Graduate Program in Comparative and Molecular Biosciences (CMB)
Program Goals and Outcomes Assessment

Educational Goals
The CMB program is transdisciplinary, bringing together basic, applied and clinical scientists from a number of colleges across the University to provide students with individualized, cutting-edge biomedical research training. Faculty in the college understood that existing programs at the University of Minnesota did not train students in the concept of one medicine, one science. A core faculty was formed, program goals and guidelines were crafted, key research faculty from across the university were invited to participate, and we enrolled our first students in the fall of 1999. We focus almost exclusively on PhD training and offer a variety of research emphasis areas, including genetic diseases, pathogenesis of infectious agents, host immunity, and comparative aspects of biology and pathology across animal species and humans. The CMB program focuses on health that spans a wide range of species, from laboratory animal, companion animal, and livestock species to humans, is unique within the University of Minnesota.

As defined in the CMB Guidelines, our mission is to train outstanding scientists in the basic mechanisms of animal and human health and disease. Students will receive both scientific training and non-technical experiences that prepare them for leadership careers as independent investigators and educators in academia, industry, and government.

Best Practices to Ensure Program Outcomes
Biomedical research is increasingly interdisciplinary and translational. Students must have a fundamental knowledge of many biological processes that maintain, regulate, and effect health and disease. Students develop scientific aptitude and gain technical proficiency in modern laboratory practices through mentored thesis research. Graduates must demonstrate critical and analytical thinking that will allow them to translate new knowledge to the field and to address future challenges impacting animal and human health.

Because professional success also will require non-technical competencies, we further stress development of:

- a broad understanding of their field of study
- effective written and oral communication
- the ability to work within teams across disciplinary boundaries
- organizational and leadership traits
- professional behavior and ethical conduct of research
- cultural and global perspective for their field of study

Instilling Skills for Career Success
The expertise and knowledge necessary to conduct scientifically rigorous research in their chosen area are formed and strengthened throughout the students’ tenure in the graduate program. CMB students are required to enroll in a Mechanisms and Health and Disease core course in which they gain a basic understanding of the principles of various biological
systems that affect health and wellness, such as infectious agents, immunology, genetics, cancer biology, nutrition, and physiology. Students are also exposed to the medical disciplines used to prevent, treat and diagnose disease, including genomics, pharmacology, vaccinology, and epidemiology.

Students must master techniques and analytical tools that can be applied to their research problem. Upon entry, students complete a series of research rotations in which they experience new techniques and gain an understanding of various type of research within their field of interest. First year students attend a course that discusses animal models of disease (CBM8303) in which they learn how to assess strengths and weaknesses of various animal models and to design appropriately controlled experiments that use animal subjects. Students acquire and hone command and understanding of their primary field of investigation primarily by conducting original hypothesis-centered research that generates new knowledge. Students must employ appropriate research design, master techniques, and apply analytical methods to achieve this goal.

Journal clubs further promote understanding of emerging technologies while challenging the student to think critically about data and experimental design outside of their primary area of investigation. To proceed to PhD candidacy, students must pass a preliminary exam in which they demonstrate a strong understanding of their field of study and defend their technological approach to their specific research problem. The dissertation research must contain sufficient impactful data to generate at least two first author scientific publications in peer-reviewed journals. Requiring students to publish their work requires that they integrate their work into the larger body of knowledge, to assess weaknesses within their study design, and to form new and insightful questions deriving from their datasets.

Non-technical skills are learned through various overlapping and programmatic requirements and activities. The importance of excellent written communication skills cannot be underestimated, and are honed through core coursework that employs writing intensive assignments. PhD students must independently develop and write an NIH-style thesis research proposal that is critiqued by their advisor and thesis committee. In addition, students must propose and craft an alternate proposal unrelated to their thesis work in which they demonstrate that they possess the creativity, critical thinking, and experimental design aptitude to be successful independent scientists. Finally, students are strongly encouraged to participate in our grant writing course (CMB5910) in which they come to understand the qualities of a sound and impactful research proposal while writing an original research or fellowship proposal. Peer review of writing assignments further promotes writing effectiveness and critical thinking.

Annual seminars assist students to develop the ability to speak effectively and clearly to both disciplinary peers and to audiences with diverse backgrounds. Seminars are presented to graduate program faculty and peers who complete written assessments to improve the student’s speaking mannerisms and use of technology to communicate science. The course coordinator and their primary advisor review the audience comments with the student. First year students, especially non-native speakers, are encouraged to enroll in a Seminar Development and Presentation course (VMED5190) in which they learn effective speaking
and how to create and use powerpoint-based slide presentations to communicate scientifically. Finally, students are required to complete one Teaching Assistantship that may include enrolling in the University's highly touted *Preparing Future Faculty* course that teaches them how to be effective communicators in various learner environments.

Science is increasingly a collaborative effort, and employers desire individuals that can work confidently and smoothly within a group. Several core courses utilize hybrid formats that include team assignments. For instance, students from 3 graduate programs (AnSci, CMB, and VMED) share an ethics course in which student teams consisting of students from each of the programs are assigned case studies to explore, review, and present to the class. There are many activities in which CMB students work collaboratively and demonstrate leadership. Each semester they collectively select, invite, and host a seminar speaker within our collegiate Science Seminar Series.

