THE UNIVERSITY OF CHICAGO

COMMITTEE ON GENETICS, GENOMICS & SYSTEMS BIOLOGY (GGSB) Graduate Program Handbook

Molecular Biosciences Cluster
Biological Sciences Division

2020-2021 Academic Year

COMMITTEE ON GENETICS & GENOMICS & SYSTEMS BIOLOGY (GGSB)
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ACADEMIC CALENDAR

Autumn Quarter 2020

September 7	Labor Day
September 21-25	Prelim Examinations Week
September 21-25	Orientation week
September 29	Autumn Quarter classes begin
October 28	Dissertation Office Draft Deadline for Autumn 2020 graduation
November 13	Winter 2021 Quarter rotation decisions due
November 13	Final Dissertation Submission Deadline Autumn 2020 graduation
November 23-27	Study Week/Thanksgiving Break
December 12	Autumn 2020 Quarter ends

Winter Quarter 2021

January 4	Winter Quarter classes begin
January 18	Martin Luther King, Jr. Day observance
February 1	First Year Winer Student Divisional Rotation Forms Due
February 3	Dissertation Office Draft Deadline for Winter 2021 graduation
February 5	Spring Quarter rotation decision due
February 19	Final Dissertation Submission Deadline Winter 2021 graduation
March 8	Thesis Advisory Committee members due (Second year students)
March 20	Winter Quarter ends

Spring Quarter 2021

March 29	Spring Quarter classes begin
April 5	Thesis Advisory Committee members due (Second year students)
April 28	Dissertation Office Draft Deadline Spring 2020 graduation
May 15	First Year Summer Student Divisional Rotation Forms Due
May 10	Date for Qualifying Exams due (Second year students)
May 15	Final Dissertation Submission Deadline Spring 2020 graduation
May 25	Memorial Day Holiday
June 12	Divisional Academic Ceremony - Spring 2020
June 13	Spring 2019 Convocation
June 13	Spring Quarter ends
May - June	Qualifying Exams held

Summer Quarter 2020

June 21	Summer Quarter begins
July 4	Independence Day observance
August 28	Summer Quarter ends

Helpful Links

Academic Calendar
Dissertation Office
Resources for Current Students
Human Genetics Graduate Program
Department of Human Genetics
Office of Graduate and Postdoctoral Affairs
Office of International Affairs
BSD & University Policies

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OTHER UNIVERSITY OFFICES

Main Number - University	773/702-1234
Main Number - Hospitals	773/702-1000
Campus Police (Call **123** from any University phone)	773/702-8181
University Voice Directory	773/702-1610
Student Health	773/702-4156
Student Counseling	773/702-9800
Student Disability Services	773/702-6000
Student Insurance (USHIP)	773/834-4543 (option #2)

COMMITTEE ON GENETICS, GENOMICS & SYSTEMS BIOLOGY WEBSITE: ggsb.uchicago.edu

PROGRAM OF STUDY IN BRIEF

The guidelines in this handbook are official policies of the Committee on Genetics, Genomics & Systems Biology (GGSB). Students and faculty of the Committee are expected to follow these policies. Students with questions not answered by this handbook are encouraged to contact the GGSB Graduate Education Administrator (Sue Levison at slevison@bsd.uchicago.edu Office: 773/702-2464 or Cell: 773/307-2237) or the Chair of GGSB, (Marcelo Nobrega - mnobrega@bsd.uchicago.edu or 773/834/7919).

First Year

The first year of graduate study is spent completing coursework, exploring research opportunities and performing laboratory rotations. Throughout their course of study, all students are registered as full-time (300 units) during the Autumn, Winter, Spring, and Summer quarters.

Graduate students in the Biological Sciences Division (BSD) are required to take 9 credits of course work for their Ph.D. Most classes are completed within the first year. In addition to the course requirements, students are required to attend the Faculty Research Seminar Series (GENE 31900) to acquaint them with faculty research programs. This series is also referred to as "AllStars". Students are also required to undertake short research projects in at least two different laboratories before beginning their dissertation research. These rotations are to be performed during the first academic year. During the Autumn, Winter and Spring quarters the rotation lasts ten weeks, coinciding with the academic quarter. One ten week or two five week rotations is done during the summer when the student is able to devote full time to research.

All students are expected to attend the monthly Genetics Seminar Series starting from the Autumn of their first year and throughout their tenure in the program (classes permitting).

Second Year

Just prior to the start of the second year, in September, students take the Preliminary Examination as a first step towards candidacy for their Ph.D.

At the beginning of the second year, students also choose a Research Advisor. Under unusual circumstances (and with approval of the Curriculum/Student Affairs Committee), students are allowed to carry out a laboratory rotation during the Autumn quarter before choosing an advisor.

Once a Research Advisor is chosen, a Student Doctoral Committee is formed. The Curriculum/Student Affairs Committee (CSAC), in consultation with the student and the student's advisor, appoints its members. The Student Doctoral Committee is comprised of the Research Advisor and three-four other faculty members, of which one will be appointed the Thesis Committee Chair. **At least three of the four committee members must have a GGSB faculty appointment.**

While most or all coursework will be completed in the first year, one course elective may be taken during the second year. If a student is interested in deferring more than one course beyond the first year, that student must petition the CSAC to receive approval.

Most of the second year is spent developing a research project and preparing the student to submit a written proposal for dissertation research. This proposal must be defended in front of the Student Doctoral Committee before the end of Spring quarter (which is known as the Qualifying Examination). Passing the Qualifying Examination permits the student to enter into candidacy for the Ph.D.

Starting in their second year, students are expected to attend and present at the Genetics Journal Club, where faculty and students review current research papers. Also in the second year, students are expected to attend the Genetics Work-in-Progress, where advanced students and Post Doc fellows give presentations.

Advanced Years

After passing the Qualifying Examination, students work full-time on thesis research while continuing to attend seminars, journal clubs, work-in-progress presentations, etc. Students are welcome to audit courses in which they have an interest with the approval of their PI.
Finally, each graduating student writes a dissertation describing his/her research, presents their work in a public seminar, and defends it before his/her Doctoral Committee members.

The dissertation research period should take approximately 12-16 quarters, with the total duration of coursework and research not to exceed 26 quarters.

Evaluation

GGSB expects each student throughout his/her term as a graduate student, to have numerous informal conversations with the Chair of GGSB, professors in their courses, their Research Advisor and (in later years) members of their Doctoral Committee. This allows students to obtain constructive advice and frequent appraisals of their progress.

Evaluation of each student's progress will take place each academic year. In the first and second years, the evaluation is based on the student's performance in courses, laboratory rotations and the Preliminary Examination. In later years, the Research Advisor and Doctoral Committee report to the CSAC on the student's dissertation research progress after the yearly meetings. If the CSAC is apprised of deficiencies in performance, the student will receive a letter describing those deficiencies along with suggestions as to how these deficiencies might be remedied.

Steering/Curriculum Committee (SCC)

The Steering/Curriculum Committee (SCC) makes all decisions regarding administrative policies for GGSB, reviews new GGSB faculty appointment applications. This faculty committee is responsible for advising all students during their first year of graduate study or until a Research Advisor has been chosen. Each student is assigned a member of the SCC to serve as temporary advisor during this time and to aid in selecting courses and arranging lab rotations. In addition, the SCC makes the final decisions on the granting of degrees and on the retention of students as degree candidates.

Curriculum/Student Affairs Committee

The Curriculum/Student Affairs Committee (CSAC) oversees the current curriculum and the development of new curriculum. This Committee conducts a quarterly review of each student's course. Members of the CSAC meet with first year students after each quarter to discuss any issues concerning the first year curriculum or other topics of concern. The GGSB Student Representatives are invited to present student concerns at the CSAC meetings as they arise.

Graduate Education Administrator

The Graduate Education Administrator, Sue Levison, provides assistance to students on a variety of questions and problems as they arise. The office is located in CLSC 1111. The office phone number is 773/702-2464; Cell phone is 773/307-2237 and e-mail address is slevison@bsd.uchicago.edu.

REQUIREMENTS FOR THE Ph.D. DEGREE

A Ph.D. candidate must fulfill certain formal coursework requirements, pass the Preliminary and Qualifying Examinations and present a satisfactory dissertation describing the results of original research.

The Committee expects a knowledge of and proficiency in genetics. This requirement will normally be met by fulfilling the formal coursework listed below, but detailed degree programs are flexible. Courses taken at other

institutions, in other departments, or as part of the Medical School curriculum may substitute for genetics courses with approval of the CSAC.

Formal Coursework: Choice of Two GGSB Tracks: Empirical Track or Computational Track

To obtain a Ph.D. in the Division of Biological Sciences, nine graded courses are required as detailed below.

GGSB has two tracks, one "Empirical Track", and the other "Computational Biology". While the two tracks are united by the common goals of using genetic, genomic and systems biology approach to address important biological questions, the training focus is different. Training of the first track is more focused on experimental techniques, especially those quantitative in nature, while the second track builds computational skills of students. The curriculum of the two tracks, as a result, will be different, as outlined below.

GGSB EMPIRICAL TRACK (4 REQUIRED COURSES AND 4 ELECTIVES)
Suggested "tracks" for students interested in concentrating in the Empirical track have been developed by the CSAC. (Model Systems, Population Genetics, Human Genetics, Developmental Genetics, and Genomics & Systems Biology). A summary of the suggested tracks can be found on the **GGSB website**. Students are required to consult with their assigned mentor prior to registration each quarter.

A total of four graded electives must be taken, one of which may be a reading course. The electives can be selected according to the student's interests and the availability of courses.

Additional questions about the curriculum should be directed to the Chair of GGSB.

