Molecular, Cellular, Developmental Biology & Genetics (MCDB&G) Graduate Program: Goals and Outcomes

1) Program Overview
Molecular, Cellular, Developmental Biology and Genetics (MCDB&G) is a strong multi-disciplinary program housed in the Department of Genetics, Cell Biology and Development (GCD), that includes faculty from 11 different departments including Pediatrics, Microbiology, Neuroscience, Plant Biology and Medicine. MCDB&G educates graduate students in the cutting-edge core disciplines and emerging disciplines of genomics, biostatistics, bioinformatics, computational modeling and comparative genome analysis. The goals of the program are to: (1) train students in these disciplines, (2) promote interdisciplinary studies, and (3) prepare students for a comprehensive range of career paths. MCDB&G trains the students who will become the scientists in the exciting next era of biological research and medicine, solving world-wide challenges to cure genetic disorders, cancers, AIDS, heart disease, diabetes, and neuro-degenerative and muscle-wasting diseases. Specific examples of exciting work from our faculty include Dan Voytas (Director of the Center for Genome Engineering) who discovered TALENS that can correct defective human genes or can modify plants to address the world food shortage (the Voytas technique was named by the journal *Science* as one of the top scientific breakthroughs of the year); and David Largaespada (Margaret Harvey Schering Land Grant Chair in Cancer Genetics) who discovered 100s of new cancer-causing genes that will lead to novel cancer drugs.

MCDB&G is a highly successful graduate program based on a wide range of criteria. The program accepts domestic and international students from top-tier institutions and aggressively seeks to promote diversity. The laboratory research performed by MCDB&G graduate students is a driving force of scientific progress at the University of Minnesota. MCDB&G graduate students perform the research that is ultimately vital to leverage grant support from the National Institutes of Health, the National Science Foundation, the American Heart Association, and other nation-wide funding agencies. Because of their high level of productivity, between 95% and 100% of MCDB&G Ph.D. and M.S. students obtain positions related to their training after graduation. Many of our graduate students obtain post-doctoral positions in prestigious laboratories at Yale, Harvard, NIH, Princeton, Duke, MIT, Stanford, UCSF, UC-Berkeley, UCLA, The Scripps Research Institute, St. Jude’s, Fred Hutchison Cancer Center, among other top-tier institutions. MCDB&G Ph.D. students graduate with an optimal Time-To-Degree, averaging 5.3 years and have an outstanding completion rate of 96.4% (compared to the national completion rate of 63%). MCDB&G students published highly impactful research in the most prestigious journals including Nature, Science, Nature Genetics, Nature Immunology, Molecular Cell, Developmental Cell, PNAS, PLoS Genetics, The Journal of Cell Biology, Current Biology, Blood. The quality and global standing of MCDB&G students is evident from the numerous contributed platform presentations at national and international scientific conferences, where the invited speakers are typically biased heavily towards faculty and post-doctoral fellows.
MCDB&G offers a Ph.D. degree as well as a M.S. degree in Genetic Counseling and joint degrees in Law (JD/M.S. and JD/Ph.D.) and Medicine (MD/Ph.D.) The MD/PhD Program combines coursework and biomedical research culminating in a dissertation and PhD degree and clinical training resulting in an MD degree. The goal of the MD/PhD Program is to link biomedical sciences and clinical practice to provide a basis for optimal research and patient care. MD/PhD students who have a strong, fundamental interest in the analysis of disease at the molecular and genetic level and who anticipate a career as a clinical or basic biomedical research are encouraged to pursue their PhD training with faculty in the MCDB&G Graduate Program. The PhD and MS requirements for the JD/PhD and JD/MS are the same as those for students pursuing only the PhD, with the important exception that some courses can be “cross counted” for credit in both programs. The M.S. degree in Genetic Counseling is a two-year Master of Science program, fully accredited by the American Board of Genetic Counseling (ABGC). Students are provided with academic expertise and clinical skills to enter the profession of Genetic Counseling. Course work with an emphasis of study in Genetic Counseling follows a distinct curriculum from the MCDB&G Ph.D. and includes diagnostic medical genetics laboratory and clinical genetics experiences instead of laboratory rotations and thesis research.

2) Process by which goals and outcomes were identified
In order to gain an inclusive perspective on the key goals and outcomes of the MCDB&G graduate program, feedback was sought from current graduate students and alumni, program faculty, current and former Directors of Graduate Studies, and DGS Assistants (the Program Body). A steering committee was formed to orchestrate collection and discussion of feedback. The Program Body was asked for input on graduate student learning in the context of skills and knowledge, gained both from the curriculum (coursework) and from the laboratory research setting. The Program Body was asked: What are the key goals of MCDB&G? Is the MCDB&G program meeting these goals? What can be done to achieve higher standards with the MCDB&G program? The DGS and steering committee compiled summary documents for circulation to the program body for comment and revision, then approval by vote.

