November 17, 2011

MARK T. STACEY
Chair, Graduate Council
Academic Senate, Berkeley Division

RE:  A Proposal for a Program of Graduate Studies for the Joint Master of Translational Medicine (MTM) Degree

In May 2011, both the College of Engineering faculty and the Department of Bioengineering faculty approved the proposed 24-unit Master of Translational Medicine (MTM) degree program, a joint degree offered by UC Berkeley and UCSF. The department vote and the College faculty vote are noted below in Table 1 and Table 2.

Table 1: Department of Bioengineering: Faculty Voting Results to Approve MTM Degree, May 2, 2011, Department Faculty Meeting

<table>
<thead>
<tr>
<th>Voting Categories</th>
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<tr>
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<tr>
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Table 2: College of Engineering Faculty Vote to Approve MTM, May 9, 2011, Collegewide Spring Faculty Meeting

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</tr>
<tr>
<td>Did not vote</td>
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The Master of Translational Medicine program is proposed to expand the offerings to our students and further Berkeley’s leadership in this important area of study. Our complete proposal, dated November 16, 2011, outlines the goals, benefits, rationale, and background for this offering. Please let me know if you would like to receive further information. Thank you.

Sincerely,

S. Shankar Sastry
Dean, College of Engineering

Cc: Kevin E. Healy, Chair, Department of Bioengineering
    Sarah Nelson, Co-Chair, Department of Bioengineering & Therapeutic Sciences, UCSF
    Kathy Giacomini, Co-Chair, Department of Bioengineering & Therapeutic Sciences, UCSF

Continued
Tejal Desai, Faculty Co-Director, MTM Program, UCSF
Diane Hill, Assistant Dean for Academic Affairs, Graduate Division
Karen Holtermann, Senior Development Director, College of Engineering
Clay Johnston, Associate Vice Chancellor of Research, UCSF
Marcia Kai-Kee, Senior Budget Coordinator
Kyle Kurpinski, Executive Director, MTM Program
Song Li, Faculty Co-Director, MTM Program, UC Berkeley
Linda Song, Associate Director, Academic Senate
Marcia Steinfeld, Executive Assistant Dean, Engineering
Andrew Szeri, Dean, Graduate Division
A PROPOSAL FOR A PROGRAM OF GRADUATE STUDIES
FOR A MASTER OF TRANSLATIONAL MEDICINE (MTM) DEGREE

A JOINT DEGREE PROGRAM

November 17, 2011

Proposed by
Department of Bioengineering | University of California, Berkeley
Department of Bioengineering and Therapeutic Sciences | University of California, San Francisco

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Section 1. Introduction

1.1 Aims and Objectives

The Department of Bioengineering at UC Berkeley and the Department of Bioengineering and Therapeutic Sciences at UCSF propose to establish a new one-year professional Master of Translational Medicine (MTM) degree that will be state-supported and intends to charge Professional Degree Supplemental Tuition. The degree will be awarded jointly by the two departments and campuses, a unique feature that draws on the technical and clinical strengths of the two institutions, making the program especially attractive to a broad range of students. The MTM program will provide opportunities for engineering professionals, Ph.D. students, postdoctoral fellows, M.D.s, M.B.A.s, Pharm.D.s, R.N.s, D.M.D.s, and J.D.s who wish to gain expertise in applying translational science and engineering approaches to produce practical solutions to pressing global and societal health issues. The target enrollment at steady state is 30 students.

“Translational medicine” refers to the process of transforming — or “translating” — basic science discoveries into practical medical technologies for use with patients. Through this professional master’s program students will learn the skills to integrate the science, technology, and business expertise required to drive scientific discoveries into public use for the improvement of health. The program leverages the expertise and technological resources of the two institutions so that students will acquire the skills to address real-world problems creatively in an interdisciplinary, team setting. The proposed program is flexible, serving students with a range of experience and training. Coursework includes hands-on instruction in core engineering fundamentals; physiology and disease processes; pre-clinical testing and trial design; regulatory issues; ethics; and the business and economics of healthcare product development. Student achievement will be individually assessed, but students from different educational backgrounds will work in teams, integrated through group capstone projects and interdisciplinary mentoring. The program will benefit from synergies with existing graduate education programs on the two campuses in clinical research, “T1” translational research (that is, research that seeks to move a basic science discovery to potential clinical application) in the biomedical sciences, and implementation/dissemination research, with training opportunities and cross-disciplinary collaboration fueling greater creativity and underlining the unique strengths of UC Berkeley and UCSF.

The rationale for such a program is strong. Investment in biomedical research by government and industry has more than doubled over the last decade, with the National Institutes of Health (NIH) budgeting nearly $32 billion alone in this area. However, the pace of practical advances in therapeutics and diagnostics has lagged dramatically; in fact, the rate of U.S. Food and Drug Administration (FDA) approvals for new drugs and devices has decreased over that time. Healthcare has become progressively more expensive with only modest improvements in health. While the pace of technological development has been staggering and has produced dramatic reductions in costs in many arenas, the biomedical enterprise is mired in inefficiencies and distractions. Bringing engineers and biomedical professionals together will produce synergies that are only sporadically realized today. Very few educational programs have attempted this focus on engineering and clinical aspects of advancing healthcare, and even fewer also integrate education in entrepreneurship and business practices, essential tools for translating practical discoveries into approved and broad use.

The UC Berkeley and UCSF bioengineering faculties have made the translation of laboratory efforts into commercial and clinical advances, in all areas, a pervasive theme and goal. We believe the proposed Master of Translational Medicine — one of the first in the U.S. to provide this unique mix of educational content — will extend that educational goal and fill a workforce void by producing leaders in engineering,
medicine, business, and many other fields who will identify more effectively — and act on — new opportunities for the development of devices, diagnostics, therapeutics, processes, software, and other tools to improve health.

The Bioengineering faculties strongly support this direction. At UC Berkeley, the Department of Bioengineering faculty voted on May 2, 2011 to approve this new degree program. Thirteen of the 19 core faculty members were present for the vote, with eleven voting “yes,” one voting “no,” and one abstention; of the four partial-appointment faculty members who were present, all voted “yes” (a quorum for College of Engineering faculty meetings is 15). Additionally, UC Berkeley’s College of Engineering faculty voted unanimously (38 “yes,” 0 “no”) on May 9, 2011, to approve the new MTM degree program.

At UCSF, the campus Academic Senate voted 162 to 8 (with 1 abstention) in January 2010 to approve this new degree program offering. (No separate vote of the faculty of the Department of Bioengineering and Therapeutic Sciences was recorded.).

The specific faculty voting results are shown below in Chart 1 and Chart 2:

**Chart 1, UC Berkeley: May 2011 Votes for Proposed MTM Degree Program**

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<th>Bioengineering Faculty</th>
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<tr>
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<td>15</td>
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<td>No</td>
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<td>No</td>
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<tr>
<td>Abstain</td>
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<td>Abstain</td>
</tr>
<tr>
<td>Did not vote</td>
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**Chart 2, UCSF: Vote for Proposed MTM Degree Program**

<table>
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<th>UCSF Academic Senate (Jan 2010)</th>
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<tr>
<td>No</td>
<td>8</td>
</tr>
<tr>
<td>Abstain</td>
<td>1</td>
</tr>
<tr>
<td>Did not vote</td>
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1.2. Historical Development of the Field and Institutional Strengths

Bioengineering has a long history at both campuses. It began informally through the collaborative activities of enterprising faculty and students more than 30 years ago. To facilitate the increasingly productive interactions between engineering and other faculty at UC Berkeley and clinical research efforts at UCSF, the Joint Graduate Group in Bioengineering was established in 1983 to offer a joint Ph.D. in bioengineering. The Ph.D. (and since 2010 a small number of terminal master’s degrees) continue to be awarded through the joint graduate group. The group is hosted by the UC Berkeley Department of Bioengineering and the UCSF Department of Bioengineering and Therapeutic Sciences, which provide resource support.

Meanwhile, at Berkeley, undergraduate education in bioengineering flourished under the auspices of the interdisciplinary Engineering Science Program in the College of Engineering. In recognition of the emergence of bioengineering as a distinct discipline in its own right, the UC Berkeley Department of Bioengineering was established in 1998, the first new department created in the College of Engineering in more than 40 years. At UCSF, the Department of Bioengineering and Therapeutic Sciences was founded in 2009, administered jointly by the UCSF Schools of Medicine and Pharmacy. It was formed by the union of the Department of Biopharmaceutical Sciences in the School of Pharmacy and the Program in Bioengineering in the School of Medicine. It is UCSF’s first inter-school department.
The history of the health and life sciences disciplines is also at a significant juncture today. Concurrent with this academic development on our two campuses, the health and life sciences are in the midst of a profound revolution triggered by new and fundamental advances in molecular and cellular biology and due in part to new technology and quantitative approaches developed in chemistry, physics, and engineering. These advances, along with our aging of the population, will increase the demand for better medical devices, therapeutics, and diagnostics at a lower cost. New policies emerging from healthcare reform will change the way medicine is practiced and create new urgency for developing more effective and less costly means to prevent and treat diseases.

Traditional curricula in the life sciences have not included the understanding of technological development that is required in many areas of the current clinical enterprise. Similarly, curricula in traditional engineering disciplines lack biomedical content, and even bioengineering curricula tend to lack a strong clinical component and an understanding of the clinical interfacing and technology translation. An academic environment that fosters interaction between physical and life sciences and that teaches students to solve clinical problems using modern engineering tools is needed.

