The Ph. D. program in Biochemistry and Molecular Biology has seven learning outcomes that graduating students should acquire during the course of their studies. Acquiring these outcomes will equip them for satisfying employment in the sciences and related areas.

Learning Outcome 1: Knowledge of factual information, theoretical principles and methodological approaches.

Each student must complete three core courses: one in molecular biology (BCH 211, “Molecular Biology,” 3 units, Fall), one in signal transduction and biochemical regulation (BCH 212, “Signal Transduction and Biochemical Regulation,” 3 units, Winter), and one in structural biochemistry (BCH 210, “Biochemistry of Macromolecules,” 4 units, Spring). The majority of students take these courses during their first year. The three core courses (described more fully in the appendix to this document) provide students with the breadth of information that forms a basis for their ongoing studies in their specialty areas. These courses are augmented by additional specialty courses and the Department of Biochemistry’s seminar series (BCH 252, “General Seminar in Biochemistry,” 1 unit, offered each quarter). Specifically, students are required to complete at least one advanced course in the Biochemistry 230 series (“Advanced Topics in Biochemistry,” 2 units, Fall, Winter, Spring) and at least nine units of graduate science or upper division courses in subsidiary fields of study (e.g., biology, cell and developmental biology, chemistry, neurobiology). The specialty courses are typically taken in the first or second year, while the seminar course is taken each quarter that the student is enrolled as a graduate student.

Approach:

The course plan for each entering student is determined by the Graduate Advisor on the basis of any undergraduate course deficiencies, the course requirements of the BMB program, and the student’s desired area of research specialization. The Graduate Advisor also helps the students choose rotations in faculty labs by identifying possible major professors whose research interests are close to the student’s own interests. The rotations, along with the final assignment to the major professor’s laboratory, contribute to the student’s acquisition of knowledge, theory, and method in biochemistry and molecular biology. The student’s Faculty Advisory Committee (selected when the student chooses a major professor, typically in the third quarter of the first year) provides additional advice concerning additional course selections the student may need in the second year. The successful completion of the written qualifying examination, consisting of two three-hour components covering all aspects of biochemistry and molecular biology at the
undergraduate and graduate levels, represents a significant learning outcome assessment for the BMB Ph.D. students, which, when added to the student’s course work, results in the student being exposed to a broad body of knowledge in biochemistry and molecular biology within his/her first two years of study.

**Assessment Methods:**

Assessment in the core and specialist courses is by letter grade, while assessment for seminars is by S/NC (on the basis of attendance). Rotations are currently graded S/NC. However we will initiate a process by which faculty can briefly comment on the student’s aptitude for research and study, thereby helping to identify and solve any deficiencies as early as possible. These comments will become part of the student’s file. In addition, assessment of the student’s project in their major professor’s laboratory is undertaken during an “Initial Research Evaluation” that is required to take place before the beginning of the student’s fourth quarter, and again during the oral qualifying examination that normally takes place during Fall Quarter of the student’s third year. Students are required to submit a written presentation of their proposed research project to their examination committee prior to the oral qualifying examination. Assessment of the written qualifying examination is by the assembled faculty of the Biochemistry Department.

**Learning Outcome 2: Critical thinking, synthesis of ideas and communication skills.**

Students will be able to critically read and analyze the scientific literature in the context of existing theories, knowing that these theories can be challenged, modified or upended, as is the nature of science. Students will be able to identify questions that remain outstanding and to identify experimental approaches that may provide answers. Most importantly, students will be able to properly apply this critical thinking and analysis ability to their own research project and, in doing so, will develop their own scientific career. Students also will be able to present and defend their research in the context of scientific argument, will be able to communicate their research outcomes to a lay audience, and will be able to successfully publish research articles in peer reviewed scientific journals.

**Approach:**

The students will commence learning these skills during their rotations, with the process becoming more focused once they have selected their major professor and research project. The preparation and presentation of the Research Proposal, in part based on the grant submission format for the NSF and the NIH, in the format stipulated within the BMB Student Handbook, is a mandatory component of the oral qualifying examination, which is expected to be completed before the end of the Fall Quarter of the student’s third year. Each year the students are required to write an Annual Research Appraisal (ARA) document, the format of which is also based on NIH and NSF guidelines. This report covers the work the students have completed in
their previous year. The preparation of this report is meant to provide training in critical thinking and scientific analysis to the students specific to their research project and field of expertise. In addition to the written document, the annual evaluation includes an oral presentation to the student’s dissertation committee. This oral presentation also provides training in critical thinking and data analysis, as well as in scientific communication. All students from their second year onwards are also required to present their research (as either an oral presentation or a poster) at the Annual BMB Research Symposium held just before the beginning of Fall Quarter each year. Oral and poster presentations at the Annual Research Symposium provide the students with the opportunity to present their research outcomes in a formal scientific session. Students will also be encouraged to apply for competitive national scholarships with some training provided in a revised format of our BCH 250 course (“Science Communication and Professionalism,” 2 units, Winter or Spring Quarter). The program’s Randolph T. and Mary K. Wedding Travel Awards provide students with up to $1,000 to defray the expenses of presenting their dissertation research at major scientific conferences in the student’s field.

