ARIZONA UNIVERSITY SYSTEM
CHIEF ACADEMIC OFFICERS GUIDELINES
FOR
REQUESTS FOR IMPLEMENTATION AUTHORIZATION
FOR NEW ACADEMIC DEGREE PROGRAM
[UNIQUE PROGRAM]

I. PROGRAM NAME AND DESCRIPTION AND CIP CODE

A. DEGREE(S), DEPARTMENT AND COLLEGE AND CIP CODE

Degree: Doctor of Philosophy (Ph.D.) in Biostatistics
Department: Not applicable
Division: Epidemiology and Biostatistics
College: University of Arizona, Mel and Enid Zuckerman College of Public Health
CIP Code: 26.1102 – Biostatistics

B. PURPOSE AND NATURE OF PROGRAM

The Ph.D. in Biostatistics will have an emphasis on the foundations of statistical reasoning and will require its graduates to complete rigorous training in applied probability and statistical analyses. This new program will prepare students who have demonstrated excellence in mathematics and the sciences to become research biostatisticians in academia, industry, or government.

Biostatisticians are trained in the skilled application of statistical methods to the solution of problems encountered in such fields as public health, medicine, nursing, pharmacy, and dentistry. They collaborate with scientists and investigators in nearly every area related to health, and have made major contributions to our understanding of chronic diseases such as AIDS, cancer, and immunology. The Ph.D. program in Biostatistics will teach these important skills and in turn will benefit The University of Arizona, the community, and state of Arizona.

Adding the Ph.D. program in Biostatistics will enhance the research environment at the University of Arizona by adding both additional faculty and graduate students who will collaborate with investigators in performing statistical analyses, writing research grants, assisting with study design, and teaching additional courses in Biostatistics that will be available to graduate students and faculty from other programs. Faculty and students also will participate in development and modification of statistical methodologies for evolving and rapidly developing areas of research. For example, areas where there is currently a need for new analytical methods include microarray and genetic linkage analyses. An added benefit is that some graduates will choose to stay at the university as instructors and researchers.

C. PROGRAM REQUIREMENTS -- List the program requirements, including minimum number of credit hours, required courses, and any special requirements, including theses, internships, etc.
Admission Requirements:

The Ph.D. program in Biostatistics is designed for individuals having strong quantitative skills with background or interest in the biological, medical, or health sciences. Students can enter the Ph.D. program with a bachelor's or a master's degree. To the extent possible, the curriculum of each student will be tailored to his or her background and interests. Those students interested solely in a Master's degree in Biostatistics will be directed to enroll in the Master in Public Health (M.P.H.) program with a concentration in Biostatistics.

Applicants are selected on the basis of their quantitative skills and potential to become effective researchers in biostatistics. Criteria for admission and financial support are: prior course work and grades, especially in quantitative courses such as mathematics, statistics, and computer sciences; Graduate Record Examination (GRE) scores; letters of recommendation that allow the evaluation of the applicant's quantitative abilities; and extent of experience or interest in the biological or health sciences.

Minimum course requirements for admission include at least one year of college level mathematics, including calculus. At least one course in linear algebra is preferred.

Degree Requirements:

Credit Hours – The curriculum will require a minimum of 45 credit hours of course work in the major, of which 30 credit hours are from required courses and 15 are electives. Students are required to select a minor and complete 9 semester hours or more (depending on requirements of the minor department) in their area of interest, and a minimum of 18 units of dissertation credit. The minimum number of required credit hours for graduation will be 72 units.

Students entering the program with a Bachelor’s degree and limited undergraduate biology course work will be required to take “Biology in Public Health Research and Practice” (CPH 505). Students with limited public health experience will be required to take “Centuries of Public Health: Sanitation, Sleuthing and Sex” (CPH 550).

Students, who enter the Ph.D. program after completion of the M.S. or M.P.H. with a concentration in Biostatistics, must complete a minimum of 18 additional credit hours of course work, 6 credits of seminar, 9 credits or more in a minor subject, and 18 dissertation units. They will be allowed to substitute more advanced courses for any required courses already completed.

Required Course Work –
Ph.D. in Biostatistics: Of the 45 hours of course work in the major, 30 credit hours will be from required courses and seminar. The remaining 15 credit hours will be from elective courses.

M.S. in Biostatistics: The M.S. degree is reserved only for students without a Master’s degree who are unable to make sufficient progress towards completion of the Ph.D. requirements. Students will not be admitted directly into the M.S. program. In the situation where the M.S. is the terminal degree, 39 credits will be required for completion: 30 credits from required courses and seminar, 6 credit hours of elective courses, and a 3 unit thesis are required for completion.
### Biostatistics Ph.D. Required Courses

<table>
<thead>
<tr>
<th>Required Courses</th>
<th>Title</th>
<th>Credit Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>(New)</td>
<td>Applied Statistical Theory I</td>
<td>3</td>
</tr>
<tr>
<td>(New)</td>
<td>Applied Statistical Theory II</td>
<td>3</td>
</tr>
<tr>
<td>(New)</td>
<td>Seminar</td>
<td>6</td>
</tr>
<tr>
<td>CPH 573a</td>
<td>Basic Principles of Epidemiology</td>
<td>3</td>
</tr>
<tr>
<td>CPH 576a</td>
<td>Biostatistics in Public Health</td>
<td>3</td>
</tr>
<tr>
<td>CPH 576b</td>
<td>Biostatistics for Research</td>
<td>3</td>
</tr>
<tr>
<td>CPH 576c</td>
<td>Applied Biostatistics Analysis</td>
<td>3</td>
</tr>
<tr>
<td>CPH 684</td>
<td>Generalized Linear and Mixed Effects Models</td>
<td>3</td>
</tr>
<tr>
<td>CPH 685</td>
<td>Biostatistical Consulting</td>
<td>3</td>
</tr>
<tr>
<td>Electives¹</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>Minor²</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Dissertation</td>
<td></td>
<td>18</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>72</strong></td>
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¹Electives may also be selected from courses taught in other programs with approval of the Candidacy Committee.

²Each Ph.D. student must complete at least 9 credit hours of course work in a minor area. This should consist of a coherent set of courses in an area (or in related areas) of application of biostatistics; the courses should be approved for graduate credit and may be from more than one program. Minor courses should be primarily applied as opposed to mathematics/statistical in nature.

### Biostatistics Ph.D. Elective Courses

<table>
<thead>
<tr>
<th>Elective Courses</th>
<th>Title</th>
<th>Credit Hrs</th>
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<tbody>
<tr>
<td>(New)</td>
<td>Advanced Linear and Nonlinear Regression</td>
<td>3</td>
</tr>
<tr>
<td>(New)</td>
<td>General Estimating Equations</td>
<td>3</td>
</tr>
<tr>
<td>(New)</td>
<td>Computer Intensive Statistical Methods</td>
<td>3</td>
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<tr>
<td>CPH 576D</td>
<td>SAS Computer Applications</td>
<td>3</td>
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<tr>
<td>CPH 652</td>
<td>Grantsmanship for a Winning Proposal</td>
<td>3</td>
</tr>
<tr>
<td>CPH 675</td>
<td>Clinical Trials and Intervention Studies</td>
<td>3</td>
</tr>
<tr>
<td>CPH 677</td>
<td>Genetic Association Studies</td>
<td>3</td>
</tr>
</tbody>
</table>
Comprehensive Exam – The exam should be taken in the 4th or 5th semester of the Ph.D. program. The written comprehensive exam will cover key topics in biostatistics and an identified minor area of study. The oral component of the exam may be scheduled once the written portion has been passed.