Four [4] Required Courses: MGCB 31400: Genetic Analysis of Model Organisms *(Autumn)* **AND** HGEN 47300: Genomics and Systems Biology (Spring)

Plus One [1] of the Following Two Courses: MGCB 31200: Molecular Biology I (Winter) **OR** MGCB 31300: Molecular Biology II (Spring)

Plus One [1] of the Following Four Courses: ECEV 44000: Fundamentals of Molecular Evolution *(Autumn)* **OR** ECEV 35600: Principles of Population Genetics I (Winter) **OR** ECEV 35901: Evolutionary Genomics (*Spring*) **OR** HGEN 46900: Human Variation & Disease (Spring)

Plus Two [2] Lab Rotations
BSDG 40100 Non-Thesis Research: Biological Sciences. Laboratory Rotation 1) (Winter **OR** Spring) **AND** BSDG 40100 Non-Thesis Research: Biological Sciences. Laboratory rotation (Summer*)* **Optional third rotation** BSDG 40102 Genetics: Lab Rotation 3. Laboratory rotation (Second 5 weeks of quarter) (Summer*)*

Empirical Track Course Electives [4 courses]:
- Must take 4 courses (see list of approved electives).
- Students may petition the CSAC for approval of courses not listed in this handbook as "approved".
- At least 3 of the 4 electives are to be taken **before** the Preliminary Exam.
- All 4 electives should be taken before the Qualifying Exam.
- One of the 4 elective courses may be taken pass/fail subject to CSAC approval.
- One of the electives may be a graded reading course (see guidelines for reading courses).

GGSB Computational Track Coursework

(Three required courses **AND** three core electives **AND** two additional elective courses **PLUS** two rotations)
Suggested "tracks" for students interested in concentrating in the Computational Biology Track have been developed by the CSAC. (Population Genetics & Evolution, Statistical Genetics, Computational Genomics, and Computational Cell Biology) A summary of the suggested tracks can be found on the **GGSB website**. Students are required to consult with their assigned mentor prior to registration each quarter.

Additional questions about the curriculum should be directed to the Chair of GGSB.

Three required courses in Computational Biology and Statistics
STAT 24400 Statistical Theory and Methods I (Autumn) **AND** HGEN 48600 Fundamentals of Computational Biology: Models and Inference (Winter) **AND** HGEN 48800 Fundamentals of Computational Biology: Algorithms and Applications (Spring)

Plus Three Core Elective Courses Chosen from the Following List
HGEN 47000 Human Genetics I (Autumn) **OR** MGCB 31400 Genetic Analysis of Model Organisms (Autumn) **OR** HGEN 47100 Introductory Statistical Genetics (Winter) **OR** ECEV 35600 Principles of Population Genetics I (Winter) **OR** ECEV 31100 Evolution of Biological Molecules (Winter) **OR** BCMB 32200 Biophysics of Biomolecules (Spring) **OR** HGEN 46900 Human Variation and Disease (Spring) **OR** HGEN 47300 Genomics and Systems Biology (Spring) **OR** MGCB 32000 Quantitative Analysis of Biological Dynamics (Spring)

Plus Two Lab Rotations
BSDG 40100 Section 11 / BSDG 40102 Section 11 Human Genetics Laboratory Rotation (Autumn, Winter, Spring, Summer) NOTE: Two lab rotations count as one class.

Plus Two [2] Additional Elective Courses Chosen From the Following List
BIOS 20186 Fundamentals of Cell and Molecular Biology (Autumn) **OR** STAT 34300 Applied Linear Statistical Methods (Autumn) **OR** STAT 37790 Topics in Statistical Machine Learning (Autumn) **OR** CMSC 37720 Computational Systems Biology ((Autumn) **OR** STAT 30900 Mathematical Computation I — Matrix Computation (Autumn) **OR** ECEV 32000 Introduction to Scientific Computing for Biologists (Winter) **OR** BIOS 20187 Fundamentals of Genetics (Winter) **OR** STAT 24500 Statistical Theory and Methods II (Winter) **OR** STAT 32950 Multivariate Statistical Analysis: Applications and Techniques (Winter) **OR** ECEV 42900 Theoretical Ecology (Winter) **OR** STAT 24610 Pattern Recognition (Spring) **OR** STAT 30210 Bayesian Analysis and Principles of Statistics (Spring) **OR** STAT 35500 Statistical Genetics (Spring) **OR** STAT 37710 Machine Learning (Spring)

ADDITIONAL GGSB REQUIREMENTS FOR BOTH EMPIRICAL AND COMPUTATIONAL TRACKS:

GENE 31800 Current Seminar Topics in Genetics This course will expose student to current research topics in genetics for the bi-monthly GGSB Invited Seminar Series. **This is a required ½ credit course for all GGSB students and will be graded Pass/Fail.** *(Autumn, Winter, Spring)*

ADDITIONAL DIVISIONAL REQUIREMENTS FOR BOTH GGSB TRACKS:

GENE 31900 Introduction to Research (Allstars) Lectures on current research by departmental faculty and other invited speakers. A required course for all first-year graduate students. *(Autumn)*

BSDG 55100 Responsible, rigorous, and reproducible conduct of research: R3CL Required of all BSD first-year doctoral students. The course is designed to stimulate thinking and facilitate discussion about the purpose and necessity of ethical conduct with respect to scientific and academic practices; to create personal awareness of the ethical dilemmas and choices that may be encountered in the course of a career in the sciences; to increase awareness and understanding of the importance of reproducible, rigorous, and transparent research; and to provide practical information regarding policies and procedures related to conduct in the Division of Biological Sciences at the University of Chicago. *(Winter)*

MGCB 32100 Senior Graduate Ethics A second training in the ethical conduct of research is required for students still registered four years after their initial training. Senior ethics training content is more closely aligned with research areas and so this training is coordinated by the individual graduate programs. *(Spring every other year)*

Students should note that several courses have prerequisites for enrollment, or require the consent of the instructor. Students entering GGSB with advanced coursework at graduate level should inquire whether this coursework can substitute for required electives.

Students are required to do **two** laboratory rotations **before** selecting an advisor and laboratory to pursue a Ph.D. dissertation.

Students are expected to maintain a grade average of "B" or higher. Students who fail to do so will be placed on academic probation with continuation in the program dependent upon improved performance. Should a student receive a D or F in any course during any quarter, the student will be immediately placed on academic probation.

Students concluding their first year without a "B" average will be terminated from the program after Spring quarter unless otherwise recommended by the CSAC.

If a student fails to pass the Preliminary Examination or the Qualifying Examination, the student will be terminated by the end of the respective quarter, unless otherwise recommended by the members of the CSAC.

Introduction to Research (Allstars)

All first-year students are required to attend the GENE 31900 Introduction to Research course ("AllStars") during the Autumn quarter. This course is designed to provide incoming students with information on the variety of faculty research opportunities available and experience with oral presentations. This course is offered pass/fail. Strict compliance with the attendance policy is required for a passing grade.

Scientific Ethics Courses (Responsible, rigorous, and reproducible conduct of research: R3CR)

All first-year students are required to attend a scientific ethics class organized by the Dean of Students Office. This course is offered during the spring quarter and features sessions on scientific ethics that often involve examining case studies. The course organizer distributes announcements with the title of each talk and the name of the faculty members who will present.

A second training in the ethical conduct of research is required for students still registered four years after their initial training. Senior ethics training content is more closely aligned with research areas and so this training is coordinated by the individual graduate programs.

Prescribed Courses

In some instances, a student's undergraduate training may not have prepared him/her for a required course. In such cases, the CSAC will prescribe an appropriate graduate or undergraduate course if necessary. In some such cases, the prescribed course can be counted as a graduate elective.

Reading Courses

All Reading Courses (GENE 39900) must be approved by the CSAC prior to registration. Every reading course must conform to the following requirements: 1) it must meet weekly, 2) the instructor must provide a syllabus for the course and an evaluation of the student's performance, both of which will become part of the student's file and 3) the student must submit a written paper.

Laboratory Rotations

Students are required to perform at least two laboratory rotations before selecting an advisor and laboratory to pursue a Ph.D. dissertation.

Students undertake short research projects in at least two different laboratories before beginning their dissertation research. The purpose of the rotation is to expose the student to different research environments, broaden his/her acquaintance with useful laboratory techniques, and introduce him/her to the conceptual framework of experimental design.

The distribution of course offerings makes it difficult for students to undertake rotations in the Autumn quarter of the first academic year. Therefore, rotations are typically performed in the Winter or Spring and Summer quarters. During the Autumn, Winter and Spring quarters the rotation lasts ten weeks, coinciding with the academic quarter. One ten week or two five week rotations is done during the Summer Quarter when the student is able to devote full time to research.

Students arrange their own rotations, in consultation with their academic advisor by contacting potential mentors directly. **After the student and mentor have agreed on the time period for the rotation, the student must complete a Divisional Lab Rotation form, signed by the mentor, the students, the Graduate Education Administrator and the Chair of GGSB to confirm the arrangement.**

Students should have their Spring quarter rotation arranged by February 1st. The Summer rotation(s) should be in place by May 15th.

Students who would like to rotate with someone who is not a member of the GGSB faculty should petition the CSAC for approval.

At the end of the rotation, the mentor will provide a written evaluation of the student's performance. The first two required rotations will be graded. Rotations, Non-Thesis Research, and Thesis Research carried out thereafter will be given a pass/fail.

Teaching Assistantships

All graduate students are required to serve as a Teaching Assistant in two courses for academic credit before the PhD degree is awarded. Courses can be undergraduate, graduate, or medical, but must be in the Biological Sciences Division.

The ability to communicate verbally and to teach are important skills for a successful research career. As such, all students are required to serve as teaching assistants (TAs) for two quarters, with responsibilities that may include leading discussion groups, writing problem sets, and running laboratories. Students normally undertake their teaching assistantships during the second and third years. A course designed to train graduate students to be an effective TA may be taken in lieu of one of the two assistantships. The student must receive approval from the Curriculum Committee prior to accepting a teaching assistantship. The two required TAships must be completed prior to the end of their fourth year of study.