We believe there is a large, unmet need for the MTM degree program. It will give students the ability to integrate principles from diverse fields to span the gap between basic science advances and their clinical utilization. The degree program will position its graduates to be leaders and significant contributors at a critical juncture in the advancement of healthcare.

Joint Master’s Degree Rationale

The proposed MTM program is situated at two outstanding campuses, both located in a major center for the microelectronics, medical-device, and biotechnology industries. UC Berkeley is a world leader in engineering and the biological sciences, while UCSF has equal credentials in biomedical research and clinical healthcare practice.

*U.S. News & World Report* consistently ranks Berkeley among the top three universities nationwide for both graduate and undergraduate engineering programs. UCSF ranked second among all medical schools in 2009 in total NIH funding, and the campus consistently has been rated as having the top pharmacy, nursing, and dentistry schools in the nation; the University Health System Consortium ranks UCSF among the top 10 of the nation’s premier academic medical centers in overall quality. The opening of a 43-acre UCSF campus at Mission Bay — with a strong focus in translational science — has enhanced significantly the campus’s ability to grow in innovative directions, including its strong interest in bringing engineering and clinical work together, the major driver in the development of the MTM degree. The interaction of clinicians, basic scientists, and engineers at UCSF and UC Berkeley — combined with the contributions of business leaders, entrepreneurs, and faculty — provides fertile ground for educating engineers and life scientists to transcend the traditional boundaries between biology, medicine, and engineering.

The 2010 National Research Council rankings place the joint bioengineering Ph.D. program (with degrees awarded through the UC Berkeley-UCSF Joint Graduate Group in Bioengineering) well within the top 10 in the nation, with a 90% confidence range of being between #2 and #8 by regression, and a 90% confidence range of being between #1 and #6 by survey. When sorted by either rating method, the joint doctoral program places third among bioengineering programs nationwide. Judging by the long-term success of the joint Ph.D. program, the proposed joint master’s program is likely to enjoy similar achievements with the benefit of existing faculty, courses, and administrative resources.
Student interest in bioengineering degree programs has been continuously strong and growing. At Berkeley, undergraduate applications to bioengineering have soared (increasing from 387 since Berkeley’s founding class in 1999 to 1,457 in 2010). Demand for the joint Ph.D. program is now comparable to the numbers of applications to much larger, mature, and well-known engineering programs at Berkeley (527 applications were received for the 2011 cycle), and more than one-third of current doctoral students have received extramural fellowships, including 36 from the NSF.

1.3 Timetable for Development of the Program and Enrollment Projections

Planning for this degree program began in late 2009. An ad hoc program committee was assembled with broad representation from several academic partner organizations: the Department of Bioengineering, UC Berkeley; the Department of Bioengineering and Therapeutic Sciences, UCSF; the Clinical & Translational Science Institute (CTSI), UCSF; and the California Institute for Quantitative Biosciences (QB3), with branches on both campuses. This group developed detailed curriculum plans, and discovered in the process that many of the program elements were already in place: clinical training courses at UCSF; leadership and entrepreneurship curricula at UC Berkeley; and highly relevant core and technical depth courses in bioengineering on both campuses. An operational framework to make a cohesive, operational program from these strong elements was needed.

A gift pledge from Andy Grove, co-founder and former CEO of Intel and a strong advocate for translational medicine, provided support for development and initial implementation of the program, envisioned as an independent professional degree with strong engineering, clinical, and business components to educate students to be able to navigate the complex technical, entrepreneurial, and regulatory landscapes for improving patient care. This was the start of the complex two-campus process for establishing a new Master of Translational Medicine degree, which has led to this proposal.

However, as the two bioengineering departments began working toward the goal of the new professional MTM degree, the strong faculty interest in translational medicine and its urgency for advancing healthcare led the faculty to propose offer an existing academic M.S. degree with a concentration in translational medicine. The leadership of the Joint Graduate Group in Bioengineering, in cooperation with the committee developing the MTM program, proposed to admit students to its existing M.S. degree program for the 2010-11 year. (The joint graduate group’s Plan II M.S. was approved in 1983 when the group was founded, but the option to offer a terminal master’s degree had never been exercised.) With the cooperation and support of the Graduate Divisions at UC Berkeley and UCSF, the first cohort of 16 M.S. students was admitted for Fall 2010; a second cohort of 16 (including 2 continuing students from the first cohort, and not including 1 student who deferred enrollment for a year) entered in Fall 2011. The joint graduate group intends to cease admitting translational medicine students to the M.S. when and if the MTM is established (a memo to this effect is included in Appendix F).

While this proposal is informed by experience with the terminal M.S. program offered through the joint graduate group, the proposed new MTM is a professional master’s degree that will encompass the complete vision outlined in the introduction and ensure the sustainability of a professional degree program of the highest quality for our students. (For details on what differentiates the current M.S. and the proposed MTM programs, see Section 1.4.)

The projections and timeline for MTM enrollment for its first three years are in Chart 3. Steady-state enrollment is anticipated to be 30; enrollments will be divided evenly between the two home campuses, so that the net increase in enrollment on each campus will be approximately 15. Any change in enrollment targets in out-years would be based on the success of the program and determined in conjunction with overall enrollment targets and approvals for both campuses.
1.4. Relation of the Proposed Program to Existing Programs at UC Berkeley and UCSF and to the Campus Academic Plans

The proposed MTM program will not overlap with any existing programs offered on either campus but will provide a unique combination of courses that is particular to this degree offering. The translational challenges that must be met by MTM graduates necessitate an understanding of the regulatory environment, economic challenges complicated by the healthcare cost structure, and the realities of healthcare practices, from operating room procedures to patient behavior. The strong clinical aspect of the MTM program is necessary for students to compete in this arena. Moreover, additional core coursework in the areas of business, leadership, and product development will be woven into the program’s scientific, clinical, and engineering basis to provide students a cutting edge foundation for this specialized field.

Projected enrollments for the MTM — 30 students at steady state — will not overly tax the faculty or substantially increase teaching workloads. Four new courses will be offered through the Bioengineering and BTS departments at UC Berkeley and UCSF: (1) the Capstone Project course (Bioengineering 296) at UC Berkeley, (2) the Capstone Project Course (Bioengineering 296) at UCSF, (3) Translational Challenges in Diagnostics, Devices, and Therapeutics (Bioengineering 270) at UCSF, and (4) Ethical and Social Issues in Translational Medicine (Bioengineering 290X) at UC Berkeley (details of all four new courses are outlined in Appendix G). Because the teaching and mentoring load for the Capstone Project courses is dispersed between the course instructors/Faculty Co-Directors and the various project leaders, existing faculty can easily accommodate the load, as is already being done for the current project work in the M.S. program. A trial version of the Bioengineering 270 course was taught by Shuvo Roy (see section 4) for the 2010-11 M.S. cohort, and will be offered again in 2011-12 and 2012-13; the complete, updated version of the course will be offered for the first MTM cohort in 2013-14, and will not significantly alter the current teaching load. Bioengineering 290X will be a 1-semester unit course that will focus on ethical issues in translational medicine, and will draw upon guest lectures and material from various members of the proposed MTM program. Although the overall change in teaching load from these four new courses is minimal, ample financial support will be allocated from the PDST revenue to support the necessary teaching efforts (see Appendix K for budgetary details). There is also adequate capacity in other graduate courses to accommodate the steady-state enrollment numbers we are proposing, and we do not see the addition of the MTM as having an impact on undergraduate course offerings.

Specifically, the Clinical & Translational Science Institute (CTSI) at UCSF provides several core epidemiology courses as part of the clinical component of the curriculum, and the Coleman Fung Institute for Engineering Leadership at UC Berkeley provides two core leadership courses as part of the business/leadership component of the curriculum. (Administrative and financial arrangements have been made with both institutes to ensure the availability of courses for MTM students; statements to this effect are included in letters of support from Professor Clay Johnston, director of CTSI, and Professor Lee Fleming, Faculty Director of the Fung Institute. Additionally, many approved electives are offered through various departments at both campuses, including the Haas School of Business, the School of Public Health, and several departments in the College of Engineering at UC Berkeley, well as through established
graduate programs at UCSF, including Pharmaceutical Sciences and Pharmacogenomics, and Biological and Medical Informatics. For more on faculty workload matters, see Section 6.1.

The MTM program will occupy a distinct niche in educating future leaders by offering clinical, entrepreneurial, business, and technical education in the defined area of healthcare. We believe it will complement and build synergy with the existing degree programs listed here (a summary of the programs is charted in Figure 1):

**Master of Science in Bioengineering (UC Berkeley | UCSF):** As described in Section 1.3, UCSF and UC Berkeley began offering a terminal M.S. with a concentration in translational medicine in Fall 2010 through the Joint Graduate Group in Bioengineering. It is the graduate group’s intention to cease admission to the M.S. as a terminal degree (except in cases where PhD candidates depart before completing the doctorate) when and if the MTM degree is approved and established (see Appendix F).

This joint M.S. degree program contains many of the curricular elements we are proposing for the new MTM degree, but there are key differences. Foremost, the MTM will be recognized and supported as a professional degree, while the M.S. is not. Current M.S. students are the beneficiaries of a professional degree experience without earning a professional degree; elements of that experience — including capstone projects, special courses, and individualized student services — are only possible because they have been underwritten by the limited private funding provided by the Andy Grove gift. The MTM degree program will be significantly more robust and sustainable — academically, financially, and in terms of the student services that accompany it.

Points of differentiation between the MTM and M.S. include these:

1) While the current M.S. draws students primarily with undergraduate degrees in bioengineering and the life sciences, the proposed MTM will also appeal to M.D.s, Pharm.D.s, D.M.D.s, Ph.D.s, and potentially those with business, policy, law, or other medical backgrounds.