Advancement to Candidacy – When the student has an approved doctoral Plan of Study on file, has satisfied all course work and residence requirements, and passed the written and oral portions of the Comprehensive Examination, he or she must file an Application to Advance to Candidacy.

Dissertation – Each student will conduct an original research project that must be summarized in a written dissertation. The student must prepare and present a dissertation proposal orally in order to obtain the approval of the dissertation committee to conduct the research. When the dissertation is complete, the student must defend it at a public presentation.

Program Length – Any student who has been admitted to candidacy for a doctoral degree (i.e., successful completion of the comprehensive examination) is expected to complete the degree within five years from the date of admission to candidacy.

D. CURRENT COURSES AND EXISTING PROGRAMS -- List current course and existing university programs which will give strengths to the proposed program.

Some required and elective courses for the proposed degree program are currently offered as part of the M.P.H. program. These courses are listed below:

<table>
<thead>
<tr>
<th>Elective Courses</th>
<th>Title</th>
<th>Credit Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPH 573a</td>
<td>Basic Principles of Epidemiology</td>
<td>3</td>
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<tr>
<td>CPH 576a</td>
<td>Biostatistics for Public Health</td>
<td>3</td>
</tr>
<tr>
<td>CPH 576b</td>
<td>Biostatistics for Research</td>
<td>3</td>
</tr>
<tr>
<td>CPH 576c</td>
<td>Applied Biostatistics Analysis</td>
<td>3</td>
</tr>
<tr>
<td>CPH 676</td>
<td>Advanced Topics in Biostatistics</td>
<td>3</td>
</tr>
<tr>
<td>CPH 684</td>
<td>General Linear and Mixed Effects Models</td>
<td>3</td>
</tr>
<tr>
<td>CPH 685</td>
<td>Statistical Consulting</td>
<td>3</td>
</tr>
</tbody>
</table>
Other elective courses to be added will be offered in the new GIDP in statistics that was recently approved by the ABOR. Many of the above courses will also be cross-listed in the new GIDP Statistics Ph.D. to reach a broader student base across campus. In addition, there are over 40 graduate-level statistics courses offered through 12 departments representing four colleges: Agriculture and Life Sciences, Engineering, Social and Behavioral Sciences, and Science. A listing of these courses is provided in Appendix I.

E. NEW COURSES NEEDED -- List any new courses which must be added to initiate the program; include a catalog description for each of these courses.

To implement the new degree program six new courses will be added: Applied Statistical Theory I and II, Advanced Linear and Non-linear Regression, Computer Intensive Statistical Methods, General Estimating Equations, and Seminar Series. Descriptions of the courses follow:

**Applied Statistical Theory (I and II), 3hrs each:**
Applied Statistical Theory will consist of two parts (I and II). The first part will focus on fundamental probability, including discrete and continuous distributions, expectation and generating functions, and distribution theory, including limit theorems, transformations and sampling theory, needed for statistical inference. The second part will focus on fundamental theory that is the basis of inferential statistical procedures, including point and interval estimation, sufficient statistics, hypothesis testing, maximum likelihood estimates, confidence intervals, criteria for estimators, methods of constructing test and estimation procedures. This course will provide theoretical basis for any of applied and advanced statistical courses. A new faculty member will be hired to develop and teach these courses.

**Advanced Linear and Non-linear Regression, 3 hrs:**
Advanced Linear and Non-linear Regression is an extension of the courses Biostatistics for Public Health (CPH 576a) and Biostatistics for Research (CPH 576b). This course will mainly focus on the statistical aspects of statistical regression models, including model structures, model estimation and model diagnostics, and will be taught using matrices approaches, which will be useful for students to handle complex datasets and explore the theoretical properties behind each regression model. This course also will provide students a strong background for advanced statistical courses, such as General Linear and Mixed Models (CPH 684). A new faculty member will be hired to develop and teach this course.

**Computer Intensive Statistical Methods, 3 hrs:**
This course will introduce computer intensive methods of statistical analysis and their application to statistical modeling. Computer intensive methods use resampling and repeated simulations to calculate standard errors, confidence intervals and significance tests to assess the quality of a statistical model. These methods are frequently used by statisticians and are also being applied by quantitative researchers in public health, social sciences, and medical sciences. This course will cover the following topics Resampling, Bootstrapping, Jackknifing, Monte Carlo Methods, and Permutation testing.
General Estimating Equations (GEE), 3 hrs:
GEE is an extension of Generalized Linear Models that provides the latter with the adjustments required to model longitudinal and clustered data. GEE is a population averaging method that models data in which the response variable is assumed to be from the exponential family of distributions that include continuous, binary and count data. This course is an extension of the course General Linear and Mixed Models (CPH 684) currently taught by Dr. Sherrill. Dr. Sherrill has agreed to teach the course and will develop it as part of his sabbatical in early 2007.

Seminar Series, 6 hrs:
This seminar series will provide a means for the faculty, students, and invited guests to present their current research projects, as well as a mechanism for students to identify mentors and dissertation advisors for their thesis project.

F. REQUIREMENTS FOR ACCREDITATION -- Describe the requirements for accreditation if the program will seek to become accredited. Assess the eligibility of the proposed program for accreditation.

The Council on Education for Public Health (CEPH) is the accrediting institution for schools of public health. A revised set of accreditation criteria was promulgated in June 2005. The new standards require that a school of public health have sufficient faculty expertise, availability of advanced-level courses, and active research, to support the development and offering of at least three doctoral degree curricula. MEZCOPH currently offers only one doctoral program, in Epidemiology. Successful implementation of the new Ph.D. in Biostatistics will help to satisfy the new accreditation criteria.

II. STUDENT LEARNING OUTCOMES AND ASSESSMENT

A. What are the intended student outcomes, describing what students should know, understand, and/or be able to do at the conclusion of this program of study?

The Ph.D. program will produce biostatisticians who can develop biostatistical methodology that can be utilized to solve problems in public health and the biomedical sciences. In addition, graduates of the Ph.D. program will be prepared to apply biostatistical and epidemiology methodology for the design and analysis of public health and biomedical research investigations. Finally, graduates of the Ph.D. program will be well suited to function as collaborators or team leaders on research projects in the biomedical and public health sciences. The program requires competency in the theory of statistics and probability, in introductory and advanced biostatistical methods and theory, and in fundamentals of epidemiologic study design. The doctoral dissertation will be the culminating experience in the Ph.D. program. Graduates of the doctoral program will have written a doctoral dissertation that focuses on the development of a new methodology or on the innovative application of biostatistical methods to a health sciences research problem.