Students with extensive teaching experience at the graduate level (e.g. while studying for a Master's degree) are permitted to petition for waiver of the teaching requirement. The petitioner must provide documented evidence of prior teaching experience. For additional information, please contact the Graduate Education Administrator.

Students may not TA for pay before completing the requirement; they may only TA the same course twice IF there is significant changes in responsibilities and opportunities to learn new skills in teaching.

Preliminary/Qualifying Examinations

The Biological Sciences Division requires that "a general oral or written qualifying examination, separate from course examinations, must be passed by the student upon the major subject offered and such subordinate subjects as may be required by the Department concerned." In GGSB, this examination has two parts 1) the Preliminary Examination and 2) the Qualifying Examination. The examination procedures have been designed to ensure that preparing for the exams should be an educational experience for the student. Questions about these examinations that are not answered by the information that follows should be directed to the Graduate Program Administrator.

Preliminary Examination (Part I)

The objective of the Preliminary Examination (Part I) is to determine the strength of a student's general

knowledge of genetics as well as his/her ability to synthesize an overview of research problems of active interest, based on the literature. The exam is typically taken in September following the student's first year.

Students must have completed the 4 required courses and at least three of the four elective courses to sit for the Preliminary Exam. Students also must have a "B" average or permission from the CSAC to take this exam.

For the Preliminary Exam, students will be given a set of questions and are expected to prepare responses to three of the questions. A starting point for references will be included with the Exam. Two weeks after receiving the questions, the student will be asked to present his/her answers orally for three questions.

The Preliminary Exam lasts for approximately two hours. Students are allowed to use books, reference materials, lecture and seminar notes to answer the questions. Students are also free to discuss the questions among themselves and with faculty. The format of the presentation should be a short lecture (approximately 15 minutes) designed to teach a generally knowledgeable group about the topic. The presentation should concisely review the pertinent background information, state the question being asked, and lay out an experimental plan (if applicable). Potential pitfalls and difficulties should be evaluated. Answers should not be read from a prepared text. However, one 5x8 note card and six PowerPoint slides for each question may be brought to the Exam. There will also be a board to write on. One of the purposes of the Preliminary Exam is to provide practice in oral presentations and discussion. The faculty will question the student further about the general subject of the presentation. There will be three examiners on each Preliminary Examining Committee from the GGSB faculty. The Preliminary Exam committee members are made public two days prior to the Exam.

Based upon the student's performance, the Preliminary Exam Committee **recommends** one of the following options:

A. Pass unconditionally.
B. Pass conditionally, with written answers to a question(s) required. Answers should be submitted within two weeks. The student will then meet again with the Exam Committee to defend his/her answers.
C. Pass conditionally, with further course work required in one or two areas.
D. Fail, with the recommendation that the student retake the exam within the quarter.
E. Fail, with the recommendation that the student leave the program.

The CSAC then meets to consider this **recommendation**, taking into account the student's overall academic performance as well as his/her performance on the Exam. If a student who fails the Exam is allowed to retake it, the Committee for the re-take will be selected by the CSAC in consultation with the Chair of the GGSB and will contain at least one member of the first Preliminary Examining Committee

The Qualifying Examination (Part II)

The Qualifying Examination (Part II) evaluates a student's ability to propose and defend a doctoral thesis research plan. Upon successful completion of this Exam, the Qualifying Examining Committee becomes the student's Doctoral Advisory Committee (i.e. Thesis Committee). A student must have the endorsement of his/her Research Advisor in order to sit for the Qualifying Examination. In the event that a Research Advisor declines to endorse a student for the Qualifying Exam, the Steering Committee will review the student's record to determine if that student will be allowed to seek a new Research Advisor or be asked to leave the program.

Once the student chooses a Research Advisor, the student, in consultation with their Research Advisor, formulates a list of four or five prospective Qualifying Exam Committee members (including the student's advisor) and submits the list to the Graduate Program Administrator who will forward it on to the CSAC for their review and approval. This review is designed to help ensure that the proposed committee members are qualified and appropriate and, in keeping with the interdisciplinary nature of the program, the expertise of the members is broad-based. It is not uncommon for the CSAC to recommend the addition of a committee member to broaden the overall expertise of the committee. Final decisions on committee membership will be made by agreement between the CSAC, the Research Advisor, and the student.

In addition to approving the initial Doctoral Advisory Committee, the CSAC must also approve replacements when members of a Doctoral Committee resign. In the event that more than one member of a Doctoral Committee resigns, the Steering Committee will meet to consider the circumstances that led to these resignations and decide on an appropriate course of action. Possible courses of action include (but are not limited to) replacement of committee members, formation of a new Doctoral Committee or reconsideration of the student's qualifications for candidacy.

After the Qualifying Exam, the Qualifying Exam Committee members will continue to serve as the Doctoral Advisory Committee throughout the course of the student's doctoral research. This Doctoral Committee will be chaired by a member other than the student's Research Advisor. The function of the Doctoral Committee is to monitor the student's progress and to assist the student in the development of their dissertation research. For this reason, the choice of the members of the Doctoral Committee should be based on their knowledge and expertise in the area of the student's research. In the event the student chooses to work with a member of the faculty who does not have an appointment in the GGSB, the student must petition the Committee for approval. **At least three members of the Doctoral Committee, including the Chair, must have faculty appointments in GGSB.** It is important to note that the Qualifying Exam is not a thesis defense. It does not require preliminary results although, if available, they can be used. The exam tests the student's ability to:

1. Choose a topic, that is, formulate an important biological question;
2. Propose a coherent set of avenues to answer the question;
3. Summarize critically the current literature on that topic; and
4. Describe a series of experiments taking into account possible pitfalls and therefore alternative approaches.

The written proposal should be modeled after an NIH postdoctoral grant application which should consist of general and specific aims (no more than one page), background and significance (no more than three pages), methods of procedure and a description of your experimental approaches (no more than six pages). This is not a place for trivial experimental details. The recommended length of the proposal, including references and figures, is 10 pages.

Prior to submitting the written proposal to his/her Doctoral Committee, the advisor must approve the proposal for distribution. The written proposal should be submitted to the Graduate Program Administrator by the fifth week of the Spring quarter of the second year (see Calendar of Events for this year's deadline). The student should practice presenting the oral exam prior to the final presentation at the Qualifying Exam. One example would be at the student's lab meetings. The oral exam should be completed by the last week of the Spring quarter. It is the student's responsibility to schedule their Qualifying Exam in a timely manner to ensure that the deadline is met. In the event that circumstances indicate a different schedule, or the student's Doctoral Committee is unable to meet prior to this time, the student must secure permission to postpone the Preliminary Examination from the CSAC. Once the student has fulfilled all course requirements and passed the Qualifying Examination, the student will be admitted into Candidacy for the degree of Ph.D.

Annual Doctoral Committee Meetings

All students are required to meet at least once a year with their Doctoral Committee and present a brief written report of their research as a basis for discussion. **This report must be submitted to all Doctoral Committee members and to the Graduate Program Administrator at least two weeks prior to the meeting**. An example of a written report can be found in the GGSB office. At least three members of the Doctoral Committee must be present. These meetings help to ensure that students are making adequate progress toward the completion of their dissertation and to provide the student with a broader base of expertise on which to draw for help and advice. They also strengthen the student's acquaintance with faculty other than their Research Advisor, providing a stronger basis for future letters of recommendation. When the Doctoral Committee approves it, the student may prepare their dissertation. Following each meeting, the Chair of the Doctoral Committee will prepare a written summary and send it to the student and the student's advisor for their approval and signature. The completed summary will then be given to the Graduate Program Administrator and subsequently provided to the student.

Penultimate Meeting

The Doctoral Committee should convene six months before a student expects to receive his/her degree to indicate their agreement that the student is nearing completion of their work and to arrange for subsequent approval that the student may begin writing their dissertation. In general, the mentor and other members of the Doctoral Advisory Committee should endeavor to minimize the possibility of an unsuccessful thesis defense via thoughtful and straightforward advice to the candidate. The Penultimate meeting is particularly important in this regard. Permission to write should not be granted if more than one member of the committee lacks confidence that the thesis will be acceptable. The written report from the penultimate meeting should contain a fairly detailed description of any additional work that needs to be completed prior to submission of the thesis. This list should be limited to a small number of minor items. If, in the judgment of the Doctoral Advisory Committee, substantial work is needed prior to the thesis defense, an additional meeting should be scheduled to review that work before permission to write is granted.

Presentation of the Dissertation

Each graduating student writes a dissertation describing his/her research. Following approval by the student's advisor, the thesis must be delivered to the Doctoral Committee for a two-week reading period. At this stage, the thesis should be in near final form and not in a draft state. The student then presents the work in a public seminar, and defends it in front of their Doctoral Committee.

The University has strict rules concerning the preparation of the dissertation. Detailed information can be obtained from the Dissertation Office located on the first floor of the Regenstein Library, Room 100B, or from the Dissertation Office webpage https://www.lib.uchicago.edu/research/scholar/phd/, which has the most current information about upcoming deadlines, required forms, etc.

The Ph.D. dissertation should contain a description of the research performed. In addition, it must contain:
1. An introduction covering the scientific background of the project(s);
2. A discussion of the student's own results and their significance in the field; and
3. A summary of their work.

These should be separate sections of the thesis and written independently by the student. Published manuscripts may be included as chapters in the thesis, but separate Introduction, Discussion and Summary sections covering the entire thesis are still required. In cases where collaborative experiments are included in the thesis, the student must clearly indicate the specific contributions made by the individuals involved.

The final dissertation, together with a certificate of approval signed by the Committee Chair, must be submitted to the Dissertation Office no later than three weeks before the date of the convocation. The final Exam Committee consists of at least five faculty members, three of whom must be members of the student's Doctoral Committee and at least three of whom are members of the GGSB faculty.