2) Additional coursework in business, leadership, and product development is an integral part of the MTM. This includes core leadership courses (Engineering 271 and 272) delivered through Berkeley’s Fung Institute, which cover “key leadership principles and management concepts specific to technology-dependent enterprises,” and a new course currently being developed (Bioengineering 270), which covers fundamentals of the design, development, and approval of new medical devices, diagnostics, and therapeutics.

3) A new course (Bioengineering 290X) that will address the various ethical and social issues specific to the field of translational medicine.

4) The capstone project courses (Bioengineering 296), which are critical to the concept of the MTM, will be new for the MTM. Current M.S. students are required to do similar work through BioE 299 (independent study), but the joint graduate group does not have the infrastructure to sustain support of capstone projects without the resources and staff that will be available to the MTM program through professional degree supplemental tuition (PDST) revenues.

5) Job placement services for graduates, which are critical to the long-term impact and success of the proposed MTM program and to the core concept of “translating” technology breakthroughs effectively.
6) The MTM will be offered through the bioengineering departments on each campus, not through the joint graduate group, giving students additional access to departmental staff, space, and resources.

**Ph.D. in Bioengineering (UC Berkeley | UCSF):** UCSF and UC Berkeley offer a joint doctoral program in bioengineering through the Joint Graduate Group in Bioengineering. While we anticipate that there will be some overlap in the courses offered, the joint Ph.D. program encompasses much broader aspects of bioengineering and is focused on independent, original research to be completed with a Ph.D. dissertation. In contrast, the MTM does not educate students with the intent of producing new disciplinary knowledge through research, but emphasizes translating existing scientific discovery into beneficial devices, diagnostics, and therapeutics for patient care.

**Master of Science in Radiology and Biomedical Imaging (UCSF):** This new M.S. program, developed by the Department of Radiology and Biomedical Imaging, enrolled its first entering class in Fall 2011. The program is intended for advanced pre-doctoral students, postdoctoral fellows, medical residents, and faculty members who wish to utilize imaging sciences to broaden their investigative projects. Coursework includes instruction in core theory drawn from imaging physics, engineering, and mathematics, linked to physiology and disease processes. Hands-on laboratory courses are an important part of the curriculum with experiments relevant for characterizing pathologies, monitoring response to therapy, and assessing underlying disease processes. Specialized topics such as quantitative imaging, research design, image analysis, and technology assessment will be available through electives.

This program is significantly different from the proposed MTM program in both scope of education and targeted applicant pool. The M.S. provides education exclusively in the biomedical subfields of radiology and imaging, whereas the MTM will offer education in a broader range of bioengineering topics, while specifically focusing on the practical application of bioengineering principles for clinical use. As stated earlier, education in the MTM program will include additional coursework in areas such as business, leadership, and product development, which are not present in the M.S. curriculum. Additionally, the M.S. program is targeted toward advanced students with a specific interest in medical imaging, while the MTM program is intended for students interested in the translational aspects of any biomedical subfield. There should be very little overlap between the applicant pools for these two programs.

**Master of Engineering (UC Berkeley):** The Master of Engineering is a professional master’s program combining discipline-specific coursework with a core leadership curriculum and a capstone project experience. Five engineering departments offer the M.Eng., and a proposal has been submitted to also offer the degree in Bioengineering, with initial concentrations in Bioengineering (Comprehensive), Biomaterials, and BioMEMS (Biological Microelectromechanical Systems). All students in the program take the core leadership courses, while the discipline-specific courses are taken in the student’s home department. The capstone project bridges the leadership curriculum (including strategy, finance, and innovation) and the technical specialization by pairing student groups with a technical opportunity in their area, under the supervision of the leadership curriculum lecturers, faculty members working in that area, and industry professionals. Graduates of this one-year program receive an M.Eng. degree granted by one of the participating engineering departments.

While the M.Eng. in Bioengineering has a distinctly engineering focus, the MTM will differ significantly in its inclusion of a strong clinical component. Although both programs share core courses in leadership and entrepreneurship, the rest of the MTM coursework and its capstone differ significantly from the M.Eng. in approach and focus. The T1 translational challenges that must be met by MTM graduates necessitate an understanding of the regulatory environment, economic challenges complicated by the cost
structure of healthcare, and the realities of healthcare practices ranging from operating room procedures to patient behavior. The strong clinical aspect of the MTM program is necessary for students to compete in this area.

The joint nature of the MTM program is critical: the two campuses provide specialized education covering all areas of translational medicine that cannot be achieved at only one campus or the other. UCSF, with its medical school, provides clinical education and experience that is unavailable at UC Berkeley. Likewise, UC Berkeley’s College of Engineering and Haas School of Business provide educational content that does not exist at UCSF. The essential partnership between Berkeley and UCSF most distinguishes the MTM from the M.Eng. in Bioengineering.

Certificate of Advanced Training in Clinical Research (ATCR) and Master of Advanced Study in Clinical Research (UCSF): The Training in Clinical Research program offers 32 individual courses related to clinical and translational research methods leading to the one-year ATCR certificate or the two-year M.A.S. These programs are intended for advanced pre-doctoral students, postdoctoral students, residents, fellows and faculty who wish to master clinical research methods and pursue independent research careers. It includes coursework that addresses the design, interpretation, and analysis of studies that involve human subjects. The program also includes a concentration (Program in Dissemination Sciences) focused on the methods and skills that guide research aimed at enhancing the adoption, adaptation, and spread of best evidence-based practices and policies in clinical care and public health. The programs are jointly funded by a CTSA NIH grant and by UCSF; they are administered by the UCSF Clinical & Translational Science Institute (CTSI).

The M.A.S. is focused on increasing the number and quality of successful clinical researchers, while the MTM specifically seeks to educate leaders who can effectively apply science and engineering technology to achieve healthcare solutions.

Master of Business Administration and Master of Public Health Concurrent Degree Program (UC Berkeley): UC Berkeley’s Haas School of Business and the School of Public Health offer a 2.5-year M.B.A./M.P.H. concurrent degree program called the Graduate Program in Health Management. Its students take courses in both schools and receive both an M.B.A. and an M.P.H. The mission of the program is to prepare graduates for positions of leadership in all aspects of healthcare, including care delivery and financing, biotechnology and medical devices, information technology, and consulting.

While the M.B.A./M.P.H. program provides education in healthcare management and leadership, it lacks the technical and engineering education provided by the MTM program. MTM graduates will be well versed in bioengineering fundamentals and technical design; M.B.A./M.P.H. graduates will not.

Ph.D. in Epidemiology and Translational Science (UCSF): This is a new program in the Department of Epidemiology and Biostatistics in UCSF’s School of Medicine is a joint effort with the UCSF Clinical and Translational Science Institute (CTSI). The program provides students with rigorous education in epidemiologic and biostatistical methods, along with opportunities for practical experience in a wide variety of applied areas to enhance their education. This is a three- to four-year course of study for individuals who wish to pursue independent research careers in epidemiology and translational science and who have already completed training at the master’s level in epidemiology, public health, or related fields. Objectives of the program include mastery of the field of epidemiology and related disciplines and their applications in translational science; learning practical aspects of conducting research, including how to work within a multidisciplinary team; acquiring experience in the instruction of epidemiology and
translational sciences; and the planning and completion of original epidemiologic/translational research that will be the subject of a dissertation and publishable manuscripts.

This program differs significantly from the MTM. It requires the original research of a doctoral program (unlike the MTM), is aimed specifically at epidemiologists, lacks the business and entrepreneurial aspects of the MTM curriculum, and does not include an engineering component.

Figure 1. Related Programs at UC Berkeley and UCSF

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<th>Master's Programs</th>
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<td>UCSF/UCB PhD: Joint Graduate Group in Bioengineering (engineers, MDs, industry)</td>
<td>UCSF PhD: Epidemiology and Translational Science (MDs, MPHs, BSs); not yet approved</td>
</tr>
<tr>
<td>UCSF/UCB MS: Joint Graduate Group in Bioengineering (terminal MS, currently ‘repurposed’)</td>
<td>UCSF MAS: Master’s in Clinical Research (MDs, PharmDs, RNs, DMDs)</td>
</tr>
<tr>
<td>UCB MEng: Bioengineering concentrations through Coleman Fung Institute (engineers)</td>
<td>UCB MBA/MPH: Business and Public Health (engineers, scientists, MDs)</td>
</tr>
<tr>
<td>UCSF MS: Radiology and Biomedical Imaging (PhDs, PharmDs, industry)</td>
<td>UCSF/UCB: Master’s in Translational Medicine (engineers, PhDs, PharmDs, MDs, RNs, DMDs, industry)</td>
</tr>
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(Target applicants are in parentheses.)

1.4.1. Relation to Campus Academic Plans

The proposed Master of Translational Medicine degree represents an innovative, collaborative approach for bridging education, healthcare, and research that spans disciplines within the health sciences, engineering, and business. It will support UC Berkeley and UCSF’s mission to be world leaders in scientific discovery and translation of these discoveries to advance healthcare. Moreover, the degree will help increase the impact and recognition of UC Berkeley and UCSF’s technological and medical contributions, regionally, nationally, and internationally.

Relation to the UC Berkeley Academic Plan

Three UC Berkeley documents guide the campus’s strategic direction in proposing the new MTM degree. Foremost is the UC Berkeley Strategic Academic Plan (Spring 2002), the most recent comprehensive plan for the campus. This is supplemented by the Self-Study of the Department of Bioengineering (August 2007), which is as a detailed codicil that is mandated by the campus plan, and by Access and Excellence (Fall 2008), Chancellor Birgeneau’s narrative that sets priorities and goals for the Berkeley campus.