At the end of doctoral training students must demonstrate all of the competencies listed below:
• Be able to describe the roles biostatistics serves in the discipline of public health.
• Describe basic concepts of probability, random variation and commonly used statistical probability distributions.
• Apply basic informatics techniques with vital statistics and public health records in the description of public health characteristics and in public health research and evaluation.
• Communicate understanding of the assumptions necessary for a given statistical procedure as well as the ability to determine if the assumptions are met for a given data set.
• Suggest preferred methodological alternatives to commonly used statistical methods when assumptions are not met.
• Recognize strengths and weaknesses of proposed approaches, including alternative designs, data sources, and analytical methods.
• Distinguish among the different measurement scales and the implications for selection of statistical methods to be used based on these distinctions.
• Apply descriptive and inferential methodologies according to the type of study design for answering a particular research question.
• Demonstrate the use of statistical theory in being able to develop or modify a statistical procedure to fit the needs of a unique data set.
• Quantitatively address a health problem by appropriate definition, study design, data collection, data management, biostatistical analysis, and interpretation of results for a variety of experimental and observational studies.
• Convey the solid theoretical training necessary for the development and study of new statistical methods; and/or adapt existing methods to new/unique problems.
• Demonstrate the ability to communicate effectively in writing reports, giving oral presentations, and teaching basic statistical material in a formal classroom setting.
• Be capable of assuming positions of leadership in a career in academia, research institutes, government, and/or industry.
• Contribute to the body of knowledge in their field of Biostatistics.

B. Provide a plan for assessing intended student outcomes.

Student outcomes will be assessed throughout the program using the tools described below.

Means for assessing students:

• Academic credentials of accepted students into the program – these include the characteristics of all previous awarded degrees, including the name of the institution, the major of the awarded degree(s), year(s) granted, and associated GPA(s); GRE test scores; and letters of recommendation from individuals well acquainted with the student’s past performance, current expertise, and future potential.
• Grading of required papers/exams and oral presentation in courses and seminars – performance on required papers, examinations, and presentations will be reflected in course grades.
• Thesis (M.S. students only) – the thesis consists of biostatistical analysis of a data set followed by a written document summarizing the background of the analytic question, a detailed explanation of the biostatistical analytic methodology used, and a comprehensive
presentation and interpretation of the results. The student must demonstrate the ability to conduct biostatistical analysis in an applied setting. The adequacy of the thesis (pass/fail) is determined by the thesis committee.

- Comprehensive Exams – the written comprehensive exam is similar to a master’s thesis, in that the student must conduct a biostatistical analysis of a data set followed by a written document summarizing the background of the analytic question, a detailed explanation of the biostatistical analytic methodology used, and a comprehensive presentation and interpretation of the results. The oral comprehensive exam tests the student on general knowledge acquired not only during the core courses, but also in any specialty and/or minor courses. The adequacy of the student’s performance (pass/fail in each case) is determined by the comprehensive exam committee.

- Dissertation – each student will conduct an original research project that must be summarized in a written dissertation. The student is required to present his/her dissertation proposal orally in order to obtain the approval of the dissertation committee to conduct the research. Students whose dissertation proposal is approved will be admitted to Ph.D. candidacy. The dissertation should involve innovative research and demonstrate a sophisticated command of biostatistical skills. When the dissertation is complete, the student must defend it at a public presentation.

- Dissertation Defense – in the dissertation defense, the student must demonstrate advanced expertise in the field, demonstrating an ability not only to defend the quality and relevance of the original dissertation research, but also to integrate it into broader biostatistical research currently being conducted by experts in the field. The adequacy of the student’s performance (pass/fail) is determined by the dissertation committee.

- Annual written progress reports – annual progress reports track the quality of performance (e.g., course grades) and its timeliness. These reports are reviewed by the Student Progress Committee, and recommendations for corrective action issued by them, as deemed necessary.

Assessing program requirements:

- Maintain continual review of educational programming and offerings through documentation of program specific learning objectives, core competencies, course availability and course content to address global public health competencies and issues relevant to the Southwest.

- Monitor student recruitment, retention, and degree completion, with an emphasis on ensuring a culturally diverse student population reflective of the Southwest.

- Evaluate the number and scope of student support services related to career placement, and provision of financial resources to ensure the program meets defined objectives.

- Conduct annual student surveys to assess the adequacy of academic advising skill and teaching effectiveness of the faculty.

- Track the ratio of students to faculty and the proportion of courses offered to students enrolled to ensure resources increase proportional to increases in student enrollment.

- Track average time to degree – trends as well as summary measures will be presented to the program faculty for discussion each year.
• Evaluate the breadth and depth of curriculum in terms of faculty satisfaction with what
students know and are able to do – the program faculty will meet every other year to
evaluate overall effectiveness of program structure and function.
• Evaluate former students’ professional development – alumni will be contacted one year
after graduation, and once every five years after, to track professional development via a
short survey.
• Learn from employers whether students were appropriately prepared – surveys will be
administered one year after graduation to appropriate employers.
• Conduct ongoing self-assessment, annual reports, and academic program reviews – once
each year the faculty will meet to discuss these assessments, taking action as necessary.
• Conduct follow-up interviews with program graduates to obtain feedback on the
graduate’s assessment of how well the Ph.D. program prepared them for their
professional careers – exit interviews will be conducted; additionally, a module will be
added to the initial post-graduation survey described above, administered one year after
graduation.
• Realign the program as needs change or as assessment shows inadequate performance.

III. STATE'S NEED FOR THE PROGRAM

A. HOW DOES THIS PROGRAM FULFILL THE NEEDS OF THE STATE OF

Doctorally-trained biostatisticians collaborate with scientists and investigators in nearly every
area related to health, and have made major contributions to our understanding of immunology;
genetics; chronic diseases such as AIDS, cancer, and cardiovascular disease; and a wide range of
other public health issues. The Ph.D. program in Biostatistics will enhance the research
environment at the University of Arizona by adding additional faculty and graduate students who
will collaborate with scientific investigators to develop statistical methods that are at the
forefront of discoveries in areas such as genetics and translational research. They will
additionally improve the research infrastructure by applying their skills in performing statistical
analyses, writing research grants, assisting with study design, and teaching additional courses.

An added benefit of the program is that some graduates will choose to remain within the state of
Arizona and contribute to its rapidly expanding biomedical research infrastructure which
includes the University of Arizona MEZCOHIP and the Colleges of Medicine, Nursing,
Pharmacy, Science, Social and Behavioral Sciences, and the Translational Genomics Research
Institute (TGEN) in Phoenix.

B. IS THERE SUFFICIENT STUDENT DEMAND FOR THE PROGRAM? --Explain and
please answer the following questions.

In the last twenty years, the demand for biostatisticians has grown dramatically, as opportunities
in the design, conduct, and analyses of biomedical and public health research projects have
continued to expand. Data from the Association of Schools of Public Health 2005 Annual Data
Report document that 7.2% (1,400) of the 19,443 students enrolled in the 37 accredited schools
of public health are pursuing a degree in Biostatistics. Almost 42% of these students are pursuing a Ph.D. Thus, we expect that there will be strong demand for the program among those that are quantitatively trained at the undergraduate level.