3) Graduate Learning Outcomes
The Program Body (including current Graduate Students and Alumni, Program Faculty, current and former Directors of Graduate Studies, and DGS Assistants) considered the following goals and outcomes to be high priority, with Skills and Scholarship identified as the most important outcomes because these assets directly impact the level of research productivity. A high level of performance in these key areas leads to excellence in research productivity and future outcomes (successful careers for graduate students).

(i) Knowledge. Broad knowledge within the core disciplines of the program: In genetics, cell biology, developmental biology and molecular biology. Detailed knowledge in specialized focus areas relevant to the thesis research. To include fundamental background knowledge and practical knowledge relating to research tools and methodology.

(ii) Skills. Excellence in a combination of assets required for careers with science at their foundation. (1) Laboratory skills. Technical competency in a wide range of experimental skills and methods. Unique
expertise in particular laboratory methods specific to the research sub-discipline and specific to the student’s thesis research area. (2) **Interdisciplinary skills.** Ability to integrate diverse laboratory methods to gain an enhanced outcome (e.g. in vivo analysis combined with computational modeling; genomic sequencing combined with bioinformatic analyses). (3) **Research Management Skills and Team work** - Ability to manage projects in terms of efficient self- and group- time management. Ability to devise and perform experimental procedures autonomously, and ability to integrate efforts of a research team to perform complex experimental procedures. Persistence in the ability to trouble-shoot and adapt procedures to gain a successful outcome. Ability to mentor peers and trainees with different levels of experience. Ability to organize and inspire a team in their research endeavors. (4) **Scientific Method** – Ability to develop and test a novel hypothesis. (5) **Communication skills** - Written and oral communication. Audience-specific communication, i.e. ability to tune delivery of material to audiences with differing levels of expertise, from experts to a broad audience of non-experts, to the lay public. (iii) **Scholarship.** A high level of academic achievement driven by intellectual curiosity and a fundamental passion for the scientific process. Independent thinking and innovation. Conduct of research in an ethical manner. Professional integrity and forward thinking towards the impact and outcomes of scientific research for society. Mentorship and collaboration.

Application of this combination of Graduate Learning Outcomes leads to: exemplary thesis research publications and research presentations at national and international meetings leading to future career success, i.e. obtaining a position as a post-doctoral scientist, a position in industry, teaching, and other professional areas of science.

4) **Assessment Processes**

**Overview.** MCDB&G graduate students are assessed throughout their graduate studies to ensure they are in compliance with the Student Academic Conduct Code and remain on track to earn a degree, according to the following expectations:

- Actively pursue thesis research with adequate and timely progress
- Maintain a cumulative GPA of at least 3.0
- Meet course requirements
- Give a student research seminar once a year
- Meet annually (at a minimum) with the thesis committee
- Attend a student research seminar series and one regular departmental seminar series
- Attend a regularly scheduled journal club
- Fulfill TA requirements (2 semesters for PhD students or 1 semester for MD/PhD and JD/PhD students)
- Attend and present a poster at the annual MCDB&G Fall retreat
- Participate and present a poster at MCSB recruiting activities
- Maintain active status with the Grad School by registering every Fall and Spring

It is required that a student’s Ph.D. Thesis encompasses substantial and novel research of high significance. To meet this requirement, students are expected to have at least one first author paper accepted for publication in a peer-reviewed journal within their research field, before being allowed to defend their work at the Final Oral Exam.
Mechanisms of Assessment.

A. Annual Committee Meeting and Student Evaluation

We employ robust strategies to closely track student progress using a multi-tiered mechanism. There are two formal components to student evaluation - an annual Thesis Committee meeting and annual evaluation by the Student Review Committee and Director of Graduate Studies. To document the outcome of the assessment process, an online cumulative record of progress is completed and reviewed (see Appendix 1; the Cumulative Record of Progress form).