The MTM program responds to many of the threads in the UC Berkeley Strategic Academic Plan (SAP). The plan directs the campus to pursue new paths of inquiry, discern and respond to long-term...
fundamental trends in society, make use of the breadth of Berkeley’s academic excellence, and build professional programs that are based on a strong foundation in traditional disciplines and significantly enriched by interaction and collaboration with existing academic and professional programs. As outlined in this proposal, MTM aligns solidly with each of these directions.

Specifically, the SAP mandates that the selection of new academic programs be based on five criteria, briefly outlined below. The proposed MTM program responds to these criteria in the following ways:

1. **Intellectual content:** Embody a field of inquiry that is sufficiently different from existing programs and carries a strong potential for Berkeley to become a leader in the new field.
   - Although many universities are engaged in the new field of translational medicine and it is a topic of strong academic interest across the country, the joint UC Berkeley-UCSF MTM degree will be the first of its kind. No other UC degree combines bioengineering and technology, business and entrepreneurship, and clinical and regulatory practices and perspectives. Because UC is at the forefront in developing this program and it is built on foundational disciplines with exceptional academic standing at Berkeley and UCSF, the potential for leadership in the new field is excellent.

2. **Societal importance:** Benefit California, the nation, and society; respond to urgent societal needs; and have a strong potential for significant positive impacts.
   - The implications are huge for translating research more rapidly and effectively into advances in health and medicine. Success in this emerging field will save lives, improve treatments, stem healthcare costs, and capitalize on the significant government and private sector investments in medical research (a $32 billion budget is proposed for 2012 for the National Institutes of Health alone). Research advances and new therapeutic opportunities are growing fast, but the pipeline channeling them into viable medical solutions is crimped. MTM graduates will have the skills to help open that pipeline, to society’s benefit. Some examples of UC Berkeley and UCSF bioengineering innovations that are translating (or awaiting translation) into health benefits are microfluidic blood analysis devices and techniques, which gather and test tiny samples of blood for fast analysis and diagnosis, even in remote areas; the long tradition of breakthroughs in medical imaging on both campuses, from early work on MRI and PET scans to the latest MPI (magnetic particle imaging) scans that can track stem cells and elucidate their interaction with other cells; and the development of the CellScope, which uses cell phone technology in analyzing and transmitting diagnostic data and will soon be deployed in a trial for tuberculosis testing in Asia. UC Berkeley and UCSF provide an ideal environment for such translational breakthroughs and education, as demonstrated by quality of translational research at both institutions (see Appendix H for additional examples).

3. **Resource base:** Engage a core of appropriate, motivated faculty; leverage and enhance Berkeley’s strengths; and create or enhance intellectual synergy across multiple disciplines.
   - The MTM curriculum spans engineering, business, and diverse health areas, bringing new synergies and critical perspectives together for problem solving in the field. Each discipline is an area of academic strength at UC Berkeley and UCSF, and, consequently, engaged faculty from both campuses are eager to collaborate. MTM will make great use of UC Berkeley/UCSF strengths: 1) UC Berkeley’s world’s leading engineering program, 2) UCSF’s outstanding clinical programs, 3) UC Berkeley’s strengths in business and entrepreneurship, and 4) the proximity and strong relationships of both campuses to the biotechnology industry to lend real-world perspectives to the program and to the work students undertake in their capstone projects.

4. **Student base:** Demonstrate sufficient potential for student enrollment.
• The Joint Graduate Group in Bioengineering has offered an M.S. with a concentration in translational medicine during 2010-11 and 2011-12, enrolling 16 students each year. The interest from high-quality students has been significant. With limited marketing, there were 83 applicants in 2010-11 (20 were admitted), growing to 186 applicants in 2011-12 (22 admitted). Offering a dedicated professional degree in translational medicine should yield even stronger interest, as evidenced by data collected from multiple student and alumni focus groups, as well as an online survey conducted in 2011 (see Section 3.2, Student Demand, for specific details). Additionally, support from industry leaders and the MTM Advisory Board suggests a strong job market for MTM graduates (see Section 3.3 regarding placement opportunities).

5. Implementation: Demonstrate that there is a clear path to implementing the program, including appropriate leadership, resources, potential outside funds, and level of dependence on campus resources.
   - Implementation plans are outlined throughout this proposal.
   - Refer to Section 8 for details of administration and governance.

The 2007 Self-Study of the Department of Bioengineering echoes these Berkeley campus themes and criteria for the further development of the department. The department’s mission is to “create technologies that enable rapid, more reliable, and scalable solutions to society’s most pressing problems” and to “expand the reach of our partners in related disciplines by providing new tools to advance the pace of discovery.” The new MTM degree’s focus on translational medicine aims to speed the journey from discovery to solutions, preparing leaders who understand technology, clinical practices, business, and the regulatory landscape — all critical for translating research more quickly into medical breakthroughs.

In addition, the self-study notes that a guiding principle of the Department of Bioengineering’s academic program is to “transform the piecework application of engineering and applied physics to disparate biological problems into a coherent engineering discipline.” The new MTM curriculum is an important piece in this strategy of coherence, educating graduate students who can provide a pathway to effective development of practical applications that draw on the department’s strategic areas: bioinstrumentation; biomaterials and nanotechnology; cell and tissue engineering; computational biology; and systems and synthetic biology.

Chancellor Birgeneau’s Access and Excellence report sounded a similar charge to the campus, to “ignite the California economy and make breakthroughs that transform our world.” The field of translational medicine targets exactly that: to leverage the billions of dollars spent on medical and bioscience research by moving results expeditiously and effectively into transformative treatments, diagnostics, and medical devices that can seed new businesses and save lives.

Relation to the UCSF Academic Plan

The proposed MTM is also well aligned with UCSF’s most recent strategic plan, adopted in 2007 (http://strategy.ucsf.edu). The MTM degree program responds directly to three of UCSF’s seven major strategic initiatives:

1. Innovating and Collaborating: Develop innovative, collaborative approaches for education, healthcare and research that span disciplines within and across the health sciences.
   - The MTM spans engineering, business, and clinical and health areas, including medicine, pharmacy, dentistry, and nursing. It is collaborative, and as the first such program, it is innovative.
2. **Translating discoveries:** *Be a world leader in scientific discovery and its translation into exemplary health.*
   - With “translation” in its title, the MTM specifically targets accelerating the rate at which discoveries and solutions are advanced to improve health.

3. **Educating leaders:** *Develop the world’s future leaders in healthcare delivery, research and education.*
   - The complexities of the future of healthcare require new approaches, based in medicine and biosciences but also informed by engineering contributions, advances in technology, a solid understanding of cost analysis and business practices, knowledge of clinical and regulatory requirements, and recognition of ethical issues that will arise in this complex landscape. The MTM degree is the first to prepare students with such a background for leadership.

### 1.5. Interrelationship of the Program with Other University of California Programs

The University of California system includes seven departments of bioengineering (at UC Berkeley, UC Davis, UC Irvine, UCLA, UC Riverside, UC San Diego, and UCSF); the remaining campuses (UC Merced, UC Santa Barbara, and UC Santa Cruz) offer degree programs in bioengineering or biomolecular engineering, and all 10 UC campuses have a variety of degree programs in the biological sciences. This program will be the only master’s degree in the UC system focusing specifically on translational medicine. Of the programs and areas of study at other UC institutions, the following list reflects the forms of intellectual inquiry that are most closely related to the activities of the proposed MTM.

**UC Davis** and **UC Irvine** offer graduate programs in Biomedical Engineering with a traditional M.S./Ph.D. research focus. They do integrate clinical sciences or technology translation, and there is no focus on applied issues such as clinical translation, healthcare costs, and regulatory issues.

**UC Los Angeles** offers traditional research degrees (M.S./Ph.D.) through the Biomedical Physics Interdepartmental Graduate Program, with concentrations in Molecular Imaging, Medical Imaging, Therapeutic Medical Physics, and Radiation Biology. In addition, the program offers graduate degrees (M.S./Ph.D.) in a broad range of traditional bioengineering disciplines. None of these degree paths are focused specifically on translational medicine.

**UC Merced** offers research degree programs (M.S./Ph.D.) in Bioengineering through its School of Engineering. These degree programs are not yet formed within a home department because of the newness of the Merced campus. There is no medical school on campus and thus there is limited research in clinical and translation medicine.

**UC Riverside** offers M.S. and Ph.D. programs in Bioengineering and a Ph.D. in Biomedical Sciences. These programs offer education with a broad range of traditional engineering and life science courses, but do not provide specific education in business fundamentals or regulatory pathways, and have no emphasis in translational medicine.

**UC Santa Cruz** runs traditional M.S./Ph.D. programs in Bioinformatics and in Engineering. Neither focuses on translational medicine.

**UC San Diego** offers the M.S., M.Eng. (see Appendix J for details), and Ph.D. degrees in Bioengineering and a Ph.D. in Bioinformatics. These program are broad traditional bioengineering curricula and do not incorporate the same components as the MTM program, such as business and strategy fundamentals or clinical and regulatory education specific to the biomedical industry.
UC Santa Barbara offers Ph.D. degrees in Biochemistry and Molecular Biology with emphasis in Biophysics and Bioengineering through its Biomolecular Science and Engineering program. There is no focused area of translational medicine and no clinical component to the program of study.

