Language (TOEFL) and satisfying the minimum score requirements as set out by the Office of Graduate Studies. The Graduate Record Examination (GRE) General Test is required for all applicants. GRE scores should be greater than 1000 (combined verbal and quantitative) and dated not more than 3 years prior to the quarter of admission.

2. **Program of Study**

The program of study will be adjusted to individual needs by the Biostatistics Graduate Advisers. The program will consist of at least 46 units of coursework, at least 18 of which must be at the graduate level. This will include the core courses listed below, covering basic material in Biostatistics and Statistics. Moreover, the Office of Graduate Studies requires that every full time graduate student must register for a minimum of 12 units per quarter. These 12 units can be made up of a combination of required coursework as described below, additional elective coursework if any, and 299’s.

The core courses for the Master's degree are:

(a) **Biostatistics Core Courses:** (8 units) Two courses taken from the Biostatistics core or elective courses: BST 222 (Survival Analysis), BST223 (Generalized
Linear Models), BST224 (Longitudinal Data Analysis), BST225 (Clinical Trials) or BST226 (Statistical Methods in Bioinformatics). Prerequisites for these courses must be satisfied.

(b) **Statistics Core Courses**: (8 units) STA 232AB (Applied Statistics)

(c) **Methods Core Courses** (8 units): Applied Multivariate Analysis STA 135, Statistical Computing STA 141. Course STA 135 may be replaced by STA 232C.

(d) **Biostatistics and Methods Electives** (8 units): Two courses with a substantial biostatistical data analysis component, at least at the upper division level, at least one of them at the graduate level.

(e) **Life Sciences Elective** (4 units): One course selected from any upper division or graduate offering in biology, epidemiology, environmental, agricultural or medical sciences.

(f) **Seminars and Professional Courses**: Biostatistics Seminar, BST 290 (Every Quarter during residence, up to five quarters maximum, 1 unit); Methods in Statistical Consulting, STA 401 (once, 3 units); Methods of Teaching Statistics, STA 390 (2 units; required once, during the first year of residence)

3. Examinations

**Basic Examination (pre-qualifying)**

Students must pass the written pre-qualifying Basic Examination on preparatory methodology which covers the courses STA 131A-131B-131C, 106 and 108. The examination must be taken and passed at the end of the first year. Each student will receive a written evaluation of performance on the entire examination, which will be discussed with the biostatistics graduate adviser. This exam will be given the week after the end of Spring Quarter finals. It can be repeated once. Failure to pass this exam at the second attempt results in the recommendation to the Dean of Graduate Studies that the student be disqualified from the Biostatistics M.S. program.

**Comprehensive Examination**

This oral examination centers around a biostatistical data analysis. The Exam Committee consists of three Biostatistics program members. The student presents the results of the data analysis and defends them before the examining committee. The comprehensive examination must be attempted before the beginning of the sixth quarter of graduate work and may be repeated once. Specific regulations concerning the Comprehensive Examination for MS Students in Biostatistics apply.
Research

Although no Master's thesis is required, research experience can be gained by electing Statistics 299 under the guidance of a Biostatistics program member. This course may be related to the project presented at the data analysis examination.

M.S. in Biostatistics Sample Study Plan

Two life sciences courses are included in the sample plan to indicate that a prerequisite may have to be fulfilled for students without prior exposure to coursework in the life sciences.

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*Basic Exam (pre-qualifying)*

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Change of Degree Objective and Double Majors

Change of degree objective and admission as double-major to Biostatistics requires endorsement by the Biostatistics Admissions and Awards Committee and is subject to approval by Graduate Studies. The program does not provide for part-time student status.