1. What is the anticipated student enrollment for this program? (Please utilize the following tabular format).

<table>
<thead>
<tr>
<th>5-YEAR PROJECTED ANNUAL ENROLLMENT *</th>
<th>1st yr</th>
<th>2nd yr</th>
<th>3rd yr</th>
<th>4th yr</th>
<th>5th yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Ph.D. Students</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

* Indicates the number of new students enrolled each year for the first five years.

Projected enrollment numbers are based on the following data:

- Ph.D. enrollment data from the Association of Schools of Public Health.
- The number of Biostatistics applicants in a comparable program at The University of Texas, School of Public Health, Division of Biostatistics.
- Available faculty for advising and mentoring.
- Number of Graduate Programs in Biostatistics nationally (156).
- Number of Ph.D. and M.S. students in the MEZCOPH Epidemiology Program.

2. What is the local, regional and national need for this program? Provide evidence of the need for this program. Include an assessment of the employment opportunities for graduates of the program during the next three years.

On a local and regional level, biostatisticians are needed to support scientific advances that improve lives and stimulate economic development. An example of this is BIO5, the newly created, collaborative biobasearch institute at the University of Arizona. BIO5 brings together scientists from 5 disciplines, agriculture, medicine, pharmacy, basic science and engineering, to solve complex biological problems. The Institute empowers scientists to tackle complex problems: how to diagnose, treat, or prevent disease, how to better feed a hungry world and how to maintain livable environments. An essential element in the success of this renewed effort is the availability of high-level biostatistical support. The additional faculty and graduate students, who will be brought into the Biostatistics Ph.D. program, will be available to collaborate with investigators in performing statistical analyses, writing research grants, assisting with study design, and teaching additional courses in Biostatistics that will be available to graduate students and faculty from other programs. This intellectual framework will help to position the University of Arizona to be at the leading edge of 21st century biological research.
Nationally in the last twenty years, the demand for biostatisticians has grown dramatically, as the opportunities for biostatisticians in design, conduct, and analyses of biomedical and public health research projects have continued to expand. According to the website of the American Statistical Association (ASA):

"While the amount of education required depends on the type and level of position sought, most statisticians hold a bachelor's or master's degree. Senior consulting or university faculty appointments usually require a doctorate. ... The demand for statisticians is currently high and is growing. According to the Occupational Outlook Handbook, published by the Bureau of Labor Statistics, the number of non-academic jobs for statisticians is expected to increase through 2008. Furthermore, colleges and universities will be hiring more and more faculty members in statistical fields. Salaries and opportunities for advancement are competitive and reflect the current demand."

According to the ASA Fall 2005 “Salary Survey Results: Biostatistics and Other Biomedical Statistics Departments and Units,” starting Assistant Professors had a median salary of $84,000, with interquartile range $81,600-$95,833 (25th to 75th percentile). This represents a 15% increase over the past five years suggesting that the demand for Ph.D. Biostatisticians is on the increase as well.

3. Beginning with the first year in which degrees will be awarded, what is the anticipated number of degrees that will be awarded each year for the first five years? (Please utilize the following tabular format).

<table>
<thead>
<tr>
<th>PROJECTED DEGREES AWARDED ANNUALLY</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td>No. Degrees</td>
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<tr>
<td>Ph.D.</td>
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<tr>
<td>1st yr</td>
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IV. APPROPRIATENESS FOR THE UNIVERSITY -- Explain how the proposed program is consistent with the University mission and strategic direction statements of the university and why the university is the most appropriate location within the Arizona University System for the program.

The Biostatistics Ph.D. program will help strengthen the academic standing of MEZCOPH, and the capacity and expertise in health, life, and biological sciences of the University of Arizona. It is most directly relevant to Focused Excellence Strategic Priority I “Build a world-class and diverse academic community at the forefront of discovery.” It will allow us to create, strengthen and support research collaborations across departments and programs, especially across colleges. Ph.D. programs in Biostatistics are housed in over 80% of the CEPH accredited schools of public
health nationwide. Thus, the addition of this doctoral program will make MEZCOPH more attractive to students and future faculty recruits. The program also will address Focused Excellence Strategic Priority III “Extend the concept of a land grant university to position the University of Arizona, across all colleges, as a model for linking scholarship and creativity to societal and community needs.” The faculty and students of the Biostatistics Ph.D. program will enhance the University capacity and expertise in the health, life and biological sciences.

V. EXISTING PROGRAMS AT OTHER CAMPUSES

A. EXISTING PROGRAMS IN ARIZONA --

1. For a unique (non-Duplicative) program, provide a statement to the effect that there are no existing programs at other Arizona public universities that duplicate the proposed program.

There are no other Ph.D. programs in Biostatistics at any of the universities in Arizona. The proposed Biostatistics Ph.D. is complementary to the recently approved G.I.D.P. that will offer a Ph.D. in Statistics. The Biostatistics Ph.D. is more applied in nature, whereas the Statistics Ph.D. will place more emphasis on theoretical statistics. It is expected that students in either program will take advantage of some courses offered by the other.

2. Other Institutions -- If this program is not currently offered at the same academic level by private institutions in the state of Arizona, provide a statement to that effect. If a similar program is currently offered by private institutions, list all programs and indicate whether the institution and the program are accredited. (A list of institutions will be provided by Board staff. Please utilize the following tabular format and contact Board staff for assistance, if needed).

There are no other Ph.D. programs in Biostatistics at any of the private universities in Arizona.

V. PROGRAMS OFFERED IN OTHER WICHE STATES

1. Identify WICHE institutions that currently offer this program. If appropriate, briefly describe the programs. (Please use the following format).

The only accredited College of Public Health in the Mountain Time Zone is at the University of Arizona. Of the 15 WICHE states, there are colleges of public health accredited by the Council on Education in Public Health at the following institutions: The University of Washington, The University of California at Berkeley, The University of California at Los Angeles, Loma Linda University and San Diego State University. Three of these schools offer doctoral programs in Biostatistics. However, since California does not participate in the Western Regional Graduate Program, Arizona residents are not eligible for in-state tuition for these graduate programs. The University of Colorado does not have a CEPH accredited school of public health, so does not offer the breadth of public health training that can be provided by the MEZCOPH Ph.D.
PROGRAMS OFFERED IN OTHER WICHE STATES

<table>
<thead>
<tr>
<th>PROGRAM</th>
<th>WICHE Institution &amp; Location</th>
<th>NCA Accreditation? (Y or N)</th>
<th>Program Accreditation? (Y or N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Ph.D. Biometry</td>
<td>University of Colorado Health Sciences Center, Denver, CO</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2 Ph.D. Biostatistics</td>
<td>University of California, Berkeley, Berkeley, CA</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>3 Ph.D. Biostatistics</td>
<td>University of California, Los Angeles, Los Angeles, CA</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>4 Ph.D. Biostatistics</td>
<td>University of Washington, Seattle, WA</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

VI. EXPECTED FACULTY AND RESOURCE REQUIREMENTS

A. FACULTY

1. Current Faculty -- List the name, rank, highest degree and estimate of the level of involvement of all current faculty who will participate in the program. If proposed program is at the graduate level, also list the number of master's theses and doctoral dissertations each of these faculty have directed to completion. Attach a brief vita for each faculty member listed.