(1) Annual Committee Meeting - Each student is required to have a meeting at least once a year with their Thesis Committee, including the advisor, to discuss academic and research progress and plans. MCDB&G student Thesis Committees are 6-member examination committees. Four members must be MCDB&G faculty (major field) and two members must be graduate faculty members in another graduate program (minor field). Before the Student Seminar, the student completes the Cumulative Record of Progress online form and alerts the Thesis Committee to review the form before the seminar and meeting. The annual meeting with the committee is held immediately after the yearly Student Seminar presentation by the student. During the meeting, all of the assessed components are discussed (see below). In addition, the student’s Individual Development Plan (IDP) is discussed. The IDP strategy was developed to respond to the National Institutes of Health (NIH) directive to further “assist graduate students to achieve their career goals within the biomedical research workforce through the use of Individual Development Plans,” with the goal of assisting graduate students to identify and pursue their chosen careers. Students maintain the “My IDP” web-based (myidp.sciencecareers.org) self-assessment tool and also complete an IDP form that was developed in conjunction with the Basic Sciences Graduate Council in the University of Minnesota Medical School. After the committee meeting, the Thesis Committee chair completes the assessment section of the Cumulative Record of Progress form and seeks feedback from the committee and student, before alerting the Student Review Committee and DGS that the form is ready for annual review.

(2) Student Review Committee – This committee meets to evaluate each student’s Cumulative Record of Progress form, as well as the student’s transcript, rotation reports, TA reports and IDP (see below). If deficiencies are detected, the student will first be called to meet with the DGS and if necessary the Student Review Committee. If the GPA falls below 3.0 at the end of a semester, the student is called to meet with the DGS. If the GPA remains below 3.0 for a second semester, the student is called to meet with the Student Review Committee – in consultation with the DGS the student may be dismissed from the program, or a plan may be formulated to give the student a chance to improve the GPA and continue in the program.

Components to be assessed.

(i) Laboratory Rotations and Coursework.

MCDB&G students must complete 24 or more Course Credits, including 16 credits graded A-F within the core disciplines as well as a course in Scientific Ethics and Public Policy. A cumulative GPA of at least 3.0
must be maintained to remain in good standing. In addition, 24 Thesis Credits are required. Students must complete 3 or 4 laboratory rotations, each 8 weeks in duration and culminating in a written paper or seminar presentation. Research mentors compile a written Rotation Report describing the student’s performance in the laboratory and the quality of the paper/seminar. The Rotation Report is delivered to the student’s Thesis Committee, the Student Review Committee and the DGS.

(ii) Teaching Assistantships (TAs).

All PhD students teach two semesters and MD/PhD and JD/PhD students teach one semester. The teaching requirement is intended to ensure that all students in the program have, as part of their graduate training, experience as instructors at the university level. Instructors complete an evaluation form at the end of the semester which is delivered to the Thesis Committee, Student Review Committee and DGS.

(iii) Student Research Seminar.

All MCDB&G students are required to attend the MCDB&G Student Seminar each week. From the second and beyond, students are required to present a Student Research Seminar approximately every 9 months. The aim of this seminar is to give each student the opportunity to present a formal seminar on their research and also to give the Thesis Committee the opportunity to assess progress towards completion of the PhD degree.

(iv) Publications and research conferences.

Through the formal mechanisms of assessment, progress towards publication of thesis research, and participation in local, national and international scientific conferences is monitored. Publication of at least one primary author paper is required before a student can proceed to defend the Ph.D. thesis.

B. Written and Oral Preliminary exams.

All MCDB&G students must participate in the Proposal Writing Course (GCD 8171) during the summer following the first year. The goal of this course is to provide students with practical experience in developing a research proposal that addresses a novel hypothesis. The format allows a smooth transition from learning grant-writing skills to completion of an application based on the thesis project. The outcome is a high-quality application that is then submitted to one of several national agencies (American Heart Association, NIH, NSF, etc.). This strategy not only enhances the skill set of the students, but increases the number of students funded by external research fellowships. The Proposal Writing Course also prepares students for their Written Preliminary Examination to be taken in the Fall Semester of Year 2.