**Assessment Methods:**

The students are required to pass their oral qualifying examination in order to progress to candidacy. An assessment of the student’s written research proposal and its oral presentation to the Oral Qualifying Examination Committee is an essential component of this examination. The ARAs are assessed by the student’s Dissertation Committee. A negative evaluation result's in the student's progress being closely monitored by the Graduate Advisor, with further written and oral presentations being requested within the normal one year time frame. Oral and poster presentations at the Annual Research Symposium are assessed by faculty judges using appropriate metrics made known to students ahead of time.

**Learning Outcome 3: Knowledge and application of ethics in research, effective interpretation of evidence and broader implications arising from these.**

Students will be able to undertake research consistent with US government, University of California and Howard Hughes Medical Institute guidelines developed for the ethical conduct of scientific research and will be able to analyze and interpret data (using appropriate statistical analyses where appropriate).

**Approach:**

The students will be made aware of the proper ethical conduct of science both through the mentorship of their major professor (with additional guidance from their oral qualifying examination committee and their dissertation committee), from compulsory attendance at the Biochemistry Department’s BCH 252 seminar series, and from completing the revised BCH 250 class (“Science Communication and Professionalism”) held during Winter or Spring Quarter of the student’s second year. The preparation and critiques of the ARAs provide students with ongoing training in
the analysis of their data, as does preparation of research papers for publication, along with the review process associated with scientific publication.

**Assessment Methods:**

Attendance at BCH 252 is compulsory and students are awarded the S/NC grade on basis of attendance. Assessment in the BCH 250 communication and professionalism class is by letter grade. The assessment of both ARAs and presentations made at the Annual Research Symposium are described above (Learning Outcome 2). Assessment of the preparation of research papers is made on the basis of successful publication.

**Learning Outcome 4: Adherence to research milestones.**

The students will learn the importance of producing scientific outcomes within a targeted and reasonable time frame, as measured by successful experimental outcomes followed by their publication in peer-reviewed professional scientific journals and their presentation at professional meetings. The students will be guided to defend their thesis within the normative time established by the program (five years).

**Approach:**

Within the laboratory of their major professor, the student’s progress towards completion and publication of research will be monitored through presentations at lab meetings and through one-on-one meetings with the student’s major professor. At the next level, the student’s dissertation committee will monitor progress on an annual basis, with the ARA being an important guiding document.

**Assessment Methods:**

The primary programmatic method of assessment will be the ARAs through the Dissertation Committees. Other assessment methods will include presentations at scientific conferences and publication of conference abstracts and research papers.

**Learning Outcome 5: Effective teaching skills.**

The students will acquire the organizational and communication skills required to be effective teachers.

**Approach:**

The program requires that each student undertake two quarters as Teaching Assistants in Biochemistry courses. All students must first complete training provided by the Teaching Assistant Development Program (TADP).
Assessment Methods:

Assessment is made through the successful completion of TADP training and through student and instructor evaluations.

Learning Outcome 6: Professional skills.

The students will learn the professional and leadership skills required to be successful scientists.

Approach:

In addition to the process outlined in the five learning outcomes above (with particular reference to the BCH 250 “Science Communication and Professionalism” course offered in Winter or Spring of the student's second year), the students will develop professional skills through the chairing of scientific sessions at the Annual Research Symposium, the mentorship of junior students in the program by two senior students (selected by their peers), student participation in BMB committees (the BMB Seminar Committee, the BMB Annual Research Symposium Committee), and in the running of the Annual Research Symposium (with faculty guidance) and in the writing and submission of grant and fellowship proposals. Students play an active role in the nomination of some BCH 252 seminar speakers and subsequently host their visits to UC Riverside.