1. Each member of the Thesis Defense Committee must vote "yes" or "no" on the defense form immediately following the defense (i.e. before leaving the room). Thesis Defense Committee members are not allowed to abstain from voting.
2. If more than one member of the Thesis Defense Committee votes "no" the student will be required to revise the thesis according to instructions provided by the Exam Committee and meet any additional conditions set by the CSAC within one week of the defense. The revised thesis must then be defended in a closed session with a committee consisting of at least one member of the original Thesis Defense Committee and at least one new member.
3. If, following the defense of the revised thesis, a candidate receives more than a single "no" vote from a committee member, the candidate will be denied the Ph.D.

Master's Degrees – Transitional and Terminal

The Committee on Genetics, Genomics & Systems Biology gives Transitional and Terminal MS degrees.

Transitional Master's Degrees

Upon completing all course requirements with a "B" average **and** successfully passing the Preliminary and Qualifying Examinations GGSB students will receive a Transitional MS degree. However, the Transitional MS Degree will only be issued **once the student has successfully defended his/her thesis** (not after qualifying exams).

Terminal Master's Degrees

For a student who decides not to complete his/her Ph.D. candidacy, or who loses Ph.D. candidacy status, but has completed all course requirements with a "B" average **and** has successfully passed the Preliminary Examination may be eligible for a Terminal Master's degree. The Steering Committee makes final decisions with respect to the granting of Master's degrees.

Seminars

In addition to formal courses, there are many regularly scheduled research seminars that help keep students updated on new developments in genetics and related disciplines.

All students are **required** to attend the Genetics Seminar Series. Students are also **expected** to attend the GGSB Journal Club and the GGSB Work-in-Progress class schedules permitting

GGSB Invited Seminar Series features a research talk by a visitor from outside the University of Chicago. Check the Events Calendar on the GGSB website for the most current schedule.

The GGSB Journal Club is a presentation of a current journal article of current relevance to the field of human genetics research. Presentations are made by second year students in consultation with a faculty member.

The GGSB Work-in-Progress format is a one-hour meeting, which includes two ~20 minute research presentations from advanced students and/or post-docs from different labs, plus time after each presentation for a discussion.

FINANCIAL SUPPORT

The Department of Human Genetics attempts to ensure that all students registered in the Ph.D. program are provided with adequate financial aid. Financial support is guaranteed to all incoming students for their first four years, subject to satisfactory academic performance. Support for subsequent years of study is subject to the student's satisfactory research progress, as determined by the faculty sponsor, the Doctoral Committee and the Division of Biological Sciences.

Sources of Support

Students receive tuition plus a stipend. The various sources of support include, but are not limited to:

- Divisional Funding
- NIH Training Grants
- External Fellowships
- University Fellowship
- Research Assistantships

Payment of Stipend Checks

Divisional funding and NIH checks are paid in equal quarterly installments at the beginning of each quarter and cover the calendar year. Taxes are owed on, but not deducted, from these stipend checks (see section on "Taxes" below).

Research Assistant Type B (RA Type B) and Research Assistant Type A (RA Type A) students are paid on a monthly basis. Taxes will be deducted from the RA Type-B checks.

Taxes

Graduate student stipends are taxable by Illinois and the Federal government. Students on fellowships and NIH training grant support must calculate and pay estimated taxes several times a year.

The following IRS forms provide information on determining what portion of your stipend is taxable and when to pay taxes you owe: Tax Benefits for Education, PUB 970; US Tax Guide for Aliens, PUB 519 and US Tax Treaties, PUB 901. IRS form 520 provides information on determining what portion of your stipend is taxable and how and when to pay taxes you owe. These forms are available from the IRS. Regenstein Library also carries tax forms particularly after January 1st. For additional information see: http://www.irs.gov/Individuals/Students

Supplies and Research Expenses

In general, costs of research supplies and equipment are covered by grants or contracts held by the faculty member in whose laboratory you are working. Limited funds for supplies are available on training grants, and are disbursed on an annual pro-rated basis, directly to the laboratories in which trainees are working.

Travel to Scientific Meetings

Attendance at scientific meetings is an important part of the educational process. Should you wish to apply for support, check with the source of your funding, (your Research Advisor, or training grant or fellowships). When making your request, please supply the following information: purpose of meeting and relevance to the research; title, place and time of the meeting; title and authors of paper being presented; and amount requested for travel, registration fees, food and lodging. GGSB is not able to provide financial support to students for scientific meetings

REGISTRATION

General Information

Approximately one week before the dates designated for registration, the Graduate Education Administrator will contact students via email informing them of the dates and times to register online. If a student does not register for their courses prior to the deadline, they will be charged a late registration fee of $100.

Special registration procedures have been established for the first year students in the Autumn quarter. During Orientation week, first year students will meet with the HG Program Chair and Curriculum Committee to finalize their Autumn Courses and map out a program of study for the first year. Also during Orientation Week, the Graduate Education Administrator will meet with first year students to assist with their Autumn registration If necessary, second year students also will meet with members of the Curriculum Committee to review their progress in the preceding year and to discuss further degree requirements.

Residency Status

All students are in one of three levels of residency, depending on the number of quarters they have been registered at the University. The three levels and the number of corresponding registration units are:

Scholastic Residence (SR) Years 1-4: Students in SR are eligible for all benefits associated with full time student status at the University, such as the student health plan, university housing, student loans and loan deferment.

Advanced Residence (AR) Years 5-12: Students in AR are eligible for all benefits associated with full time student status at the University, such as the student health plan, university housing, student loans and loan deferment. :

Extended Residence (ER) - Years 12 and beyond: Students in ER are entitled to use of the library, email accounts, networked access, and faculty contact, but not to other benefits or facilities.

Leave of Absence

During Scholastic and Advanced Residence a student may, if necessary, apply for a Leave of Absence from the Ph.D. program to be approved by the GGSB Chair and the CSAC. Only students in good academic standing will be granted a Leave of Absence.

Pro-Forma Registration

Students in Advanced Residence, whose dissertation research requires residence away from Chicago, may register pro-forma. A fee per quarter is assessed, and keeps the student in full-time registration for purposes of reporting to outside agencies such as to defer student loans. Pro-forma status establishes a good faith relationship between the student and the University. The following regulations apply:

- Pro-forma registration is approved for only one academic year at a time and the maximum pro-forma enrollment allowed is eight quarters
- Applications for pro-forma registration must be approved in writing by the Department of Human Genetics Program Chair, whose signature means that the student's work away from Chicago is recognized as essential to the dissertation. Normally, students applying for pro-forma status will have been admitted to candidacy and have had dissertation topics approved.
- An applicant for renewal of pro-forma status must show the GGSB Program Chair that good use has been made of the time already spent "on location" and that additional time is essential to completing the original task. Renewals of pro-forma status must be approved by the Office of Graduate and Postdoctoral Affairs.
- A student on pro-forma status may not be gainfully employed for more than 19 hours a week.
- Pro-forma students may not use the facilities of the University or the time of its faculty, except for progress reports that may be required by the students' program.
- The Registrar will certify that a pro-forma student is duly registered at the University to any agency requiring such certification.
- The fact that a registration is pro-forma will be noted on the student's academic record.
- Pro-forma registrations do not count toward satisfying a student's residence requirements toward a degree.

Visiting Non-Degree Students

Students who have moved to the University with their advisor but who are still registered at their home institution are given the status of Visiting Non-Degree Students. This gives them access to the libraries and to athletic facilities while they are completing their degrees.

MISCELLANEOUS INFORMATION

Curriculum Committee

This faculty committee is responsible for advising all students during the first year of graduate study or until a research advisor has been chosen. Each student will be assigned a member of the committee to serve as temporary advisor during this time and to aid in selecting courses and arranging lab rotations. This committee conducts a quarterly review of each student's course performance and administers the preliminary examination. Members of the Curriculum Committee meet with first-year students after each quarter to discuss any issues concerning the first-year curriculum or other topics of concern.

Student Representatives

GGSB students have student representatives to represent GGSB student concerns as needed at the quarterly Steering/Curriculum Committee meetings. At any time should a student representative have an agenda item

for one of these meetings, they should contact the Graduate Education Administrator to add that item to the agenda for the next meeting. Each representative has a two year term, with one representative new each year, and the other tenured by one year. Each summer, once a representative's two year term has expired, a new representative is appointed. Student representatives also participate in Molecular Biosciences Cluster events, such as Orientation, Retreat and Recruitment planning. These representatives are volunteers who are interested in participating and contributing to these events. The Student Representative will ask for volunteers each year. Students interested in becoming a student representative should contact the Graduate Education Administrator.

Molecular Biosciences Retreat

The Molecular Biosciences Annual Retreat provides an opportunity for students, post-docs, and faculty to meet in a pleasant, informal setting to learn about the various research programs of the various research laboratories. The program consists of several sessions of presentations by students and post-docs. Each session is chaired by a faculty member. There is also a poster session. The Retreat is held annually in the Autumn quarter.

ID & Privileges Office

The ID & Network Privileges Office, located in the lobby of Regenstein Library (1100 E. 57th Street), is a joint venture between the Library and IT services. They offer a variety of services to the University community. Their main services include: UChicago Cards, Library access and privileges and Passport photos

Bursar's Office

The Bursar's Office, located at 6030 S. Ellis Avenue, 2nd floor and is open to the public weekdays from 9:00 a.m. to 4:00 p.m. The University Cashier (In-Person Cash and Check Payments) is located at 5525 S. Ellis (55th and Ellis Parking Structure). Students may contact the follow Bursar's Office number for information:

- Tuition Inquiries & Bursar Restrictions: 773/702-7086
- Other Information: 773/702-8000
- For additional information go to: http://bursar.uchicago.edu/

Student Wellness
(Student Health Services / Student Counseling Services / University Student Health Insurance Plan (USHIP)

Student Health Services provides health care to all registered students in the University. It is funded by a mandatory quarterly Student Services Fee. Payment of this fee allows the student access to the University's Student Health Services. Some specialized and emergency care is not covered, nor does the fee include the cost of outside referrals, laboratory tests, and hospitalizations.