<table>
<thead>
<tr>
<th>Faculty Member</th>
<th>Rank</th>
<th>Highest Degree</th>
<th>M.S. Theses Directed</th>
<th>Ph.D. Dissertations Directed</th>
<th>Ph.D. Committee Member</th>
<th>Level of Involvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sylvan Green</td>
<td>Professor</td>
<td>M.D.</td>
<td>-</td>
<td>-</td>
<td>5</td>
<td>1.0 FTE</td>
</tr>
<tr>
<td>Denise Roe</td>
<td>Professor, Senior Associate Dean</td>
<td>Dr.P.H.</td>
<td>-</td>
<td>2</td>
<td>15</td>
<td>1.0 FTE</td>
</tr>
<tr>
<td>Duane Sherrill</td>
<td>Professor, Associate Dean</td>
<td>Ph.D.</td>
<td>7</td>
<td>4</td>
<td>10</td>
<td>1.0 FTE</td>
</tr>
<tr>
<td>James Ranger-Moore</td>
<td>Associate Professor, Division Director</td>
<td>Ph.D.</td>
<td>4</td>
<td>3</td>
<td>13</td>
<td>1.0 FTE</td>
</tr>
<tr>
<td>Stefano Guerra</td>
<td>Assistant Professor</td>
<td>Ph.D.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.5 FTE</td>
</tr>
<tr>
<td>Chiu-Hsieh Hsu</td>
<td>Assistant Professor</td>
<td>Ph.D.</td>
<td>1</td>
<td>-</td>
<td>2</td>
<td>1.0 FTE</td>
</tr>
</tbody>
</table>
Sylvan Green, MD
Dr. Green is a Professor in the Epidemiology & Biostatistics Division of the Mel and Enid Zuckerman College of Public Health, and Director of Biometry at the Arizona Cancer Center, University of Arizona, Tucson, Arizona; he holds the Linda McCartney Breast Cancer Chair in Biometry. Before joining the faculty of the University of Arizona in 2002, he was Professor of Epidemiology & Biostatistics (directing the Biostatistics Division) at Case Western Reserve University. Before his appointment at CWRU, he had a 24-year research career at the NIH, including seven years as Chief of the Clinical and Diagnostic Trials Section, Division of Cancer Prevention and Control, NCI. He received an A.B. in 1966 and an M.D. in 1972, both from the University of Pennsylvania. He is a Fellow of the American College of Epidemiology and a Past President of the Society for Clinical Trials. He is a Statistical Editor of the Journal of the National Cancer Institute and JNCI Deputy Editor for Cancer Spectrum, as well as a past Associate Editor of Controlled Clinical Trials. He teaches courses for the Epidemiology and M.P.H. graduate degree programs. In addition, he organizes and participates in a variety of educational activities focused on design and analysis of intervention trials. For example, he is a continuing faculty member for the American Society of Clinical Oncology and American Association for Cancer Research Workshop on Methods in Clinical Cancer Research, the American College of Surgeons Course in Clinical Trials Methods, and the NCI Summer Curriculum in Cancer Prevention. His research interests are in design and analysis of clinical trials, prevention trials, and epidemiologic studies, and in applying biostatistical and computer methodologies to medical and public health problems. He has published in the medical, statistical, and epidemiological literature, and has been a strong advocate of large randomized trials for research in treatment, prevention, and behavioral interventions.

Denise Roe, DrPH
Dr. Roe is a Professor in the Epidemiology & Biostatistics Division and Senior Associate Dean in the Mel and Enid Zuckerman College of Public Health, University of Arizona, Tucson, Arizona. She received a B.A. in Biology from UCLA in 1977, a M.S. in Biometrics from the University of Colorado in 1979, and a Dr.P.H. in Biostatistics from UCLA in 1988. She has been on the faculty of the University of Arizona since 1988. She collaborates with researchers in the Zuckerman College of Public Health, Arizona Cancer Center, College of Medicine and College of Pharmacy in the design, conduct and statistical analysis of clinical, prevention and laboratory studies. She has been a co-author on multiple scientific papers resulting from this research. She additionally teaches biostatistics courses for the Epidemiology and M.P.H. graduate degree programs. Her statistical research interests include developing and evaluating
statistical methods useful in clinical trials, prevention studies, pharmacokinetics, and longitudinal studies. She has served as the President-Elect, President, and Past-President of the Western North American Region of the International Biometric Society (1999 – 2001), and as a Member of the Committee of Presidents of Statistical Societies (1999 – 2001). She is a member of the Association of Schools of Public Health Data Committee and the Associate Deans Retreat Planning Committee.

Duane Sherrill, Ph.D.
Dr. Sherrill is a Professor in the Epidemiology & Biostatistics Division and Associate Dean of Research in the Mel and Enid Zuckerman College of Public Health, University of Arizona, Tucson, Arizona. He received his Ph.D. in Biostatistics from the University of Colorado in 1987 and has been a faculty member at the University of Arizona since 1988. He currently is the director of two programs, the Arizona Clinical Research Training Program and Biometry core of the General Clinical Research Center. He is known internationally for his work in methodology for longitudinal analysis and has published several review articles on this topic. In addition, he teaches two advanced biostatistics courses for the Biostatistics M.P.H. graduate degree program and will add another if the proposal for a new Ph.D. degree is approved. His research interests include the natural history of respiratory diseases, in particular asthma, and assessment of risk factors for development of respiratory diseases. He has been an author and co-author on multiple scientific papers resulting from this research.

James Ranger-Moore, Ph.D.
Dr. Ranger-Moore has worked at the University of Arizona since 1990 and has been a faculty member in MEZCOPH since its inception in 2000. He is currently Associate Professor of Public Health and has been the Director of the Division of Epidemiology and Biostatistics since 2004. Dr. Ranger-Moore’s research is in cancer prevention, with an emphasis on the analysis of sub-visual information from digital images of biopsies to gauge cancer risk, assess chemopreventive agents, and provide early detection of cancer. He has published extensively in this area, and numerous other topical areas in the field of cancer prevention. He has been the Director of the Biometry Core for the Chemoprevention of Skin Cancer Program Project since 2001. He routinely teaches multiple sections of CPH 576a, Biostatistics for Public Health, to over 100 graduate students each year.