Assessment Methods:

In addition to the assessments outlined above, assessment is also made through the active participation of the students in the committees on which they serve and their abilities to perform the tasks assigned to them (such as chairing sessions at the Annual Research Symposium or hosting invited speakers). Feedback to the students is made through conversation with the relevant committee chair or the Graduate Advisor on the basis of these faculty members own observations or on the comments of invited guests, other faculty or students. Success in the writing and submission of grant and fellowship proposals will be evaluated by the number awarded. The success rate will be annually reviewed by the program and remedial strategies discussed and instigated. Other assessments will include presentations at scientific conferences and publication of conference abstracts and research papers

Learning Outcome 7: Satisfaction with the program and the student’s chosen career path.

Students will have an academically and professionally enriching experience within the program and will leave with the tools necessary to embark on their career of choice in the sciences.
Approach:

The students will be canvassed annually both as a group and individually for their assessment of the program through discussions with the Department Chair the BMB Graduate Advisor. These comments will then be brought to the attention of the Faculty and appropriate changes or clarifications enacted where appropriate. Exit interviews of all students will be conducted by both the Department Chair and the BMB Graduate Advisor. The BMB Student Handbook will be updated annually.

Assessment Methods:

Assessment of student concerns and advice will be made by the Biochemistry Department Faculty. Assessment of the Program’s ability to meet the needs of the students will be by periodic internal and external review as determined by Graduate Division.
WASC Assessment Plan for MS Program

The Biochemistry and Molecular Biology Graduate Program allows students to earn a Master’s Degree. This degree can be completed either in an exclusively course dependent manner or as a combination of coursework and a research-based dissertation. **For students choosing to obtain the M. S. degree on the basis of both coursework and a dissertation, the seven learning outcomes of the BMB Ph.D. program will apply.** For students choosing to obtain the M. S. degree exclusively through coursework, the BMB M. S. program has three learning outcomes that graduating students should achieve during the course of their studies. Achieving these outcomes will equip them for satisfying employment in the sciences and related areas.

**Learning Outcome 1: Knowledge of factual information, theoretical principles and methodological approaches.**

Each student must complete three core courses: one in molecular biology (BCH 211, “Molecular Biology,” 3 units, Fall), one in signal transduction and biochemical regulation (BCH 212, “Signal Transduction and Biochemical Regulation,” 3 units, Winter), and one in structural biochemistry (BCH 210, “Biochemistry of Macromolecules,” 4 units, Spring). These courses are augmented by additional specialty courses in biochemistry and related fields and the Department of Biochemistry’s seminar series (BCH 252, “General Seminar in Biochemistry,” 1 unit, offered each quarter) for a total of 36 units of credit, including at least 18 units taken at the graduate level. Specifically, students are required to complete at least one advanced course in the Biochemistry 230 series (“Advanced Topics in Biochemistry,” 2 units, Fall, Winter, Spring).

**Approach:**

The course plan for each entering student is determined by the Graduate Advisor on the basis of any undergraduate course deficiencies and the course requirements of the BMB program. The successful completion of the written qualifying examination, consisting of two three-hour components covering all aspects of biochemistry and molecular biology at the undergraduate and graduate levels, represents a significant learning outcome for the BMB M.S. students, which, when added to the student’s course work, results in the student being exposed to a significant body of knowledge in biochemistry and molecular biology.

**Assessment Methods:**

Assessment in the core and specialist courses is by letter grade, while assessment for seminars is by S/NC (on the basis of attendance). Assessment of the comprehensive written examination is by the assembled faculty of the Biochemistry Department.
**Learning Outcome 2: Knowledge and application of ethics in research, effective interpretation of evidence and broader implications arising from these.**

Students will be able to undertake research consistent with US government, University of California and Howard Hughes Medical Institute guidelines developed for the ethical conduct of scientific research and will be able to analyze and interpret data (using appropriate statistical analyses where appropriate).

**Approach:**

The students will be made aware of the proper ethical conduct of science through mandatory attendance at the Biochemistry Department’s BCH 252 seminar series.

**Assessment Methods:**

Attendance at BCH 252 is required and students are awarded the S/NC grade on basis of attendance. Assessment in the BCH 250 communication and professionalism class is by letter grade.

**Learning Outcome 3: Satisfaction with the program and their chosen career path.**

Students will have an academically and professionally enriching experience within the program and will leave with the tools necessary to embark on their career of choice in the sciences.

**Approach:**

The students will be canvassed annually both as a group and individually for their assessment of the program through discussions with the Department Chair the BMB Graduate Advisor. These comments will then be brought to the attention of the Faculty and appropriate changes or clarifications enacted where appropriate. Exit interviews of all students will be conducted by both the Department Chair and the BMB Graduate Advisor. The BMB Student Handbook will be annually updated.