University Student Health Insurance Plan (USHIP) In addition to participation in Student Health Services, all students are **REQUIRED** to carry a health insurance plan (either university student health insurance or comparable insurance) to cover the costs of hospitalization, outpatient diagnostic and surgical procedures, laboratory tests and catastrophic illness. Charges for university insurance are assessed for each of three quarters (Autumn, Spring, Winter); there is no charge for coverage for the Summer Quarter. Additional information can be found on the, University Student Health Insurance Plan (USHIP) website

Students with comparable group insurance coverage through a parent, spouse, or their own policy may request that participation in the university program be waived. However, they must cover the cost of alternative health insurance out of their own pocket.

Student Counseling Services
UChicago Student Wellness is committed to promoting the mental health and well-being of UChicago undergraduate and graduate students by providing accessible, high-quality, culturally sensitive mental health services. We also provide outreach and consultation to the University community. All of their services are

covered by the Student Services Fee, and there is no additional cost for students to access our services. Call 773.702.9800 to make an appointment with a therapist. Additional links and informaiton can be found on the Student Wellness website.

For location, hours, how to make appointments and additional information please see the Student Wellness website.

Student Disability Services

To ensure the intellectual richness of research and education, the University of Chicago seeks to provide an environment conducive to learning, teaching, working, and conducting research that values the diversity of its community. The University strives to be supportive of the academic, personal, and work-related needs of each individual and is committed to facilitating the full participation of students with a disability in the life of the University.

Student Disability Services works to provide resources, support, and accommodations for all students with disabilities and works to remove physical and attitudinal barriers, which may prevent their full participation in the University community.

Contact Student Disability Services directly for general questions about accommodations for University classes, programs or activities, please contact them at: 773-702-6000, or via email:
General: disabilities@uchicago.edu
Exams: proctor@uchicago.edu
Notetaking: notetake@uchicago.edu
Alternative Format Text: text.sds@uchicago.edu

Please see below for additional important and helpful University of Chicago links

Human Genetics Graduate Program Resources Page

CNetID account assistance

Computing Facilities

Copying, Printing & Scanning

Doc Films

Gerald Ratner Athletics Center

Office of International Affairs

Outreach and Volunteer Opportunities

Recreation on & Near Campus

Safety and Security

Transportation & Parking

TransLoc

UGo NightRide Shuttles

University of Chicago Events

University of Chicago Student Events

University of Chicago Student Organizations

Chicago at Large

Chicago is a fantastic city for cultural pursuits including museums, music, theatre, and dining out. The Chicago Symphony Orchestra, the Lyric Opera, jazz and blues clubs, The Goodman Theater, and off-loop theatres are all excellent. Both inexpensive ethnic restaurants and expensive special-occasion restaurants abound.

Chicago Area Festivals, Exhibits and Special Events Websites

For information on outdoor concerts, cultural and neighborhood festivals, art fairs and other special events in the Chicagoland area visit the following websites:

The Chicago Convention and Tourism Bureau: www.choosechicago.com

Special Events Management: www.chicagoevents.com

The Chicago Park District: http://www.chicagoparkdistrict.com

The City of Chicago: http://www.cityofchicago.org/city/en.html

Metromix: http://chicago.metromix.com/

The Chicago Reader: http://www.chicagoreader.com

The Chicago Music Guide: http://www.chicagomusicguide.com

Block Club Chicago: https://blockclubchicago.org/

The Magnificent Mile: http://www.themagnificentmile.com/

The Promontory: http://promontorychicago.com/

Ravinia: http://www.ravinia.org

The Chicago Symphony Orchestra: https://cso.org/

Chicago Architecture Center: http://www.architecture.org/

The Museum of Broadcast Communications: https://www.museum.tv/

The Museum of Science and Industry: http://www.msichicago.org

The Field Museum: http://www.fieldmuseum.org

Illinois Holocaust Museum & Education Center: https://www.ilholocaustmuseum.org/

The International Museum of Surgical Science: https://imss.org/

The Alder Planetarium: http://www.adlerplanetarium.org

John G. Shedd Aquarium: http://www.sheddaquarium.org

The Art Institute: http://www.artic.edu

Kohl's Children Museum: http://www.kohlchildrensmuseum.org

The Peggy Notebaert Nature Museum: http://www.naturemuseum.org/

Lincoln Park Zoo: http://www.lpzoo.com

Brookfield Zoo: http://www.brookfieldzoo.org

Navy Pier: http://www.navypier.com

Broadway in Chicago: http://www.broadwayinchicago.com

The League of Chicago Theatres: http://www.chicagoplays.com

The Goodman Theatre: http://www.goodmantheatre.org/

The Looking Glass Theatre: https://lookingglasstheatre.org/

Theater Wit: http://www.theaterwit.org/

The Second City: http://www.secondcity.com/

Steppenwolf Theatre: http://www.steppenwolf.org

The Chicago Botanic Gardens: http://www.chicago-botanic.org

The Morton Arboretum: http://www.mortonarb.org

Chicago Public Library: https://www.chipublib.org/

Chicago Sport and Social Club: http://www.chicagosportandsocialclub.com/

Chicago Athlete: http://www.mychicagoathlete.com/

Fleet Feet Sports: http://www.fleetfeetchicago.com

Divvy Bikes – Bike Sharing System: http://divvybikes.com/

Forest Preserves of Cook County: https://www.chipublib.org/

Illinois State Parks: https://www.dnr.illinois.gov/recreation/Pages/default.aspx

Illinois Bike Trails: http://www.traillink.com/stateactivity/il-bike-trails.aspx

Starved Rock State Park: http://www.starvedrockstatepark.org/

Indiana State Parks: http://www.in.gov/dnr/parklake/

Indiana Dunes: http://www.indianadunes.com/

Wisconsin State Parks: http://dnr.wi.gov/topic/parks/

Wisconsin Bike Trails: http://dnr.wi.gov/topic/parks/activities/bike.html

EMPIRICAL TRACK - COURSES AVAILABLE TO GGSB STUDENTS

For detailed information on course time schedules visit the **Academic Information System**

EMPIRICAL TRACK: FOUR [4] REQUIRED COURSES AND FOUR [4] ELECTIVE COURSES

FOUR [4] REQUIRED COURSES IN GENETICS:

MGCB 31400 Genetics Analysis of Model Organisms. Fundamental principles of genetics discussed in the context of current approaches to mapping and functional characterization of genes. The relative strengths and weaknesses of leading model organisms are emphasized via problem-solving and critical reading of original literature. *Autumn.*

AND

HGEN 47300 Genomics and Systems Biology. This lecture course explores technologies for high-throughput collection of genomic-scale data, including sequencing, genotyping, gene expression profiling, and assays of copy number variation, protein expression and protein-protein interaction. In addition, the course will cover study design and statistical analysis of large data sets, as well as how data from different sources can be used to understand regulatory networks, i.e., systems. Statistical tools that will be introduced include linear models, likelihood-based inference, supervised and unsupervised learning techniques, methods for assessing quality of data, hidden Markov models, and controlling for false discovery rates in large data sets. Readings will be drawn from the primary literature. Evaluation will be based primarily on problem sets. *Spring.*

Plus one [1] of the following two courses:

MGCB 31200 Molecular Biology I. Nucleic acid structure and DNA topology; methodology; nucleic-acid protein interactions; mechanisms and regulation of transcription in eubacteria, and of replication in eubacteria and eukaryotes; mechanisms of genome and plasmid segregation in eubacteria *Winter.*

OR

MGCB 31300 Molecular Biology II. The content of this course will cover the mechanisms and regulation of eukaryotic gene expression at the transcriptional and post-transcriptional levels. Our goal is to explore research frontiers and evolving methodologies. Rather than focusing on the elemental aspects of a topic, the lectures and discussions highlight the most significant recent developments, their implications and future directions. *Spring.*

Plus one [1] of the following four courses:

ECEV 44000 Fundamentals of Molecular Evolution. Covers major theories that form the foundation for understanding evolutionary forces governing molecular variation and divergence and genome organization. It explores the evolutionary assembly of genes, the origin of novel gene function, the population genetics of repetitive DNA variation, and the evolution of multi-gene families. *Winter.*

OR

ECEV 35600 Principles of Population Genetics I. Examines the basic theoretical principles of population genetics, and their application to the study of variation and evolution in natural populations.
Topics include selection, mutation, random genetic drift, quantitative genetics, molecular evolution and variation, the evolution of selfish genetic systems, and human evolution. *Spring.*

OR

ECEV 35901 Evolutionary Genomics. This course is a summary and analysis for the investigation of genomic evolution, a rapidly growing area in molecular evolution as a consequence of genomic studies in recent years. We will lecture basic tools and conceptual progresses in the field, including molecular clock, codon usages, new gene evolution and evolution related to sex reproduction and behavior genetics. We will discuss all major issues in the area, adaptive evolution of genomes, gene orders, codon evolution, intron evolutions, gene transfer, transposable elements, and Structure and variation in prokaryotic genomes. One debate will be organized, where students will have opportunity to practice how to express their ideas articulately. *Spring (every other year*

OR

HGEN 46900 Human Variation and Disease. This course focuses on principles of population and evolutionary genetics and complex trait mapping as they apply to humans. It will include the discussion of genetic variation and disease mapping data. *Spring.*

GRADED LAB ROTATIONS TO BE TAKEN IN WINTER, SPRING & SUMMER QUARTERS:

BSDG 40100 Non-Thesis Research: Biological Sciences. Laboratory rotation – (10 weeks) *Winter, Spring*

BSDG 40100 Non-Thesis Research: Biological Sciences. Laboratory rotation – (5 weeks) *Summer.*

BSDG 40102 Non-Thesis Research: Biological Sciences. Third Laboratory rotation (Optional) (Second 5 weeks of quarter) *Summer.*

ADDITIONAL GGSB REQUIREMENT:

GENE 31800 Current Seminar Topics in Genetics. This course will expose student to current research topics in genetics for the bi-monthly GGSB Invited Seminar Series. **This is a required ½ credit course for all GGSB students and will be graded Pass/Fail.** *Winter, Spring*

ADDITIONAL DIVISIONAL REQUIREMENTS:

GENE 31900 Introduction to Research (Allstars). Lectures on current research by departmental faculty and other invited speakers. A required course for all first-year graduate students. *Autumn, Winter.*

BSDG 55100 Responsible, rigorous, and reproducible conduct of research: R3CL. Required of all BSD first-year doctoral students. The course is designed to stimulate thinking and facilitate discussion about the purpose and necessity of ethical conduct with respect to scientific and academic practices; to create personal awareness of the ethical dilemmas and choices that may be encountered in the course of a career in the sciences; to increase awareness and understanding of the importance of reproducible, rigorous, and transparent research; and to provide practical information regarding policies and procedures related to conduct in the Division of Biological Sciences at the University of Chicago. Winter quarter only. *(Winter)*

MGCB 32100 Senior Graduate Ethics. A second training in the ethical conduct of research is required for students still registered four years after their initial training. Senior ethics training content is more closely aligned with research areas and so this training is coordinated by the individual graduate programs. *Spring.*

FOUR [4] ELECTIVE COURSES CHOSEN FROM THE FOLLOWING LIST:
(Students may petition the Curriculum & Student Affairs Committee for approval of courses not listed below)

Genetics:

GENE 39900 Readings in Genetics. A course designed by a student and faculty member. All reading courses must be approved by the Curriculum/Student Affairs Committee prior to registration. See page 9 for our policy on reading courses. *Autumn, Winter, Spring, Summer.*

Biochemistry & Molecular Biology:

BCMB 30400 Protein Fundamentals. The course covers the physical-chemical phenomena that define protein structure and function. Topics include: the principles of protein folding, molecular motion and molecular recognition; protein evolution, design and engineering; enzyme catalysis; regulation of protein function and molecular machines; proteomics and systems biology. *Autumn.*

BCMB 30600 Nucleic Acid Structure and Function. This course focuses on the biochemistry of nucleic acids. Topics include nucleic acid structure, folding, and chemistry, protein-nucleic acid interactions, non-coding RNAs, and the enzymology of key processes such as DNA replication, repair and recombination. A special emphasis is placed on primary literature. Prereq: Courses in Biochemistry, molecular biology and organic chemistry. *Autumn.*

Developmental Biology:

DVBI 33850 Evolution and Development.
The course will provide a developmental perspective on animal body plans in phylogenetic context. The course will start with a few lectures, accompanied by reading assignments. Students will be required to present a selected research topic that fits the broader goal of the course and will be asked to submit a referenced written version of it after their oral presentation. Grading will be based on their presentation (oral and written) as well as their contributions to class discussions. *Autumn*

DVBI 36200 Stem Cells and Regeneration.
The course will focus on the basic biology of stem cells and regeneration, highlighting biomedically relevant findings that have the potential to translate to the clinic. We will cover embryonic and induced pluripotent stem cells, as well as adult stem cells from a variety of systems, both invertebrate and vertebrates. *Autumn.*

DVBI 36400 Developmental Mechanisms. This course provides an overview of the fundamental questions of developmental biology, with particular emphasis on the genetic, molecular and cell biological experiments that have been employed to reach mechanistic answers to these questions. Topics covered will include formation of the primary body axes, the role of local signaling interactions in regulating cell fate and proliferation, the cellular basis of morphogenesis, and stem cells. *Winter.*

DVBI 35600 Vertebrate Development. This advanced-level course combines lectures, student presentations, and discussion sections. It covers major topics in the developmental biology of vertebrate embryos (e.g., gastrulation, segmentation, nervous system development, limb patterning, organogenesis). The course makes extensive use of the current primary literature and emphasizes experimental approaches including embryology, genetics, and molecular genetics. *Spring.*

DVBI 36100 Plant Development and Molecular Genetics. Genetic approaches to central problems in plant development will be discussed. Emphasis will be placed on embryonic pattern formation, meristem structure and function, reproduction, and the role of hormones and environmental signals in development. Lectures will be drawn from the current literature; experimental approaches (genetic, cell biological, biochemical) used to discern developmental mechanisms will be emphasized. Graduate students will present a research proposal in oral and written form; undergraduate students will present and analyze data from the primary literature, and will be responsible for a final paper. *Spring.*

Ecology & Evolution:

ECEV 32500 Evolutionary Aspects of Gene Regulation. This advanced level course focuses on reading and participation. Each meeting period is dedicated to a new Topic, several of which make up a Module. Typical modules are: transcription factors and cis-regulatory elements, functional consequences of regulatory changes and RNAi as an alternative mechanism of gene regulation. Students present and discuss several papers from the primary literature during this course. *Autumn.*

ECEV 35800 Classics of Evolutionary Genetics. Major classic papers in evolutionary genetics that had great impact on the development of the field are reviewed. *Spring.*

Human Genetics:

HGEN 47000 Human Genetics I. This course covers classical and modern approaches to studying cytogenetic, Mendelian, and complex human diseases. Topics include chromosome biology, human gene discovery for single gene and complex diseases, non-Mendelian inheritance, mouse models of human
disease, cancer genetics, and human population genetics. The format includes lectures and student presentations. *Autumn.*

HGEN 47100 Introductory Statistical Genetics. This courses focuses on genetic models for complex human disorders and quantitative traits. Topics covered also include linkage and linkage disequilibrium mapping genetic models for complex traits, and the explicit and implicit assumptions of such models. *Winter.*

HGEN 47400 Introduction to Probability and Statistics for Geneticists. This course is an introduction to basic probability theory and statistical methods useful for people who intend to do research in genetics or a similar scientific field. Topics include random variable and probability distributions, descriptive statistics, hypothesis testing and parameter estimation. Problem sets and tests will include both solving problems analytically and analysis of data using the R statistical computing environment. *Autumn.*

Molecular Genetics & Cell Biology:

MGCB 31300 Molecular Biology II. The content of this course will cover the mechanisms and regulation of eukaryotic gene expression at the transcriptional and post-transcriptional levels. Our goal is to explore research frontiers and evolving methodologies. Rather than focusing on the elemental aspects of a topic, the lectures and discussions highlight the most significant recent developments, their implications and future directions. *Spring.*

MGCB 31500 Genetic Mechanisms
Advanced coverage of mechanisms involved in promoting genome stability and genome evolution. A variety of experimental systems are explored from bacteriophage to humans. Topics include the genetics and biochemistry of DNA repair, homologous and site-specific recombination, transposition and genome rearrangement. Two of three weekly meetings are lecture and the third student led discussion of recent papers from the primary literature. The course emphasizes experimental design and interpretation of primary data. *Spring.*

MGCB 31600 Cell Biology I. Eukaryotic protein traffic and related topics, including molecular motors and cytoskeletal dynamics, organelle architecture and biogenesis, protein translocation and sorting, compartmentalization in the secretory pathway, endocytosis and exocytosis, and mechanisms and regulation of membrane fusion. *Autumn.*

MGCB 31700 Cellular Biology II. This course covers the mechanisms with which cells execute fundamental behaviors. Topics include signal transduction, cell cycle progression, cell growth, cell death, cancer biology, cytoskeletal polymers and motors, cell motility, cytoskeletal diseases, and cell polarity. Each lecture will conclude with a dissection of primary literature with input from the students. Students will write and present two short research proposals, providing excellent preparation for preliminary exams. Cell Bio I 31600 is not a prerequisite *Winter*

MGCB 32900 Plant Development and Molecular Genetics. Growth, differentiation and development in plants at the organismal, cellular, and molecular level. The regulatory function of environmental factors, hormones and phytochrome on gene expression and the possible evolutionary relationships will be studied. The molecular genetic advances in Arabidopsis and maize are a central feature of the course. *Spring.*

Cell Physiology:

CPHY 35000 Systems Biology, Self-Assembly & Complexity. The unifying theme of the course is Systems Biology, Self-Assembly and Complexity, covering a wide range of forward-looking topics where exploiting the approaches of chemistry, physics, computer science, statistics, and mathematics will be necessary to gain key insights into biological mysteries. Topics will be as broad as nucleic acid structure and function at the nano- and meso-scales, determinants of protein-nucleic acid interaction specificity, finding short sequence needles in genome-size haystacks, sequencing and mining genomes and even speculations on the chemical origins of life. Spring.