Stefano Guerra, Ph.D.
Dr. Guerra is an Assistant Professor in the Epidemiology & Biostatistics Division, Mel and Enid Zuckerman College of Public Health, University of Arizona, Tucson, AZ. He received his MD from the University of Milan, Italy, in 1996, an M.P.H. (concentration area in Epidemiology) from the University of Arizona in 2001, and a Ph.D. (major in Epidemiology and minor in Genetics) from the University of Arizona in 2003. He has been on the faculty of the University of Arizona since completion of his Ph.D. in 2003. He is involved in the design and conduct of several long-term cohort studies on respiratory diseases, including a study on the genetics of chronic obstructive pulmonary disease (COPD), of which he is the principal investigator. He has been (co)author on multiple papers in peer-reviewed scientific journals. He teaches a graduate course on genetic association studies (CPH 677). His research interests include molecular and genetic epidemiology of asthma and COPD, and methodological issues in statistical genetics.
Chiu-Hsieh Hsu, Ph.D.
Dr. Hsu is an Assistant Professor in the Epidemiology & Biostatistics Division in the Mel and Enid Zuckerman College of Public Health, University of Arizona, Tucson, Arizona. He received a M.S. in Biostatistics from the University of Michigan in 2000, and a Ph.D. in Biostatistics from the University of Michigan in 2003. He has been on the faculty of the University of Arizona since 2003. He collaborates with researchers in the Zuckerman College of Public Health, Arizona Cancer Center and College of Medicine in the design, conduct and statistical analysis of clinical and prevention studies. He additionally teaches biostatistics courses for the Epidemiology and M.P.H. graduate degree programs. His research interests are two-fold. The first focuses on developing new statistical methods to analyze survival data subject to informative censoring. The second focuses on proposing novel statistical models for recurrent adenoma data from colorectal polyp prevention trials. The latter is highly motivated by the colorectal cancer prevention projects he has been working on through the Arizona Cancer Center since 2003. He has published several papers in both areas.

Walter Piegorsch, Ph.D.
Dr. Piegorsch is Professor of Mathematics at the University of Arizona, Tucson, AZ, and also a member of the Research Faculty of the University’s BIO5 Institute. He earned his Ph.D. in Statistics at the Biometrics Unit, Cornell University, Ithaca, NY in 1984, after which he spent nine years as a practicing statistician with the U.S. National Institute of Environmental Health Sciences in Research Triangle Park, NC, and then 13 years as a faculty member with the Department of Statistics at the University of South Carolina, Columbia, SC. His research focuses on modeling and analysis for environmental data, with emphasis on environmental hazards and risk assessment. His other areas of interest include geo-spatially referenced disaster informatics, simultaneous inference for regression analyses including generalized linear models, and the historical development of statistical thought as prompted by problems in the biological and environmental sciences. Dr. Piegorsch has held a number of professional positions, including Chairman of the American Statistical Association Section on Statistics & the Environment (2004); Vice-Chair of the American Statistical Association Council of Sections Governing Board (1997-1999), and election to the Council of the International Biometric Society (2002-2005). For 2006-2008 he serves as Joint-Editor of the Journal of the American Statistical Association (Theory & Methods Section), the flagship journal of the association. He also has served as Co-Editor-in-Chief of the Encyclopedia of Environmetrics, a major publication in the quantitative environmental sciences published in 2002 by John Wiley & Sons, and as a member of many journal editorial boards. Dr. Piegorsch has been honored as a Fellow of American Statistical Association (1995), a Member (by Election, 1995) of the International Statistical Institute, and has received the Distinguished Achievement Medal of the American Statistical Association Section on Statistics and the Environment (1993), and the University of South Carolina Educational Foundation Research Award for Science, Mathematics, and Engineering (2000).

Moshe Shaked, Ph.D.
Dr. Shaked is a Professor in the Mathematics Department at the University of Arizona. He was awarded a Ph.D. in Statistics from the University of Rochester in 1975. Since that time he has held positions at the University of New Mexico, the University of British Columbia, and Indiana University, before moving permanently to the University of Arizona in 1981. His main research
interests include stochastic orders and reliability theory, but he has participated in research projects in economics, epistemology, and statistical inference.

**Bruce Walsh, Ph.D.**
Dr. Walsh is Professor and Associate Department Head in Ecology & Evolutionary Biology. He also holds adjunct positions in the Departments of Animal Sciences, Plant Sciences, Molecular and Cellular Biology, and Epidemiology and Biostatistics. Dr. Walsh received his Ph.D. in genetics from the University of Washington in 1983. He joined the University of Arizona faculty in 1986. His area of interest is statistical applications in genetics and evolutionary biology.

Electives in math and epidemiology (e.g., MTH 555, MTH 569, EPI 573a) are currently being offered by the Math department and the Epidemiology program, and need not be staffed by Biostatistics Program faculty.

2. Additional Faculty -- Describe the additional faculty needed during the next three years for the initiation of the program and list the anticipated schedule for addition of these faculty.

Given the need to implement three additional courses, it is expected that one additional tenure-eligible (TE) faculty member will need to be hired to cover all programmatic needs. A search for a junior TE biostatistician is already planned for 2007. An additional non-tenure eligible faculty position is being recruited by the Arizona Cancer Center and will be available to teach in the doctoral program.

3. Current FTE Students and Faculty -- Give the present numbers of FTE students and FTE faculty in the department or unit in which the program will be offered.

There are 68.7 FTE students and 14.3 FTE faculty in the Epidemiology and Biostatistics Division.

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Degree Program</th>
<th>FTE Students</th>
<th>FTE Faculty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epidemiology</td>
<td>M.S.</td>
<td>6.67</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ph.D.</td>
<td>27.56</td>
<td>8.81</td>
</tr>
<tr>
<td></td>
<td>M.P.H.</td>
<td>25.78</td>
<td></td>
</tr>
<tr>
<td>Biostatistics</td>
<td>M.P.H.</td>
<td>8.67</td>
<td>5.5</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>68.68</td>
<td>14.31</td>
</tr>
</tbody>
</table>

4. Projected FTE Students and Faculty -- Give the proposed numbers of FTE students and FTE faculty for the next three years in the department or unit in which the program will be offered.
### B. LIBRARY

1. **Current Relevant Holdings** -- Describe the current library holdings relevant to the proposed program and assess the adequacy of these holdings.

   Students at the MEZCOPH have access to any of the libraries on the University of Arizona campus—the Main Library System, Science-Engineering Libraries, Fine Arts Library, Law Library, and Arizona Health Sciences Library. The Main Library system contains almost 7,000,000 items, displaying 4,000 plus periodicals, books, microforms, maps, government publications, manuscripts and non-book media. The primary resource for Biostatistics Ph.D. students, the Arizona Health Sciences Library (AHSL), is a specialized library designed to meet the needs of the Colleges of Medicine, Nursing, Pharmacy, and Public Health. The AHSL contains over 212,000 volumes and receives approximately 2,100 periodical and serial publications. The collection includes books, journals, audiovisuals, electronic resources, and access to selected commercial databases. The University of Arizona also shares research resources with Northern Arizona University and Arizona State University through an interlibrary cooperative agreement.

   Library information services staff at the AHSL are available to assist students with constructing search strategies specific to their field of research or study. Librarians can offer assistance and expertise with the following databases: MEDLINE, PubMed, STAT!Ref, Web of Science, CINAL, ABI Inform, International Pharmaceutical Abstracts, NCBI Entrez databases, and an array of evidence-based medicine databases. These services are provided free to faculty and students.

2. **Additional Acquisitions Needed** -- Describe additional library acquisitions needed during the next three years for the successful initiation of the program.

   No new acquisitions are anticipated at this time.