1.6. Department, Graduate Group, of School That Will Administer the Program
The Department of Bioengineering at UC Berkeley and the Department of Bioengineering and Therapeutic Sciences at UCSF will administer the program jointly. For details on governance, see Section 8.

1.7. Evaluation of the Program
The MTM degree program will be reviewed as a component of each campus’s departmental or graduate program review procedures. At Berkeley, the Program Review Oversight Committee (PROC) establishes these; at UCSF, the process for providing evaluating every graduate program is delegated to the Graduate Council and stated in the Academic Senate Bylaw 125(6).

At Berkeley, since MTM is a new graduate degree for the Department of Bioengineering, the Dean of the College of Engineering will appoint a broad-based review committee — with members from the engineering faculty, the College’s and MTM’s external advisory boards, and a Berkeley faculty member outside the College — to conduct a thorough evaluation after the first three years of the program, i.e., to review academic years 2013-14, 2014-15, and 2015-16. Berkeley’s PROC process, with its external and internal review procedure, will encompass the MTM as part of the overall departmental review of Bioengineering.

A similar procedure is followed at UCSF: At the request of Graduate Council, the Graduate Division recruits an external review committee of senior faculty members in the same field as the program, plus a faculty representative from the Graduate Council and from Graduate Division. After a thorough review, final report to the Graduate Dean identifies strengths and weaknesses of the program and recommendations to ensure its excellence.

Section 2: Program
Applicants to the MTM program are expected to include students from a wide variety of educational backgrounds, as mentioned previously, from those with bachelor’s degrees in engineering and biosciences fields to professional engineers and Ph.D.s, M.D.s., and postdoctoral fellows, among others. The diversity in clinical, technical, and academic backgrounds of the students will be a strength of the program, by stimulating cross-disciplinary discussions and practical projects. However, it also produces challenges in curriculum development to assure that each student has a fundamental understanding of principles represented across the translational spectrum. For example, those with prior clinical training will need focused training in engineering principles, while those with engineering backgrounds will need to become familiar with clinical needs and medical decision making. All students will need to demonstrate understanding of research design, product development, regulatory issues, and business principles, assessed through the successful completion of the core MTM coursework and evaluation of the capstone project.

2.1. Preparation for Admission
Applicants seeking admission to the MTM program should have a high degree of demonstrable technical and scientific aptitude, as evidenced by successful completion of relevant, rigorous coursework and/or
professional experience. The MTM degree program will have the same rigorous academic criteria for admission as the other approved graduate-level programs in the College of Engineering at UC Berkeley and the Schools of Medicine and Pharmacy at UCSF. The requirements of applicants will be consistent with University standards. A bachelor’s degree, or recognized equivalent, in engineering, life sciences, medicine, or related discipline from an accredited institution is required. Applicants will be evaluated on their choice of undergraduate and graduate coursework, the rigor of the major(s), the competitiveness of their academic institution(s), and their undergraduate and graduate grade-point averages. Prior research or industry experience, especially in a translational area, is also considered. Applicants are also required to take the GRE or the MCAT, and consideration will be given to their performance on those exams and, if required, the TOEFL. In certain cases, applicants pursuing or holding advanced degrees may use other test scores (GMAT, DAT, etc.) in lieu of the GRE or MCAT, as determined by the Joint Admissions Committee (see next paragraph). The statement of purpose, personal statement, and three letters of recommendation will be evaluated for indications of academic promise, career objectives that align with the program, and leadership potential. Students should be prepared for a possible interview, and should be able to clearly demonstrate their interest in translational medicine.

Applicants will submit a single application to the Berkeley campus for admission to the joint program. Decisions on admission will be made jointly by the two campuses, led by the program’s Co-Directors (one from each campus), in consultation with the Joint Admissions Committee composed of members of the MTM Program Committee from both campuses (see Section 8 for a description of the program’s governance structure). The Registrar’s Offices on both campuses are already familiar with the issues of joint enrollment in the Bioengineering Ph.D. program and have successfully managed these same issues during the first year (2010-11) of the terminal M.S. program offered by the Joint Graduate Group in Bioengineering. The Registrar’s Offices have been notified of the MTM proposal, and the MTM program staff will work closely with the both offices to ensure that these same procedures are utilized for efficient joint operation of the proposed MTM program.

Accepted students will be assigned to a home campus based on their prior academic training, as determined by the Joint Admissions Committee. In general, students with a strong technical, business, or engineering background will be assigned preferentially to the Berkeley campus, while students with a strong medical background (M.D.s, Pharm.D.s, D.M.D.s, R.N.s, etc.) will be assigned preferentially to the UCSF campus. The admissions committee will use its discretion to ensure that the division of students between home campuses is always as close to 50/50 as possible. Unlike the Ph.D. program, there will be no need for students to change home campus in this one-year master’s program, as resources on both campuses are available to all students, and any student may be assigned to any capstone project, regardless of home campus.

2.2. Program of Study

The flexibility of the MTM electives is designed to appeal to students with diverse backgrounds, and to allow the program to quickly and efficiently produce graduates who will be leaders in fields with emerging relevance to translational medicine. The MTM will prepare engineers, bioscientists, and clinicians to bring innovative treatments and devices into clinical use. Most MTM graduates will be expected to work in industries that deliver healthcare products or provide patient care. Each student will participate in an interdisciplinary design-project course (capstone) taught by an engineering faculty member with input from industry and clinical collaborators.
Each student’s Academic Adviser approves the student’s study plan — informed by our list of suggested electives for each field. However, students will take courses in three different areas, weighed by the particular student’s academic needs: (1) Bioengineering, (2) Clinical Research and Development, and (3) Business, Entrepreneurship, and Technology. The Bioengineering thrust will be flexible enough to accommodate interest and projects in diverse fields such as imaging, micro-electromechanical Systems (MEMS), ergonomics, and tissue engineering. Clinical Research training will prepare students to apply engineering principles to relevant clinical problems. The addition of business and leadership courses will give MTM graduates the ability to evaluate potential projects according to a wide variety of critical criteria — they will be able to consider the economic, organizational, regulatory, clinical, and technical issues associated with translating a given piece of research or technology into clinical use. Furthermore, they will be positioned to successfully pursue those projects and thus increase the rate at which bench research impacts patient care.

Critical to the curriculum is the required capstone project (an enrollment minimum of 6 semester or 9 quarter units over the year-long program). For the capstone course sequence, students engage in a professionally-oriented, team study under the supervision of a project leader and the Faculty Co-Director on the student’s home campus, who serves as both the course instructor and the student’s Research Adviser. The goal of the capstone course is to synthesize the technical, clinical, economic, and regulatory issues involved in the design and market implementation of medical devices, diagnostics, and therapeutics. Each student must file a final report and business model produced in this course for successful completion of the degree. In addition to a final report and presentation, each student will be individually evaluated by his or her Research Adviser throughout the course of the year during regularly scheduled progress update meetings. An additional Academic Senate faculty member in bioengineering will also read the final report and help evaluate the student. The course description is provided in Section 5 below, and complete information on this course (which is currently pending approval) is included in Appendix G.

The structure of the curriculum and timeline for completion of the degree is provided in Chart 4.
Chart 4: Sample Course Curricula for MTM Program (24s/36q units)

<table>
<thead>
<tr>
<th>Fall Semester/Quarter</th>
<th>Winter Quarter</th>
<th>Spring Semester/Quarter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anti-Medical School: Translational Challenges in Medicine (1q unit = 2/3s unit)</td>
<td>Translational Challenges in Diagnostics, Devices,</td>
<td>Engineering Leadership II (3s units)</td>
</tr>
<tr>
<td></td>
<td>and Therapeutics (2q units = 4/3s units)</td>
<td></td>
</tr>
<tr>
<td>Engineering Leadership I (3s units)</td>
<td>Clinical Trials (1.5q units = 1s unit)</td>
<td>Business Elective (2s units)</td>
</tr>
<tr>
<td>Designing Clinical Research (2q units = 4/3s units)</td>
<td>Clinical Elective (2q units = 4/3s units)</td>
<td>Capstone Project (4s units)</td>
</tr>
<tr>
<td>Bioengineering Elective (4s units)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capstone Project (2s units)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethical and Social Issues in Translational Medicine (1s unit)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>FALL SUBTOTAL: 12s units</strong></td>
<td><strong>WINTER + SPRING SUBTOTAL:</strong> 12.67s units</td>
<td><strong>GRAND TOTAL:</strong> 24.67s units</td>
</tr>
</tbody>
</table>

Note that students will enroll at their “home” institution (UC Berkeley or UCSF), but will often take courses at both institutions concurrently. To fulfill minimum-unit enrollment requirements at their home campus (12 semester units at Berkeley / 8 quarter units at UCSF), students may enroll in additional units of the appropriate capstone course, but only 6 total semester units (or equivalent) may be applied toward the degree.

### 2.2.1 Concentrations

There will be no concentrations offered within the MTM degree program. However, since the backgrounds of the students are expected to be diverse, a variety of electives will be offered to provide an individually tailored curriculum for each student in the program. For example, a student with a medical background might choose to take courses related to his intended residency, while an engineering student with entrepreneurial interests might select particular business courses that supplement her technical expertise. Two different sample programs are outlined in Section 2.2.6.

### 2.2.2 Plan to Be Offered

The MTM will be offered on Plan II, consisting of completion of a minimum of 24 semester/36 quarter units and completion of a capstone master’s project.