Computer Science:

CMSC 37720 Computational Systems Biology. Introductory concepts of systems biology, computational methods for analysis, reconstruction, visualization, modeling and simulation of complex cellular networks including biochemical pathways for metabolism, regulation and signaling. Students will have the opportunity to explore systems of their own choosing and will participate in developing algorithms and tools for comparative genomic analysis, metabolic pathway construction, stoichiometeric analysis, flux analysis, metabolic modeling and cell simulation. A particular focus of the course will be on furthering our understanding of the computer science challenges in the engineering of prokaryotic organisms. The course requires written assignments, programming assignments and a final course project. *Autumn.*

Statistics:

STAT 22000 Statistic Methods and Applications. Statistics 22000 provides an introduction to how statisticians think about describing data, data collection and research design, probability and randomness, and inference from a sample to a population. *Autumn, Winter, and Spring.*

STAT 23400 Statistical Models/Method. This course presents basic ideas of probability theory and statistics and will provide a broad background in statistical methodology and exposure to probability models and the statistical concepts underlying the methodology. Probability is developed for the purpose of modeling outcome of random phenomena. Random variables and their expectations are studied; including means and variances of linear combinations, and an introduction to conditional expectation. Binomia, Poisson, normal and other standard probability distributions are considered. Some probability models are studied mathematically and others via simulation on a computer. Sampling distributions and related statistical methods are explored mathematically, studied via simulation and illustrated on data. Statistical methods for describing data and making inferences based on samples from populations are presented. Methods include, but are not limited to, inference for means and variances for one- and two-sample problems, correlation and simple linear regression. Graphical and numerical data descriptions are used for exploration, communication of results, and comparing mathematical consequences of probability models and data. Mathematics is employed to the level of univariate calculus and is less demanding than that required by STAT 24400. *Autumn, Winter.*

STAT 22600 Analysis of Qualitative Data. This is an introduction to the theory and applications of statistical methods for investigating the relationships among discrete variables. The course will present methods for analyzing categorical data, standard methods for contingency tables such as odds ratios, tests of independence and various measures of association, generalized linear models for binary data and count data, logistic regression for binomial data, loglinear models for Poisson data. The statistical techniques discussed will be presented by many real examples involving both physical and social science data. PQ: Statistics 22000 or equivalent. It is expected that the students have a good understanding of basic descriptive statistics such as means, variances and expectation, of the inferential notions of estimate, confidence intervals and significance or hypothesis testing. Familiarity with one statistical package, e.g. Stata, Sas, Splus, Spss, Minitab and ability to access Web sites and to download files from the Web are required. *Winter.*

STAT 24400 Statistical Theory and Methods I. Principles and techniques of statistics with emphasis on the analysis of experimental data. First quarter: Discrete and continuous probability distributions, transformation of random variables; principles of inference including Bayesian inference, maximum likelihood estimation, hypothesis testing, likelihood-ratio tests, multinomial distributions and chi-square tests. Second quarter: Multivariate normal distributions and transformations, Poison processes, data analysis, t-tests, confidence intervals, analysis of variance and regression analysis. *Autumn, Winter.*

STAT 24500 Statistical Theory and Methods II. Principles and techniques of statistics with emphasis on the analysis of experimental data. First quarter: Discrete and continuous probability distributions, transformation of random variables; principles of inference including Bayesian inference, maximum likelihood estimation, hypothesis testing, likelihood-ratio tests, multinomial distributions and chi-square tests. Second quarter: Multivariate normal distributions and transformations, Poison processes, data analysis, t-tests, confidence intervals, analysis of variance and regression analysis. *Autumn, Winter.*

STAT 35500 – Statistical Genetics. This is an advanced course in statistical genetics. Prerequisites are Human Genetics 47100 and Statistics 24400 and 24500. Students who do not meet the prerequisites may enroll on a P/NP basis with consent of the instructor. Prerequisites are either Human Genetics 47100 or statistics preparation at the level of Statistics 24400 and 24500. This is a discussion course and student presentations will be required. Topics vary and may include, but are not limited to, statistical problems in linkage mapping, association mapping, map construction, and genetic models for complex traits. *Spring*.

A complete list of courses is available on the Academic Information System and the GGSB Program website

GGSB COMPUTATIONAL TRACK - COURSES

For detailed information on course time schedules visit the **Academic Information System**

For additional information please view the Doctoral Training in Computational Genomics website

GGSB COMPUTATIONAL TRACK: THREE [3] REQUIRED COURSES AND THREE [3] CORE ELECTIVES PLUS TWO [2] ADDITIONAL ELECTIVES PLUS TWO [2] ROTATIONS

THREE [3] REQUIRED COURSES:

STAT 24400 Statistical Theory and Methodology I. This sequence is a systematic introduction to the principles and techniques of statistics, as well as to practical considerations in the analysis of data, with emphasis on the analysis of experimental data. This course is the first quarter of a two-quarter systematic introduction to the principles and techniques of statistics, as well as to practical considerations in the analysis of data, with emphasis on the analysis of experimental data. This course covers tools from probability and the elements of statistical theory. Topics include the definitions of probability and random variables, binomial and other discrete probability distributions, normal and other continuous probability distributions, joint probability distributions and the transformation of random variables, principles of inference (including Bayesian inference), maximum likelihood estimation, hypothesis testing and confidence intervals, likelihood ratio tests, multinomial distributions, and chi-square tests. Examples are drawn from the social, physical, and biological sciences. The coverage of topics in probability is limited and brief, so students who have taken a course in probability find reinforcement rather than redundancy. Students who have already taken STAT 25100 may choose to take STAT 24410 (if offered) instead of STAT 24400. Students taking either STAT 24400 or STAT 24410 will have appropriate preparation for STAT 24500. *Autumn, Winter.*

AND

HGEN 48600 Fundamentals of Computational Biology: Models and Inference. Covers key principles in probability and statistics that are used to model and understand biological data. There will be a strong emphasis on stochastic processes and inference in complex hierarchical statistical models. Topics will vary but the typical content would include: Likelihood-based and Bayesian inference, Poisson processes, Markov models, Hidden Markov models, Gaussian Processes, Brownian motion, Birth-death processes, the Coalescent, Graphical models, Markov processes on trees and graphs, Markov Chain Monte Carlo. PQ: STAT 244 or equivalent. *Winter*

AND

HGEN 48800 Fundamentals of Computational Biology: Algorithms and Applications. This course will cover principles of data structure and algorithms, with emphasis on algorithms that have broad applications in computational biology. The specific topics may include dynamic programming, algorithms for graphs, numerical optimization, finite-difference, schemes, matrix operations/factor analysis, and data management (e.g. SQL, HDF5). We will also discuss some applications of these algorithms (as well as commonly used statistical techniques) in genomics and systems biology, including genome assembly, variant calling, transcriptome inference, and so on. *Spring*

PLUS THREE [3] CORE ELECTIVES CHOSEN FROM THE FOLLOWING LIST

HGEN 47000 Human Genetics I. This course covers classical and modern approaches to studying cytogenetic, Mendelian, and complex human diseases. Topics include chromosome biology, single gene and complex diseases, non-Mendelian inheritance, cancer genetics, human population genetics, and genomics. The format includes lectures and student presentations. *Autumn*

OR

MGCB 31400 Genetic Analysis of Model Organisms. Fundamental principles of genetics discussed in the context of current approaches to mapping and functional characterization of genes. The relative strengths and

weaknesses of leading model organisms are emphasized via problem-solving and critical reading of original literature. *Autumn.*

OR
HGEN 47100 Introductory Statistical Genetics. This course focuses on genetic models for complex human disorders and quantitative traits. Topics covered also include linkage and linkage disequilibrium mapping genetic models for complex traits, and the explicit and implicit assumptions of such models. *Winter.*

OR
ECEV 35600 Population Genetics I. Kreitman, Steinrücken. Examines the basic theoretical principles of population genetics, and their application to the study of variation and evolution in natural populations. Topics include selection, mutation, random genetic drift, quantitative genetics, molecular evolution and variation, the evolution of selfish genetic systems, and human evolution. *Spring.*

OR
HGEN 31100 Evolution of Biological Molecules. The course connects evolutionary changes imprinted in genes and genomes with the structure, function and behavior of the encoded protein and RNA molecules. Central themes are the mechanisms and dynamics by which molecular structure and function evolve, how protein/ RNA architecture shapes evolutionary trajectories, and how patterns in present-day sequence can be interpreted to reveal the interplay data of evolutionary history and molecular properties. Core concepts in macromolecule biochemistry (folding and stability of proteins and RNA, structure-function relationships, kinetics, catalysis) and molecular evolution (selection, mutation, drift, epistasis, effective population size, phylogenetics) will be taught, and the interplay between them explored. *Winter*

OR
BCMB 32200 Biophysics of Biomolecules. This course covers the properties of proteins, RNA, and DNA, as well as their interactions. We emphasize the interplay between structure, thermodynamics, folding, and function at the molecular level. Topics include cooperativity, linked equilibrium, hydrogen exchange, electrostatics, diffusion, and binding. *Spring*

OR
HGEN 46900 Human Variation and Disease. This course focuses on principles of population and evolutionary genetics and complex trait mapping as they apply to humans. It will include the discussion of genetic variation and disease mapping data. *Spring.*

OR
HGEN 47300 Genomics and Systems Biology. This lecture course explores technologies for high-throughput collection of genomic-scale data, including sequencing, genotyping, gene expression profiling, and assays of copy number variation, protein expression and protein-protein interaction. In addition, the course will cover study design and statistical analysis of large data sets, as well as how data from different sources can be used to understand regulatory networks, i.e., systems. Statistical tools that will be introduced include linear models, likelihood-based inference, supervised and unsupervised learning techniques, methods for assessing quality of data, hidden Markov models, and controlling for false discovery rates in large data sets. Readings will be drawn from the primary literature. Evaluation will be based primarily on problem sets. *Spring.*

OR
MGCB 32000 Quantitative Analysis of Biological Dynamics. The basic focus of the course will be quantitative approaches to understanding organization and dynamics at the molecular, subcellular and cellular levels, and will rest on three pillars - modern imaging and image analysis, quantitative analysis and presentation of data, mathematical modeling and computer simulations *Spring*

ADDITIONAL REQUIRED COURSES

GRADED LAB ROTATIONS TO BE TAKEN IN WINTER, SPRING & SUMMER QUARTERS:

BSDG 40100 Non-Thesis Research: Biological Sciences. Laboratory rotation – (10 weeks) *Winter, Spring*
BSDG 40100 Non-Thesis Research: Biological Sciences. Laboratory rotation – (5 weeks) *Summer.*
BSDG 40102 Non-Thesis Research: Biological Sciences. Third Laboratory rotation (Optional) (Second 5 weeks of quarter) *Summer.*

ADDITIONAL GGSB REQUIREMENT:

GENE 31800 Current Seminar Topics in Genetics. This course will expose student to current research topics in genetics for the bi-monthly GGSB Invited Seminar Series. **This is a required ½ credit course for all GGSB students and will be graded Pass/Fail.** *Autumn, Winter, Spring*

ADDITIONAL DIVISIONAL REQUIREMENTS:

GENE 31900 Introduction to Research (Allstars). Lectures on current research by departmental faculty and other invited speakers. A required course for all first-year graduate students. *Autumn*

BSDG 55100 Responsible, rigorous, and reproducible conduct of research: R3CL. Required of all BSD first-year doctoral students. The course is designed to stimulate thinking and facilitate discussion about the purpose and necessity of ethical conduct with respect to scientific and academic practices; to create personal awareness of the ethical dilemmas and choices that may be encountered in the course of a career in the sciences; to increase awareness and understanding of the importance of reproducible, rigorous, and transparent research; and to provide practical information regarding policies and procedures related to conduct in the Division of Biological Sciences at the University of Chicago. Winter quarter only. *Winter*

MGCB 32100 Senior Graduate Ethics. A second training in the ethical conduct of research is required for students still registered four years after their initial training. Senior ethics training content is more closely aligned with research areas and so this training is coordinated by the individual graduate programs.