### C. PHYSICAL FACILITIES AND EQUIPMENT

1. **Existing Physical Facilities** -- Assess the adequacy of the existing physical facilities and equipment available to the proposed program. Include special classrooms, laboratories, physical equipment, computer facilities, etc.
Classroom and office space: Drachman Hall provides over 18,500 net square feet (NSF) of
permanently assigned space to the Mel and Enid Zuckerman College of Public Health. The
College's administrative and support offices, the academic divisions, research programs (such as
the Rural Health Office, Border Health Initiatives, Prevention Research Center, etc.), and
employee offices (faculty, research staff, and students) are all housed in the new facility. Some
research programs remain off-site due to their unique program needs and requirements for a
community setting. Wet-laboratory type space also is housed in adjacent university assigned
facilities to meet specific research and instructional needs.

Drachman Hall also includes approximately 27,785 NSF of instructional space for the Colleges
of Public Health, Nursing and Pharmacy. The instructional facility contains three 125
workstation lecture halls; one distributed learning classroom; two collaborative classrooms with
60 workstations each; two collaborative classrooms with 40 workstations each; one collaborative
classroom with 20 workstations; and one computer classroom that will be able to accommodate
50 students. In addition, 18 breakout or discussion rooms and related service areas are available
for instructional or research needs. The new facility provides MEZCOPH with the position of
home department, allowing priority assignment for all instructional and conference space.

Computing Facilities: The MEZCOPH computing infrastructure consists of 12 servers running
Windows 2000 and Windows 2003. These servers are used for a variety of purposes including
web hosting, file sharing, authentication, virtual private networking (VPN), network printing,
and other special project specific applications.

The College’s faculty and staff use approximately 300 personal computers acquired through
division, college or research-funded resources. These are all Windows based systems, connected
to the network in a variety of ways depending on location. With the occupancy of Drachman
Hall, the number of sites requiring IT support have been reduced to seven. On-campus locations
have network speeds of 10 or 100 megabits/sec; three sites use wireless (point to point)
connections to establish connectivity, and the remainder use DSL or T1 connections. Within
Drachman Hall, the network utilizes voice over IP (VoIP) technology, which allows for both
telephone and data service over the same set of cables. Wireless data networking is also being
utilized in and around the building, complementing the wired data connection points within the
building.

Student access to computing technology is facilitated through the Arizona Health Sciences
Center’s library and its Learning Resource Center. In Drachman Hall, a room for training and
public health specific instructional needs, equipped with 21 computer stations, is available solely
for use by MEZCOPH faculty, students and staff. These facilities provide students with access to
special technologies, and local and Internet resources. Additionally, the Center for Computing
and Information Technology and the Integrated Learning Center, on the main campus, provide
similar access to computing labs and resources. A help desk is available at each of these
facilities. Internet-based videoconferencing, outside of the classrooms constructed for that
purpose, is available via two mobile units within Drachman Hall.
Videoconferencing capabilities are available in designated Drachman Hall classrooms. These classrooms can be used to hold “real-time” synchronous classes with remote locations, while allowing lectures to be recorded and re-used for online distance-based courses. Synchronous classes and lectures can be distributed to various conference rooms in the Arizona Health Sciences facilities, Northern Arizona University’s School of Health Professions, the University of Arizona College of Medicine’s Phoenix Programs offices, and various Health Care facilities and educational sites locally and throughout Arizona, via the Internet or the Arizona Telemedicine Program network. Online courses will be made available generally through the public Internet using the learning management systems and tools available through The University of Arizona Center for Computing and Information Technologies. Video services are generally provided through Biomedical Communications, an auxiliary unit that provides technical support to the Arizona Health Sciences colleges. The Division of Biomedical Communications provides communications media planning and production services in support of the public service, research and instructional programs offered by the Arizona Health Sciences colleges.

2. Additional Facilities Required or Anticipated -- Describe physical facilities and equipment that will be required or are anticipated during the next three years for the proposed program.

No additional facilities support is requested at this time. New hires will require computer hardware and software; these needs are addressed routinely in start-up packages, and no additional resources are requested.

D. OTHER SUPPORT

1. Other Support Now Available -- Include support staff, university and non-university assistance.

   The Mel and Enid Zuckerman College of Public Health’s senior administrative component consists of the Dean, one Senior Associate Dean, two Associate Deans, two Assistant Deans, three Educational Program Chairs, and three Division Directors. Presently, there are 24.63 FTE management staff (management at the research administrative levels), 81.54 FTE research staff (at all levels), and 34.18 FTE administrative support staff (combined research and administration).

2. Other Support Needed, Next Three Years -- List additional staff needed and other assistance needed for the next three years.

   Additional 1.00 FTE support for doctoral programs in the Office of Student Services and Alumni Affairs.

VII. FINANCING

A. SUPPORTING FUNDS FROM OUTSIDE SOURCES -- List.
It is expected that students will be able to receive Research Assistantships or part-time employment positions as part of investigator-initiated research grants, program project grants, and center grants whose principal investigators are in the colleges of the Arizona Health Sciences Center. Such grants can provide good opportunities for working on data management and most importantly on data analyses.

**B. NEW ACADEMIC DEGREE PROGRAM BUDGET PROJECTIONS FORM –**

Complete the appropriate budget form, available at [http://www2.nau.edu/ugstudy/UCC Forms.htm](http://www2.nau.edu/ugstudy/UCC Forms.htm) describing the current departmental budget and estimating additional costs for the first three years of operation for the proposed program. Please note that these costs for each year are incremental costs, not cumulative costs.

The Biostatistics Ph.D. program budget is attached.

**VIII. OTHER RELEVANT INFORMATION**

None
Appendix I
University of Arizona Graduate-level Statistics Courses

Courses listed alphabetically by department.

**AN S 513 -- Statistical Genetics for Quantitative Measures (3 units)**
*Description:* This course is intended to develop skills for the analysis of genetic data including information on molecular markers and phenotypes for the purpose of localizing putative genes of interest on chromosomes and to properly analyze microarray data. It is assumed you are comfortable with regression theory, covariance, and correlation.

**AN S 553 -- Statistics for Applied Biological Experiments (3 units)**
*Description:* This course is intended for graduate students in the biological sciences. Topics covered will include parameter estimation, hypothesis testing, regression and ANOVA, graphical exploration of data, Bayesian statistics and resampling methods, and experimental design. Principles of statistical practice will be highlighted and practical experience gained through laboratory homework exercises. The statistical language R will be used for analysis; however, other software such as SAS could be used.

**AREC 517 -- Introductory Mathematical Statistics for Economists (3 units)**
*Description:* This course covers the basic mathematical statistics topics necessary for a deep understanding of applied econometrics. Topics include random variables probability theory, probability and density functions, sampling, hypothesis.

**AREC 549 -- Applied Econometric Analysis (3 units)**
*Description:* Econometric model-building, estimation, forecasting and simulation for problems in agricultural and resource economics. Applications with actual data and models emphasized.

**AREC 559 -- Advanced Applied Econometrics (4 units)**
*Description:* Emphasis in the course is on econometric model specification, estimation, inference, forecasting, and simulation. Applications with actual data and modeling techniques are emphasized.

**ECOL 581 -- Advanced Topics in Biological Statistics (3 units)**
*Description:* Advanced topics in statistical methodology relevant to Biology, Genetics and Ecology. Maximum likelihood, General Linear Models, randomization methods, power, distribution theory.