**Capstone Project**

Candidates for the degree must complete a capstone project, defined as “professionally-oriented individual or group study or research, culminating in a written report,” of at least 6 semester units (or equivalent). Two separate, but equivalent, capstone courses will be available: a UC Berkeley capstone course for Berkeley-based students and a UCSF capstone course for UCSF-based students. Students can distribute the 6 semester units (or 9 quarter units) for the project evenly over the Fall and Spring semesters at Berkeley.
or the Fall, Winter and Spring quarters at UCSF, though many may elect to take more units in later terms, after they have completed several preparatory courses in the Fall. The capstone courses — Bioengineering 296 — will be offered through UC Berkeley’s Department of Bioengineering and UCSF’s department of Bioengineering and Therapeutic Sciences, respectively.

Members of the MTM Program Committee will help design several capstone projects in collaboration with clinical, academic, and/or industry partners (a.k.a., the “project leaders”), aiming to incorporate emerging technologies, industry requirements, and the potential for significant economic or social impact with regard to medicine and healthcare. Non-clinical project leaders are required to have a clinical collaborator for their project. All projects will be designed and vetted by the MTM Program Committee, in consultation with the MTM Advisory Board.

The Faculty Co-Director on each campus will serve as instructor for the course and will work directly with the project leaders to ensure that the projects adhere to capstone requirements and objectives. In addition, each Co-Director will also act as Research Adviser to each student in the class, and will provide individual mentorship and guidance as needed. Each capstone project will engage project teams of approximately 2-5 students. The capstone project team will meet at least once a week, typically with the project leader and/or course instructor, to engage in discussion focused on understanding and overcoming technical risks, marketplace risks, industry barriers, and potential policy risks. In tandem, the team develops and tests a tangible work product that responds to an identified industry problem.

Although the capstone project involves group teamwork, each student will be individually evaluated on design, analysis, synthesis, and communication skills based on a particular capstone topic, as well as the engineering fundamentals relevant to the particular project. The MTM Faculty Co-Directors – serving as the instructors for the capstone courses on their respective campuses – will have final approval of student work in the courses, assisted by an additional Academic Senate faculty member who will review the final project and the individual students’ contributions. Input from the clinical, academic, and/or industry partners will be part of this process, but the final grade will be determined by the two Academic Senate faculty members. For a complete description of the capstone course and required project, see Appendix G.

### 2.2.3 Unit Requirements

Students are required to take 24 semester/36 quarter units of upper-division and graduate courses, including the 6 semester or 9 quarter units of the master’s capstone project course as described above. At least 12 semester/18 quarter units must be in 200-series courses.

### 2.2.4 Foreign Language

Not required.

### 2.2.5 Required and Recommended Courses

The program will draw largely on existing courses from UC Berkeley’s Department of Bioengineering and College of Engineering, and UCSF’s Department of Bioengineering and Therapeutic Sciences and Clinical and Translational Science Institute (CTSI) training programs. Students may also have the opportunity to participate in UCSF-sponsored professional outreach courses, targeted to the biotechnology and pharmaceutical industry, as approved by the Academic Advisers.

The MTM core curriculum focuses on three components — (1) bioengineering, (2) clinical research and development, and (3) business, entrepreneurship, and technology — all culminating in the completion of
a capstone project. An ethics course is also strongly recommended (included within the “bioengineering” component), and there is an approved list of electives from both campuses. In this section, the specific courses offered are listed and organized into the three sections. For reference, two sample programs for the MTM degree are shown in Chart 5 and Chart 6. For full descriptions of the required and highly recommended courses listed below, see Section 5.

The bioengineering core of the curriculum includes required capstone project work in addition to the strongly recommended courses of Anti-Medical School: Translational Challenges in Medicine (Bioengineering 260; UCSF, 1 quarter unit) and Translational Challenges in Diagnostics, Devices, and Therapeutics (Bioengineering 270; UCSF, 2 quarter units). The former is a needs-finding course that puts students in touch with clinicians best qualified to identify and evaluate clinical needs. The latter focuses on the critical evaluation of needs and potential solutions. Ethical and Social Issues in Translational Medicine (Bioengineering 290X; UC Berkeley, 1 semester unit) is also strongly recommended, as it covers various ethical issues related to the clinical and technical work in the field of translational medicine. Additional bioengineering electives bring technical depth to a particular design area (imaging, MEMS, etc.) relevant to translational medicine (see the list at the end of this section for details on each elective course).

The clinical core likewise includes required capstone project work in addition to strongly recommended classes in clinical research (Epidemiology 150.03; UCSF, 2 quarter units) and clinical trials (Epidemiology 205; UCSF, 1.5 quarter units). These courses are taught at UCSF in the Training in Clinical Research (TiCR) program. Additionally, students may opt to take electives such as Epidemiology 213 (UCSF, 2 quarter units), which explores how cost affects decision making in a clinical context, or Epidemiology 260 (UCSF, 1.5 quarter units), which explains the regulatory process for development and approval of new medical innovations.

Finally, the business, entrepreneurship and technology core recommended courses consider organizational theory, economics, and entrepreneurship from a technical perspective. In combination, these courses teach students to design based on strong engineering principles and real clinical need. At the same time, students learn to take a leadership role on a project. All students are strongly encouraged to take the UC Berkeley Engineering Leadership series (Engineering 271 and 272; UC Berkeley, 3 semester units each). Several approved electives are available to fulfill the remaining unit requirements (see list at the end of this section for specific details including campus and unit hours for each elective course).

The required, recommended, and elective courses are as follows:

BIOENGINEERING (at least 10 semester units or 15 quarter units)

Required Courses
- Bioengineering (BIO ENG) 296 (UC Berkeley) – Capstone Project [6s units] (F, Sp), Li*
- Bioengineering (BIO THERAP) 296 (UCSF) – Capstone Project [9q units] (F, W, Sp), Desai*

Strongly Recommended Courses

UC Berkeley (in semester units)
- Bioengineering (BIO ENG) 290X – Ethical and Social Issues in Translational Medicine [1s unit] (F), Johnson

UCSF (in quarter units; one quarter unit = 2/3 semester unit)
- Bioengineering (BIO THERAP) 260 – Anti-Medical School: Translational Challenges in Medicine [1q units] (F), Shuman/Desai
- Bioengineering (BIO THERAP) 270 – Translational Challenges in Diagnostics, Devices, and Therapeutics [2q units] (W), Roy

**Electives: Approved List**

**UC Berkeley (in semester units)**

- Bioengineering (BIO ENG) C145L – Introductory Electronic Transducers Laboratory [3 units] (F)
- Bioengineering (BIO ENG) 210 – Cell Mechanics and the Cytoskeleton [3 units] (Sp)
- Bioengineering (BIO ENG) 211 – Tissue Mechatrontransduction [3 units] (F)
- Bioengineering (BIO ENG) C214 – Advanced Tissue Mechanics [3 units] (Sp)
- Bioengineering (BIO ENG) 215 – Models of Cell Mechanics: Dynamics of the Cytoskeleton [3 units] (F)
- Bioengineering (BIO ENG) C216 – Macromolecular Science in Biotechnology and Medicine [4 units] (Sp)
- Bioengineering (BIO ENG) C217 – Biomimetic Engineering – Engineering from Biology [3 units] (F)
- Bioengineering (BIO ENG) C218 – Stem Cells and Directed Organogenesis [3 units] (Sp)
- Bioengineering (BIO ENG) 221 – Introduction to Micro and Nanobiotechnology: BioMEMS [3 units] (F)
- Bioengineering (BIO ENG) C223 – Polymer Engineering [3 units] (F)
- Bioengineering (BIO ENG) 231 – Intro to Computational Biology [4 units] (F)
- Bioengineering (BIO ENG) 251 – Micro/Nanofluidics for Bioengineering and Lab-On-A-Chip [4 units] (Sp)
- Bioengineering (BIO ENG) C265 – Principles of Magnetic Resonance Imaging [3 units] (F, Sp)
- Bioengineering (BIO ENG) C279 – Occupational Biomechanics [4 units] (Sp)
- Bioengineering (BIO ENG) C280 – Introduction to Nano-Science and Engineering [3 units] (F, Sp)
- Electrical Engineering (EL ENG) C245 – Introduction to MEMS Design [4 units] (F, Sp)
- Mechanical Engineering (MEC ENG) 132 – Dynamic Systems and Feedback [3 units] (F, Sp)
- Neuroscience (NEUROSC) C217D – Biological and Public Health Aspects of Alzheimer’s Disease [3 units] (Sp)
- Public Health (PB HLTH) 200C1 – Health Policy and Management Breadth Course [2 units] (F)***
- Public Health (PB HLTH) 222A – Health Care Technology Policy [2 units] (F)
- Public Health (PB HLTH) 260A – Principles of Infectious Diseases [4 units] (F, Sp)

**UCSF (in quarter units; one quarter unit = 2/3 semester unit)**

- Bioengineering (BIOENG PRG) 221 – Tissue Mechanobiology [2 units] (F, W, Sp)
- Bioengineering (BIO THERAP) 230A – Radiologic, Nuclear and Molecular Imaging Methods [3 units] (F)
- Bioengineering (BIO THERAP) 230B – Physics of Medical Imaging [3 units] (F, W)
- Bioengineering (BIO THERAP) 230C – Molecular Imaging [3 units] (Sp)
- Bioengineering (BIO THERAP) 240 – Principles of Nuclear Magnetic Resonance Imaging [3 units] (F)
- Bioengineering (BIO THERAP) 241 – Magnetic Resonance Spectroscopy [3 units] (F, W)
- Bioengineering (BIO CELL & TISBI) 242 – Principles of Tissue Engineering [3 units] (F, W, Sp)
- Bioengineering (BIO THERAP) 244 – Image Processing & Analysis [3 units] (F, W, Sp)
- Bioengineering (BIO THERAP) 245 – Electromagnetic Neuroimaging [3 units] (F, W, Sp)
- Bioengineering (BIO THERAP) 247 – Introduction to Magnetic Resonance Imaging System and Hardware [3 units] (Sp)
- Bioengineering (BIO THERAP) 280 – Clinical Aspects of Bioengineering [3 units]
- Pharmacology (PHARMACOL) 245A – Basic Principles of Pharmaceutical Sciences [3 units] (F)
- Pharmacology (PHARMACOL) 245C – Principles of Pharmacogenomics [3 units] (F)