The successful independent scientist, especially in academia, must also be able to manage many tasks simultaneously. They must manage a research team, each with different levels of ability and often with little experience that will require strong people skills that include the ability to communicate a clear vision and to motivate their workforce. Leadership opportunities are available through serving as the CMB student representative on the graduate program advisory committee, organizing the monthly CMB student group meetings in which they address program issues and opportunities, and via participation in the University of Minnesota Council of Graduate Students. Graduate students are invited to meet with all external seminar speakers and faculty candidates. Importantly, our current students are actively engaged in hosting and interacting with new applicants who interview at the college and CMB graduate program each winter. Accepting these responsibilities requires that the student be able to organize and prioritize their research, coursework, and external interests accordingly. It also helps student develop effective approaches for organizing meetings, engaging all group members, and reflecting critically on all viewpoints or action plans proposed by the group.

The pressure of publishing and competing successfully for grants is greater than at any time in our history. Further, because research teams often consist of members from different cultural and national backgrounds, it is important that our graduates have a strong ethical compass. Many of our graduates pursue careers within academia in which they will advise new learners and serve as behavioral role models. In addition to observing their own advisor’s actions, students gain professional perspective through various leadership opportunities noted above. In addition, students are required to complete an ethics course that specifically addresses plagiarism, data recording and ownership, intellectual property, publishing standards, and use of animal and human research subjects.

The veterinary and biomedical research workforce is culturally rich and dynamic, largely because all cultures have agricultural systems and most diseases are common to humans across the globe. Just over 50% of CMB graduate students matriculate from outside the US, female students slightly outnumber male students, and many incoming students have already earned a DVM degree or foreign equivalent. Thus, by participating in our common graduate seminar series and working within the student group to host seminar speakers and
new applicants, CMB students share their own experiences and cultural customs. In addition, the required Ethics course provides a forum for open and respectful discussion and exchange of viewpoints regarding accepted behavior, animal use, and inherent cultural biases. CMB students are encouraged to enroll in courses outside of our graduate program if it will assist their thesis research. This allows them to interact with students from other life sciences graduate programs and to value different experimental approaches. Finally, all incoming students are matched with a more senior student who serves as an informal resource for information and advice during the first year of study.

The graduate program and the college invest funds that allow students to attend national and international meetings and workshops that they may not normally have the opportunity to experience. This is an important learning mechanism for them in that they discover that a different audience may have quite new perspectives on their work. It also promotes the students’ ability to communicate with various audiences and to consider alternate technical approaches that might employ in their thesis research. Importantly, students gain a bigger view of how their work can be translated into a medical program or to advance a given food industry sector. Together these experiences help broaden a student’s cultural aptitude and global perspective of their field of study. It also educates students on agricultural challenges unique to various populations or nations, and broadens their ability to consider different approaches to address various problems.

**Assessing Program Success**

For the entirety of our existence, the CMB has employed a series of processes that monitor student progress in the program and success upon graduation. During their training, students file an annual report of activities and completed coursework that also includes a statement of goals for the coming year. Students must meet at least annually with their thesis committee to review research progress and to address any areas for improvement in their core knowledge, technical aptitude, and professional development. As stated above, all students present an annual seminar to program faculty and peers. This provides an opportunity to gauge their intellectual growth as well as their research productivity. Prior to ascending to PhD candidacy, students must pass both a written and oral preliminary examination in which they must demonstrate sufficient core knowledge, an ability to communicate their project and experimental aims, an understanding of the techniques used in their research, and the importance of their work to the field of study. Finally, students must publish at least part of their work prior to defending their PhD dissertation.

The CMB program strongly considers that the numbers and types of awards our students receive to be primary measures of program and student success. CMB students have twice been awarded the Best PhD Dissertation Award (2002, 2007), and have a much higher than average success rate for Graduate School Doctoral Dissertation Awards. Students continually merit external fellowships from agencies such as the NIH, NIFA, and the Morris Animal Foundation. Students present regularly at national conferences and regularly earn “Best Presentation” recognitions. In addition, students publish an average of 3.2 manuscripts derived from their thesis work. Together, these data indicate that their training is sound and that their thesis work is rigorous and impactful. Current CMB student
information, including research foci, awards, and recent publications is available at http://www.cvm.umn.edu/students/ms-phd/CMB/CMBstudents/index.htm.

Post-graduation career trajectories are sometimes difficult to track. However, the Graduate Programs Coordinator conducts an exit interview with all departing students whether or not they have successfully completed the requirements for the degree. This helps us identify potential shortcomings in the program as well as establishing where students matriculate immediately post-graduation. To help us stay connected to our graduates, we issue an electronic quarterly alumni newsletter in which we encourage graduates to share their career news. We maintain an alumni database that we update as alumni change employers in order to assess long term benefits of their CMB education. Information on recent graduates, including first position post-graduation, awards, and honors, can be viewed at http://www.cvm.umn.edu/students/ms-phd/CMB/CMBAlumni/index.htm.