**ECON 517 -- Introductory Mathematical Statistics for Economists (3 units)**
*Description:* This course covers the basic mathematical statistics topics necessary for a deep understanding of applied econometrics. Topics include random variables, probability theory, probability and density functions, sampling, hypothesis testing, and point and interval estimation.
HWR 545 -- Statistical Hydrology (3 units)
**Description:** Application of statistics and probability to uncertainty in the description, measurement, and analysis of hydrologic variables and processes, including extreme events, error models, simulation, sampling. Graduate-level requirements include an in-depth simulation project.

HWR 645 -- Stochastic Methods in Subsurface Hydrology (3 units)
**Description:** Application of the theory of stochastic processes and random fields to natural variability in subsurface hydrology.

HWR 655 -- Stochastic Hydrology (3 units)
**Description:** Topics and applications will vary with instructor. Advanced application of statistics and probability to hydrology, time series analysis and synthesis, and artificial neural network methods, as applied in the modeling of hydro-climatic sequences or Bayesian and other analyses in the decision making process of water resources. A combination of theory and application to the fields of hydrology, environmental and water resources engineering, climatic modeling, and other related natural resource modeling.

MATH 509C -- Statistics for Research (3 units)
**Description:** Statistical concepts and methods applied to research in other scientific disciplines. Principles of estimation and hypothesis testing for standard one- and two-sample procedures. Correlation, linear regression. Contingency tables and analysis of variance.

MATH 561 -- Regression and Multivariate Analysis (3 units)

MATH 562 -- Time Series Analysis (3 units)
**Description:** Methods for analysis of time series data. Time domain techniques. ARIMA models. Estimation of process mean and autocovariance. Model fitting. Forecasting methods. Missing data. Students will be expected to utilize standard statistical software packages for computational purposes.

MATH 563A -- Probability Theory (3 units)
**Description:** Random variables, expectation and integration, Borel-Cantelli lemmas, independence, sums of independent random variables, strong law of large numbers, convergence in distribution, central limit theorem, infinitely divisible distributions.
MATH 564 -- Theory of Probability. (3 units)
**Description:** Probability spaces, random variables, weak law of large numbers, central limit theorem, various discrete and continuous probability distributions. Graduate-level requirements include more extensive problem sets or advanced projects.

MATH 565A -- Stochastic Processes (3 units)
**Description:** Stochastic Processes in continuous time: Levy processes, Martingales, Markov processes, introduction to stochastic integrals.

MATH 565B -- Stochastic Processes (3 units)
**Description:** Stochastic Processes in continuous time: Levy processes, Martingales, Markov processes, introduction to stochastic integrals.

MATH 566 -- Theory of Statistics (3 units)
**Description:** Sampling theory. Point estimation. Limiting distributions. Testing Hypotheses. Confidence intervals. Large sample methods. Graduate-level requirements include more extensive problem sets or advanced projects.

MATH 567A -- Theoretical Statistics (3 units)

MATH 567B -- Theoretical Statistics (3 units)

MATH 568 -- Applied Stochastic Processes (3 units)
**Description:** Applications of Gaussian and Markov processes and renewal theory, Wiener and Poisson processes, queues. Graduate-level requirements include more extensive problem sets or advanced projects.

MATH 570 -- Categorical Data Analysis (3 units)
MATH 571 -- Design of Experiments (3 units)
**Description:** Principles of designing experiments. Randomization, block designs, factorial experiments, response surface designs, repeated measures, analysis of contrasts, multiple comparisons, analysis of variance and covariance, variance components analysis.

MATH 574 -- Introduction to Geostatistics (3 units)
**Description:** Exploratory spatial data analysis, random function models for spatial data, estimation and modeling of variograms and covariances, ordinary and universal kriging estimators and equations, regularization of variograms, estimation of spatial averages, non-linear estimators, includes use of geostatistical software. Application of hydrology, soil science, ecology, geography and related fields.

PSYC 507A -- Statistical Methods in Psychological Research (3 units)
**Description:** Statistical research design, methods and metascience. Variants and extensions of the general linear model including bivariate and multiple regression, analysis of variance and covariance, planned orthogonal contrasts and multiple comparisons, simultaneous and sequential canonical correlation analysis, discriminant function analysis and multivariate analysis of variance.

PSYC 507B -- Statistical Methods in Psychological Research (3 units)
**Description:** Statistical research design, methods and metascience. Application of the structural equations modeling to manifest variable (path analysis) and latent variable (multivariate) causal analysis, confirmatory and exploratory factor analysis, and hierarchical (variance component) linear models, including generalizability theory, meta-analytic, and growth curve parameter models.

PSYC 507C -- Research Design & Analysis of Variance (3 units)
**Description:** This course provides an overview of research design and statistical analysis with a special focus on Analysis of Variance. Various designs including between subjects, repeated measures, mixed, hierarchical and Latin Square designs are covered. Other topics addressed are contrasts among means and trends analysis.

RNR 613 (ENTO 613) -- Applied Biostatistics (4 units)
**Description:** Introductory and advanced statistical methods and their applications in ecology. Focuses on how research design dictates choice of statistical models; explores principles and pitfalls of hypothesis testing.

SIE 520 -- Stochastic Modeling I (3 units)
**Description:** Modeling of stochastic processes from an applied viewpoint. Markov chains in discrete and continuous time, renewal theory, applications to engineering processes.

SIE 525 -- Queueing Theory (3 units)
**Description:** Application of the theory of stochastic processes to queueing phenomena; introduction to semi-Markov processes; steady-state analysis of birth-death, Markovian, and general single- and multiple-channel queueing systems.
SIE 530 -- Engineering Statistics (3 units)
**Description:** Statistical methodology of estimation, testing hypotheses, goodness-of-fit, nonparametric methods and decision theory as it relates to engineering practice. Significant emphasis on the underlying statistical modeling and assumptions. Graduate-level requirements include additionally more difficult homework assignments.

SIE 531 -- Simulation Modeling and Analysis (3 units)
**Description:** Discrete event simulation, model development, statistical design and analysis of simulation experiments, variance reduction, random variate generation, Monte Carlo simulation. Graduate-level requirements include a library research report.

SIE 533 -- Time Series Modeling, Analysis, and Applications (3 units)
**Description:** Principles for identifying parametric time series models from discrete data and relationship to autovariance, spectrum, and the Green's function from linear system theory are considered. Theory is developed for application to prediction characterization, signature analysis, and process identification and control. The applications of these theories include precision engineering, experimental mode analysis, process monitoring and diagnosis, quality control, analysis of machining operations, etc.

SIE 536 -- Experiment Design and Regression (3 units)
**Description:** Planning and designing experiments with an emphasis on factorial layout. Includes analysis of experimental and observational data with multiple linear regression and analysis of variance.

SOC 570A -- Social Statistics (3 units)
**Description:** Problems in classical regression analysis, single equation generalizations, simultaneous equations, time series models, hierarchical models.

SOC 570B -- Social Statistics (3 units)
**Description:** Latent variable models, pooled cross-section models, event history models.