CLINICAL R&D (at least 6 semester units or 9 quarter units)

**Required Courses**
- Bioengineering (BIO ENG) 296 (UCB) – Capstone Project (F, Sp), Li*
- Bioengineering (BIO THERAP) 296 (UCSF) – Capstone Project (F, W, Sp), Desai*

**Strongly Recommended Courses**
- Epidemiology (EPID & BIO) 150.3 (UCSF) – Designing Clinical Research for Residents and Students [2q units] (Su II, F), Bibbins-Domingo
- Epidemiology (EPID & BIO) 205 (UCSF) – Clinical Trials [1.5q units] (W), Grady

**Electives: Approved List**

UCSF (in quarter units; one quarter unit = 2/3 semester unit)
- Epidemiology (EPID & BIO) 213 – Decision and Cost-Effectiveness Analysis in Medicine [2 units] (W, Sp), Kahn
- Epidemiology (EPID & BIO) 260 – Development and Approval of Drugs and Devices [1.5 units] (Sp), Chin

BUSINESS, ENTREPRENEURSHIP, AND TECHNOLOGY (at least 8 semester units or 12 quarter units)

**Required Courses**

*No specific courses are explicitly required.*

**Strongly Recommended Courses**
- Engineering (ENGIN) 271 (UCB) – Engineering Leadership I [3s units] (F)
- Engineering (ENGIN) 272 (UCB) – Engineering Leadership II [3s units] (Sp)

**Electives: Approved List**

UC Berkeley (in semester units)
- Chemical & Biomolecular Engineering (CHM ENG) 295D – Development of Biopharmaceuticals [2 units] (Sp)
- Chemical & Biomolecular Engineering (CHM ENG) 295P – Introduction to New Product Development [3 units] (F)
- Engineering (ENGIN) 290 – Special Topics in Management of Technology [2,3 units] (F, Sp)
- Engineering (ENGIN) 290J – Entrepreneurship in Biotechnology [2 units] (Sp)
- Engineering (ENGIN) 298A – Richard Newton Distinguished Innovator Lecture Series [1-6 units] (F, Sp)
- Industrial Engineering (IND ENG) 171 – Introduction to Design of Human Work Systems and Organizations [3 units] (F)
- Industrial Engineering (IND ENG) 191 – Technology Entrepreneurship [3 units] (F)
- Law (LAW) 276.61 – Biotechnology Law [2 units] (Sp)
- Master of Business Administration (MBA) 205 – Organizational Behavior [2 units] (F, Sp)
- Master of Business Administration (MBA) 209F – Fundamentals of Business [3 units] (F, Sp)
- Master of Business Administration (MBA) 290B – Biotechnology Industry Perspectives and Business Development [2 units] (F, Sp)
- Master of Business Administration (MBA) 296 – Innovation in Healthcare [2 units] (F, Sp)
- Mechanical Engineering (MEC ENG) 290P – New Product Development: Design Theory and Methods [3 units] (F)
- Public Health (PB HLTH) 200C1 – Health Policy and Management Breadth Course [2 units] (F)***

UCSF (in quarter units; one quarter unit = 2/3 semester unit)
- Biochemistry (BIOCHEM) 210 – A Life Scientist’s Guide to Intellectual Property. [1.5 units] (W)
- Biochemistry (BIOCHEM) 241 – Idea to IPO & Beyond [3 units] (F, W, Sp)
- Biochemistry (BIOCHEM) 247 – Corporate Finance Survival Skills. [1.5 units] (Sp)

* A total of 6 semester units (or 9 quarter units) of Bioengineering 296 must be applied to the degree, apportioned between Bioengineering and Clinical R&D, as needed. Additional BioE 296 units may be taken (in order to meet the minimum enrollment requirements of 12 units per semester at Berkeley or 8 units per quarter at UCSF), but only 6 total semester units (or total quarter units) may be applied to the degree. Course instructors will change annually based on Faculty Co-Director appointments.

** Currently approved elective courses for the proposed Master of Translational Medicine program. Additional elective courses may be added in future years as approved by the MTM Program Committee.

*** May be used either as a Bioengineering or Business elective.

The support of Berkeley’s College of Engineering and UCSF’s CTSI, including access to the specified core and elective courses, is articulated in letters from Professor Clay Johnston, faculty director of CTSI; Professor Lee Fleming, faculty director of UC Berkeley’s Fung Institute for Engineering Leadership; and Professor Jitendra Malik, Associate Dean for Special Academic Initiatives in the College of Engineering (see Appendix C). The deans of the schools and colleges offering electives that are on the approved list for MTM students have also been apprised of the proposed new degree and its anticipated enrollment.

Professional Outreach Courses
In addition to the UC Berkeley and UCSF courses mentioned above, MTM students may participate in two UCSF-sponsored outreach courses — the American Course on Drug Development and Regulatory Sciences (ACDRS) and Pharmacokinetics for Pharmaceutical Scientists (PKPS) — at reduced tuition rates, as approved by the Academic Advisers. Both programs are housed at the UCSF Mission Bay campus and are sponsored by the Department of Bioengineering and Therapeutic Sciences. The courses — targeting professionals in the biotechnological, pharmaceutical, and regulatory industries — will help students learn
about drug development and regulatory sciences and about personalized medicine and systems pharmacology. These courses both provide certificates for completion and will complement and extend the education in the MTM program. They are briefly described below:

**American Course on Drug Development and Regulatory Sciences (ACDRS)**
The ACDRS integrates the cutting-edge concepts and best practices of medical product development and regulatory sciences. Attendees are professionals in the biopharmaceutical industry, academic and government scientists, and decision and policy makers who desire more in-depth, comprehensive, and systematic immersion into modern medical product development, regulation, and market introduction. The ACDRS teaching faculty includes experts from academia; regulatory agencies such as the U.S. Food and Drug Administration; pharmaceutical device, diagnostic, and biotechnology industries; coverage and reimbursement organizations; professional societies; and the National Institutes of Health. The course consists of six sessions over a period of two years. Participants who successfully complete the two-year course cycle and pass the final exam are awarded a Course Certificate.

**Pharmacokinetics for Pharmaceutical Scientists (PKPS)**
PKPS is a weeklong short course covering the basic principles of pharmacokinetics with an emphasis on physiologic conceptualization and problem solving. The course aims to greatly enhance pharmacokinetic knowledge and integrate pharmacokinetic principles and concepts into everyday practice. Attendees include pharmacists, physicians, pharmacologists, and other professionals in the pharmaceutical sciences who aim to use pharmacokinetics for the development and testing of drugs. The first three and one half days focus on essential pharmacokinetic parameters and how they are employed to summarize and predict temporal relationships, while in the remaining time participants choose from three of six elective topics offered. An optional half-day course is also included at the end of the program.

### 2.2.6. Sample Programs

The MTM is consistent with the Plan II master’s degree, which comprises completion of a minimum of 24 semester or 36 quarter units of study including 6 semester or 9 quarter units of capstone project work and a written report. Most students are expected to finish the degree in a 12-month period: one full academic year (including summer). Sample programs are outlined in Chart 5 and Chart 6 below.
**Chart 5: MTM Sample Program #1**

The following is a sample program tailored for a hypothetical student with a predominantly technical background who is particularly interested in starting a new business based on nanotechnology-focused medical devices. In addition to the core recommended courses, this sample program features elective courses in nanobiotechnology (BioE 221) and biotechnology entrepreneurship (E 290J). In this hypothetical example, the student is UC Berkeley-based and must register for 2.0 additional units of BioE 296 (capstone project) during the Fall semester and 3.0 units during the Spring semester in order to meet Berkeley’s semesterly minimum enrollment requirement of 12.0 semester units. Note that these additional units are for enrollment purposes only, and are not counted toward the degree.

<table>
<thead>
<tr>
<th>1. Fall</th>
<th>2. Winter</th>
<th>3. Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>BioE 260 (UCSF)</td>
<td>Anti-Medical School: Translational Challenges in Medicine (1q)</td>
<td>BioE 270 (UCSF) Translational Challenges in Diagnostics, Devices, and Therapeutics (2q)</td>
</tr>
<tr>
<td>Epi 150.03 (UCSF)</td>
<td>Deigning Clinical Research (2q)</td>
<td>Epi 205 (UCSF) Clinical Trials (1.5q)</td>
</tr>
<tr>
<td>BioE 290X (UCB)</td>
<td>Ethical and Social Issues in Translational Medicine (UCB) (1s)</td>
<td>Epi 213 (UCSF) Decision and Cost-Effectiveness Analysis in Medicine (2q)</td>
</tr>
<tr>
<td>BioE 296 (UCB)</td>
<td>Capstone project (2s) [toward degree]</td>
<td></td>
</tr>
<tr>
<td>E 271 (UCB)</td>
<td>Engineering Leadership I (3s)</td>
<td></td>
</tr>
<tr>
<td>BioE 221 (UCB)</td>
<td>Introduction to Micro and Nanobiotechnology: BioMEMS (4s units)</td>
<td></td>
</tr>
<tr>
<td>BioE 296 (UCB)</td>
<td>Additional capstone project units (2s) [NOT toward degree]</td>
<td>BioE 296 (UCB) Additional capstone project units (3s) [NOT toward degree]</td>
</tr>
<tr>
<td>Total equivalent sem units</td>
<td>14.0 semester units [12.0 toward degree]</td>
<td>3.67 semester units</td>
</tr>
</tbody>
</table>

**GRAND TOTAL:** 29.67 semester units (only 24.67 semester units counted toward degree)
Chart 6: MTM Sample Program #2

The following is a sample program tailored for a student with a medical background who is particularly interested in the business aspects of medical imaging. In addition to the core recommended courses, this sample program features a series of elective courses in medical imaging (BioE 230A-B-C) as well as business electives in intellectual property (Biochem 210) and healthcare innovation (MBA 296). In this hypothetical example, the student is UCSF-based, and meets UCSF’s quarterly enrollment requirement of 8.0 quarter units by appropriately distributing the capstone units (BioE 296) across the three quarters.