**Assessment Methods:**

Assessment of student concerns and advice will be made by the Biochemistry Department Faculty. Assessment of the Program’s ability to meet the needs of the students will be by periodic internal and external review as determined by Graduate Division.
Appendix

The content and learning objectives for each of the BMB Program’s core courses are as follows:

**BCH 210. Biochemistry of Macromolecules (4)** Lecture, 4 hours.
Prerequisite(s): BCH 110A, BCH 110B, BCH 110C or equivalents; BCH 184 (may be taken concurrently); CHEM 109; graduate standing or consent of instructor.

**Learning Objectives:** Students are expected to attain an understanding of basic principles related to the molecular architecture of proteins and nucleic acids especially with respect to modern experimental approaches for analyzing their structure and function. Fundamentally, students must attain an understanding of the principles underlying the use of macromolecular X-ray crystallography and other methods (e.g., low-angle X-ray diffraction, neutron diffraction, NMR spectroscopy, and cryoelectron microscopy) for determining macromolecular structures and the use of spectroscopic and thermodynamic methods for the determination of enzyme mechanisms and for quantitatively describing protein:ligand, protein:protein and protein:nucleic acid interactions. These methods include absorption spectroscopy (electronic and vibrational), circular dichroism, fluorescence spectroscopy, NMR spectroscopy (relating to protein dynamics), and EPR spectroscopy. Students must also attain an understanding of the analysis of rapid-reaction enzyme kinetics and the principles underlying single-molecule studies of biological molecules in action.

**BCH 211. Molecular Biology (3)** Lecture, 3 hours.
Prerequisite(s): BCH 110A, BCH 110B, BCH 110C or equivalents; graduate standing or consent of instructor.

**Learning Objectives:** Students are expected to attain an understanding of the mechanisms by which gene expression is executed and regulated. Fundamentally, they must attain a detailed understanding of the machinery and mechanisms involved in transcription including chromatin structure, RNA processing and splicing (both cis and trans splicing), RNA editing, RNA transport and localization, RNA stability, translation, RNA silencing, protein targeting, protein secretion, chaperones, protein splicing, and apoptosis. Comprehension of these subjects as they largely pertain to eukaryotes is expected. In addition to this understanding of the mechanisms by which each step in gene expression is achieved, an appreciation of the interrelationship among the steps is expected. For example, students are expected to know the interrelationship between epigenetics and transcription; the role of transcription in 3’-end formation and polyadenylation as well as in controlling RNA stability; the role of RNA silencing in the epigenetic control of transcription and the role of apoptosis in regulating translation. Students are expected to attain an appreciation of how disparate mechanisms are similar.
**BCH 212. Signal Transduction and Biochemical Regulation (3)** Lecture, 3 hours. Prerequisite(s): BCH 110A, BCH 110B, BCH 110C or equivalents; graduate standing or consent of instructor.

**Learning Objectives:** Students are expected to attain an understanding of the cellular mechanisms by which extra- and intracellular signaling molecules are detected and how these molecules trigger programmatic changes in response to stress and developmental cues. Students are expected to develop a detailed understanding of the function and role of receptors in detection of these signaling molecules. Additionally, students are expected to gain knowledge of the various types of protein modifications involved in propagation and termination of a signaling event. Students will also build an understanding of the roles of second messengers and protein factors that are commonly found in eukaryotic signal transduction pathways. Knowledge of these topics will be developed within the context of several different signal transduction pathways, which will include information pertaining to the specific agonist(s) of each pathway.

**Assessing Learning Outcomes:** In order to determine student success with regard to the learning objectives outlined for each of the three core courses, questions pertaining to these learning objectives are included as part of the written comprehensive examination. This examination is required of all students in the Biochemistry and Molecular Biology graduate program following completion of their graduate coursework and represents a key opportunity to assess whether students have gained the necessary knowledge from their core coursework. Questions on this comprehensive exam are structured in a way that will allow for quantification of student success relating to achievement of the learning objectives. Additionally, these questions are constructed in a manner that allows comparison of success rates over a multi-year period so that trends can be determined regarding student achievement in the graduate program. Data on each student’s performance on each topic included in the written comprehensive exam are being collected separately so that the assessment of each learning objective can be quantified individually. Through this approach, the effectiveness of the Biochemistry and Molecular Biology graduate program regarding assimilation of a core set of principles can be determined. This information will provide guidance for future curricular changes.