PRELIMINARY WRITTEN EXAMINATION

The goal of the Preliminary Written Examination is to test the ability to independently (a) develop a novel hypothesis that addresses a significant problem, (b) develop a set of well-crafted experiments to test a hypothesis (c) interpret data obtained (d) anticipate difficulties and devise alternative strategies and (e) draw conclusions based on predicted experimental outcomes.
Exam Instructions: The Preliminary Written Examination should propose a novel hypothesis that addresses a previously unanswered question of biological significance and that describes a research plan that tests a hypothesis. The scope should be sufficiently narrow that it represents a 3-4 year project that can be completed by an individual, not a broad NIH grant to support 5-10 people. The proposed topic should be of significant importance such that the anticipated results would be suitable for publication in a leading journal in the field. It is encouraged to consider a wide range of techniques to evaluate the validity of the hypothesis. Students write a research proposal based on one of three papers that cover topics in the major fields represented by the MCDB&G program. The papers are posted two days before the official start of the exam. The student selects one of these papers as the basis for their proposal and the completed proposal is submitted within two weeks. The proposal must be of the student’s own creation. Students have complete freedom to take the problem in any direction they wish, but the hypothesis and proposed experiments must be grounded in the exam paper. Proposals that simply describe the same studies of a molecule (or closely related molecule) using a different model organism are not acceptable. Students may not consult with another student, colleagues or their advisor during the preparation of the exam or ask anyone to read/edit their proposal prior to submission. Format: The proposal should include an NIH-formatted Specific Aims page (1 page, single-spaced). The Research Strategy (8-10 pages, double-spaced) should contain a Background & Significance section (1-2 pages) and a Research Plan (6-8 pages). The Research Plan should consist of one or two specific aims. The length restriction includes figures plus legends but does not include references. The entire proposal must have 1 inch margins all around, using an 11 or 12 pt Arial or Helvetica font. Evaluation: The Preliminary Exam committee will evaluate the proposal. Each proposal will be reviewed by two primary reviewers who will provide detailed critiques and will also be read by a third member of the committee. The exam will be graded (20 pts for Specific Aims, 20 pts for Significance, 10 pts for Innovation, 50 pts for Research Plan) and each reviewer will submit a score. The final score will be the average of the three scores. The exam committee will meet to discuss the review and rating of all of the exams. The final scores will determine if the student earns a Pass with Distinction (95 or higher), Pass (90 or above) Pass with Revisions (70-90), Fail (69 or lower). Students will have two weeks to revise and re-submit their proposals. The original three reviewers will evaluate the revised proposal. The revised proposal must be rated Pass or Fail and two "Fails" means an overall failure. If the revised examination is rated as a Fail, then the MCDB&G Executive Steering Committee (ESC) will review the student’s performance on the examination, their academic record and consult with the Chair of the Exam Committee, the Student Review Committee and the student's advisor. They will then determine if the student cannot continue in the program or if they may have a final opportunity to pass the Written Preliminary Examination.

PRELIMINARY ORAL EXAMINATION

The Oral Preliminary Examination must be taken by the end of the Spring Semester in Year 2. The goal of the Preliminary Oral examination is to examine a student’s general knowledge in the core areas of the MCDB&G program and to test their problem solving skills, particularly in areas related to their written proposal, their own research area and completed course work. It is intended to be an open-ended examination. All six Thesis Committee members must be present for the exam. The advisor is a silent
observer, not an active participant in the questioning. However, the advisor is a full voting member of the committee. Ahead of the Oral Examination, the student must deliver to the Thesis Committee the final Written Preliminary Examination plus the reviews, the grant proposal that was developed during the Proposal Writing Course. The student prepares two presentations for the exam: (1) An outline of the Written Preliminary proposal, and (2) An outline of the thesis research. The student must be prepared to present the thesis project as a “chalk talk” in 10 - 15 minutes. A typical time-line for a preliminary oral examination is as follows. The student will be allowed about 5 minutes to begin presenting the Written Preliminary proposal before questioning starts. The portion of the examination devoted to the Written Preliminary proposal is followed by, or integrated with, general questions and then the chalk talk on the thesis research. Upon completion of the exam the committee members and the advisor will vote by secret ballot. This will be followed by a discussion and then a final vote. Possible results are pass, pass with reservations, or fail. Procedures for lifting reservations must be specified by the committee members. These will be clearly explained to the student at the exam and a written summary of the requirements to lift the reservations will be sent to the student, the advisor and DGS within 2 days of the exam. If the result is fail, the prelim oral exam may be taken a second time only with unanimous approval (vote) of the committee, and the same exam committee must conduct the exam. After The Exam: The Oral Examination Report form, which is sent to the chair of the exam committee ahead of time, must be signed and returned to the Graduate School after the exam by the student. If the result is pass with reservations or fail, a letter describing the basis for the examination committee’s decision must be submitted to the DGS by the Committee Chair within a week of the exam.

FINAL ORAL EXAMINATION

The Final Examination is primarily the thesis defense, although the questions and discussion may cover related areas. The first portion of all final oral examinations is a one-hour seminar given by the student covering the thesis research. This seminar must be publicly announced and all interested faculty and students are invited. Following a brief period of questions from the audience, the second portion of the examination consists of additional questions to the candidate from the members of the examination committee. The second section of the examination is not open to the public. The outcome of the final examination is pass or fail, determined by secret ballot.