PLUS TWO [2] ADDITIONAL ELECTIVES CHOSEN FROM THE FOLLOWING LIST

BIOS 20186 Fundamentals of Cell and Molecular Biology. This course is an introduction to molecular and cellular biology that emphasizes the unity of cellular processes amongst all living organisms. Topics are the structure, function, and synthesis of nucleic acids and protein; structure and function of cell organelles and extracellular matrices; energetics; cell cycle; cells in tissues and cell-signaling; temporal organization and regulation of metabolism; regulation of gene expression; and altered cell functions in disease states. *Spring*

OR
STAT 34300 Applied Linear Statistical Methods. This course introduces the theory, methods, and applications of fitting and interpreting multiple regression models. Topics include the examination of residuals, the transformation of data, strategies and criteria for the selection of a regression equation, nonlinear models, biases due to excluded variables and measurement error, and the use and interpretation of computer package regression programs. The theoretical basis of the methods, the relation to linear algebra, and the effects of violations of assumptions are studied. Techniques discussed are illustrated by examples involving both physical and social sciences data. *Autumn*

OR
STAT 37790 Topics in Statistical Machine Learning "Topics in Statistical Machine Learning" is a second graduate level course in machine learning, assuming students have had previous exposure to machine learning and statistical theory. The emphasis of the course is on statistical methodology, learning theory, and algorithms for large-scale, high dimensional data. The selection of topics is influenced by recent research results, and students can take the course in more than one quarter. Autumn

OR
CMSC 35490 Special Topics in Machine Learning. Learned emulators leverage neural networks to increase the speed of physics simulations in climate models, astrophysics, high-energy physics, and more. Recent

empirical results have illustrated that these emulators can speed up traditional simulations by up to eight orders of magnitude. However, little is understood about these emulators. While it is possible that recent results are representative of what is possible in most settings, a more likely scenario is that these approaches are more effective for some simulators than others, and that learned emulators achieve strong average-case performance but fail to capture rare but important phenomena. In this graduate seminar course we will provide an overview and investigate recent literature on this topic, focusing on the following questions: 1. Introduction to learned emulators: how do they work, where have they been successful so far and what are the goals in this field? 2. Two different paradigms of learned emulation: physics vs. data driven. What are the advantages and pitfalls of each? 3. Robustness of emulation to noise: what is known so far? 4. Parameter estimation: how to handle parameter uncertainty? We will provide a list of papers covering the above topics and students will be evaluated on in-class presentations. *Autumn*

OR

CMSC 37720 Computational Systems Biology. Introductory concepts of systems biology, computational methods for analysis, reconstruction, visualization, modeling and simulation of complex cellular networks including biochemical pathways for metabolism, regulation and signaling. Students will have the opportunity to explore systems of their own choosing and will participate in developing algorithms and tools for comparative genomic analysis, metabolic pathway construction, stoichiometeric analysis, flux analysis, metabolic modeling and cell simulation. A particular focus of the course will be on furthering our understanding of the computer science challenges in the engineering of prokaryotic organisms. The course requires written assignments, programming assignments and a final course project. Autumn .

OR

ECEV 32000 Introduction to Scientific Computing for Biologists. The course will cover basic concepts in computing for an audience of biology graduate students. The students will receive basic training in the use of version control systems, databases and regular expressions. They will learn how to program in python and R and how to use R to produce publication-grade figures for their manuscripts, and how to typeset scientific manuscripts and theses using LaTeX. All the examples and exercises will be biologically motivated and will make use of real data. The approach will be hands-on, with lecturing followed by exercises in class. *Winter*

OR

STAT 30900. Mathematical Computation I: Matrix Computation. This is an introductory course on numerical linear algebra, which is quite different from linear algebra. We will be much less interested in algebraic results that follow from axiomatic definitions of fields and vector spaces but much more interested in analytic results that hold only over the real and complex fields. The main objects of interest are real- or complex-valued matrices, which may come from differential operators, integral transforms, bilinear and quadratic forms, boundary and coboundary maps, Markov chains, correlations, DNA microarray measurements, movie ratings by viewers, friendship relations in social networks, etc. Numerical linear algebra provides the mathematical and algorithmic tools for analyzing these matrices. Topics covered: basic matrix decompositions LU, QR, SVD; Gaussian elimination and LU/LDU decompositions; backward error analysis, Gram-Schmidt orthogonalization and QR/complete orthogonal decompositions; solving linear systems, least squares, and total least squares problem; low-rank matrix approximations and matrix completion. We shall also include a brief overview of stationary and Krylov subspace iterative methods; eigenvalue and singular value problems; and sparse linear algebra. *Autumn*

OR

BIOS 20187 Fundamentals of Genetics. The goal of this course is to integrate recent developments in molecular genetics into the structure of classical genetics with an emphasis on recent advances in genetics and genomics. Topics include Mendelian inheritance, genotype-phenotype relationships, linkage analysis, modern gene mapping techniques, gene expression, model systems genetics and analysis of genetic pathways. *Autumn*

OR

STAT 24500 Statistical Theory/Method-2. This course is the second quarter of a two-quarter systematic introduction to the principles and techniques of statistics, as well as to practical considerations in the analysis of data, with emphasis on the analysis of experimental data. This course continues from either STAT 24400 or STAT 24410 and covers statistical methodology, including the analysis of variance, regression, correlation, and some multivariate analysis. Some principles of data analysis are introduced, and an attempt is made to present

the analysis of variance and regression in a unified framework. Statistical software is used. *Winter.*

OR
STAT 32950 Multivariate Statistical Analysis: Applications and Techniques. This course focuses on applications and techniques for analysis of multivariate and high dimensional data. Beginning subjects cover principal component analysis, factor model, canonical correlation, multi-dimensional scaling, discriminant analysis, clustering, and common techniques of dimension reduction. Further topics on statistical learning for high dimensional data and complex structures include penalized regression models (LASSO, ridge, elastic net), sparse PCA, independent component analysis, Gaussian mixture model, and Expectation-Maximization methods. Theoretical derivations will be presented with emphasis on motivations, applications, and hands-on data analysis. *Spring*

OR
ECEV 42900 Theoretical Ecology. An introduction to mathematical modeling in ecology. The course will begin with linear growth and Lotka-Volterra models, and proceed to partial differential equations. The course's perspective will emphasize numerical computations and fitting models to data. *Winter*

OR
STAT 24610 Pattern Recognition This course treats statistical models and methods for pattern recognition and machine learning. Topics include a review of the multivariate normal distribution, graphical models, computational methods for inference in graphical models in particular the EM algorithm for mixture models and HMM's, and the sum-product algorithm. Linear discriminative analysis and other discriminative methods, such as decision trees and SVM's are covered as well. (Spring)

OR
STAT 30210 Bayesian Analysis and Principles of Statistics This course continues the development of Mathematical Statistics, with an emphasis on Bayesian analysis and underlying principles of inference. Topics include Bayesian Inference and Computation, Frequentist Inference and interpretation of p values and confidence intervals, Decision theory, admissibility and Stein's paradox, the Likelihood principle, Exchangeability and De Finetti's theorem, hierarchical modelling, multiple comparisons and False Discovery Rates. The mathematical level will generally be at that of an easy advanced calculus course. We will assume familiarity with standard statistical distributions (e.g., Normal, Poisson, Binomial, Exponential), with the laws of probability, expectation, conditional expectation, etc., and exposure to common statistical concepts such as p values and confidence intervals. Familiarity with the R statistical language will also be expected, and homework assignments will include programming problems in R. (Spring)

OR
STAT 35500 Statistical Genetics. This is an advanced course in statistical genetics. Prerequisites are Human Genetics 47100 and Statistics 24400 and 24500. Students who do not meet the prerequisites may enroll on a P/NP basis with consent of the instructor. Prerequisites are either Human Genetics 47100 or statistics preparation at the level of Statistics 24400 and 24500. This is a discussion course and student presentations will be required. Topics vary and may include, but are not limited to, statistical problems in linkage mapping, association mapping, map construction, and genetic models for complex traits. *Spring*

OR
STAT 37710 Machine Learning. This course provides hands-on experience with a range of contemporary machine learning algorithms, as well as an introduction to the theoretical aspects of the subject. Topics covered include: the PAC framework, Bayesian learning, graphical models, clustering, dimensionality reduction, kernel methods including SVMs, matrix completion, neural networks, and an introduction to statistical learning theory. *Spring*

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