<table>
<thead>
<tr>
<th>1. Fall</th>
<th>2. Winter</th>
<th>3. Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>BioE 260 (UCSF)</td>
<td>BioE 270 (UCSF)</td>
<td>E 272 (UCB)</td>
</tr>
<tr>
<td>Anti-Medical School: Translational Challenges in Medicine (1q)</td>
<td>Translational Challenges in Diagnostics, Devices, and Therapeutics (2q)</td>
<td>Engineering Leadership II (3s)</td>
</tr>
<tr>
<td>Epi 150.03 (UCSF)</td>
<td>Epi 205 (UCSF)</td>
<td>BioE 230C (UCSF)</td>
</tr>
<tr>
<td>Deigning Clinical Research (2q)</td>
<td>Clinical Trials (1.5q)</td>
<td>Molecular Imaging (3q)</td>
</tr>
<tr>
<td>BioE 290X (UCB)</td>
<td>Epi 213 (UCSF)</td>
<td>MBA 296 (UCB)</td>
</tr>
<tr>
<td>Ethical and Social Issues in Translational Medicine (1s)</td>
<td>Decision and Cost-Effectiveness Analysis in Medicine (2q)</td>
<td>Innovation in Healthcare (2s)</td>
</tr>
<tr>
<td>BioE 296 (UCSF)</td>
<td>BioE 230B (UCSF)</td>
<td>BioE 296 (UCSF)</td>
</tr>
<tr>
<td>Capstone project (2q)</td>
<td>Physics of Medical Imaging (3q)</td>
<td>Capstone project (5q)</td>
</tr>
<tr>
<td>E 271 (UCB)</td>
<td>E 271 (UCB)</td>
<td>BioE 296 (UCSF)</td>
</tr>
<tr>
<td>Engineering Leadership I (3s)</td>
<td>Engineering Leadership I (3s)</td>
<td>Capstone project (2q)</td>
</tr>
<tr>
<td>BioE 230A (UCSF)</td>
<td>Biochem 210 (UCSF)</td>
<td>A Life Scientist’s Guide to Intellectual Property (1.5q)</td>
</tr>
<tr>
<td>Radiologic, Nuclear, and Molecular Imaging Methods (3q)</td>
<td>Biochem 210 (UCSF)</td>
<td></td>
</tr>
<tr>
<td>Total equivalent qtr units</td>
<td>15.0 quarter units</td>
<td>13.0 quarter units</td>
</tr>
<tr>
<td>GRAND TOTAL: 41.5 quarter units</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.2.7. Advising System: Procedures for Assigning Graduate Advisers for Students

Academic advising of MTM students will be the primary responsibility of the bioengineering departments on each campus. Each Program Co-Director will nominate a Head Academic Adviser (one at UC Berkeley and one at UCSF, to be appointed by each respective chair) to work with their home campus students on program planning, choosing electives, identifying a capstone project, and other aspects of academic planning. Academic Advisers will be thoroughly familiar with the MTM curriculum and may approve new elective courses (in conjunction with the Program Committee) based on the needs of the students. If needed, the Faculty Co-Directors may also name Assistant Graduate Advisers to aid the Head Academic Advisers. These Assistant Graduate Advisers may have additional knowledge of particular elective courses and may help tailor a course schedule for a student with specific academic needs.
Each student will receive additional advising specific to the capstone project work from the faculty Co-Director on the student’s home campus, who will serve as Research Adviser (as described in Appendix G). Research Advisers will provide mentorship and guidance on project work and on the requirements and successful completion of the final presentation and report.

2.3. Relationship Between This Master’s Degree and the Ph.D. Program

There is no existing Ph.D. program in translational medicine at either UC Berkeley or UCSF.

Section 3: Projected Need

3.1 Enrollment Target

As stated previously, the one-year MTM program is designed for steady-state enrollment of 30 students per year (see Chart 3 in Section 1.3). We hope to enroll students for the degree in Fall 2013, and we plan to ramp up to steady state in three years, enrolling 20 students for 2013-14, 26 for 2014-15, and 30 for 2015-16. Based on our budget and proposed professional degree supplemental tuition (PDST), enrollment of 28 students will be a sufficient to sustain the program; resources from both sponsoring bioengineering departments will be adequate to bridge the gap in the first two years as the program ramps up. We believe we can easily achieve our steady-state target of 30 students within the three-year time frame, given the extremely high demand for bioengineering programs — at Berkeley, UCSF, and nationwide — and the historically outstanding quality of applicant pools attracted to other bioengineering degree programs at both campuses. Although the MTM program will have an additional financial expense for students in the form of the PDST, initial data suggests this will not be a deterrent to prospective students as described in the next section.

3.2. Volume and Quality of Student Demand for the Program

In 2010 the College of Engineering at Berkeley undertook a strategic-planning process to inform its plan to increase the number of master’s degrees it awards, based on national reports of the importance of the master’s degree in developing the workforce needed to advance in engineering and technology. As part of the process, the College conducted a series of market assessments of engineering master’s programs. This market testing included several professionally moderated student and alumni focus groups, online surveys to gauge student interest areas and prospective demand, and benchmarking of competitive master’s programs offered by top engineering schools in the United States.

Four student focus groups were held in April-May 2009 and four student and alumni focus groups held in September 2010. These focus groups were professionally moderated by an external marketing consultant. The Engineering Dean’s Office conducted the online surveys in August 2010 with recent alumni and current student populations. The benchmarking of competitive programs was conducted in early 2010 by the Engineering Dean’s Office and additional benchmarking was done in summer 2010 by an external marketing consultant. The schools included in this benchmarking are those identified as “Top 10” Engineering graduate programs by U.S. News & World Report.

The consistent finding across this market testing was very strong student and alumni demand for leading professional master’s programs, such as the proposed MTM degree program. Among the core findings in the two rounds of focus groups were positive comments about educational opportunities that combine engineering and business/entrepreneurship courses, interest in programs that could be completed in one year, and an acceptance of the higher costs of professional degrees, which, while of concern to some
respondents, was seen by others as expected for a professional master’s, as long as the program delivered value — expertise, connections, and improved career prospects. Working professionals also expressed great interest in professional programs (although this population prefers a part-time option).

In a 2011 online poll sent to 1,278 of our bioengineering undergraduates and recent alumni (those who graduated after 1999), 130 respondents answered questions regarding the proposed MTM program. When asked, “How interested would you be in pursuing a master’s degree through the MTM program?” 35% (45/130) responded “7 - Very Interested” on a scale of 1 (Not Interested) to 7 (Very interested), and more than 67% of respondents (86/130) indicated some level of interest. More than 36% of the respondents (46/130) indicated that they are seriously considering pursuing a master’s-level graduate degree. Of the responses from alumni currently working in industry (43), ~44% (19/43) said they would consider returning to school to pursue this degree. Additionally, of the responses from alumni who have or are currently pursuing a medical degree (13), ~70% expressed at least some interest in the program (9/13), including ~25% (3/13) who were “very interested.” Clearly, interest is high among current and former bioengineering students, signaling a clear demand within the discipline for the proposed degree.

A key factor in the high volume and quality of student demand for the MTM degree is the strong evidence showing that earning such a degree will elevate students’ career earning potential. As is further described in the following section and shown in Chart 7 and Chart 8, students who complete a master’s degree will have substantial opportunity to increase their post-degree salary level.

Anticipated demand for the MTM program is further supported by the quantity of applications to the joint M.S. in Bioengineering, which recently admitted its second cohort of students. The program received 83 applications (with minimal advertising) in 2010, and 186 applications in 2011. Applicants were high quality domestic and foreign students; specifically, in 2010, the average GPA of the enrolled students was 3.44 (4.00 scale), and the average GRE scores were 599 on the verbal reasoning section (~86th percentile) and 744 on the quantitative reasoning section (~80th percentile), while in 2011, the average GPA of the enrolled students rose to 3.52 (4.00 scale), and the average GRE scores increased to 600 on the verbal reasoning section (~86th percentile) and 780 on the quantitative reasoning section (~88th percentile). This one-year change demonstrates demand from applicants with increasingly strong academic backgrounds; for comparison, the entering cohort of the M.Eng. program in UC Berkeley’s College of Engineering, also a new program, has an average GPA of 3.6 and GRE scores in the 82nd percentile in verbal reasoning and in the 92nd percentile in quantitative reasoning. In addition to high-quality academic performance, most Bioengineering M.S. applicants in 2010 and 2011 also had significant academic research experience, and many had additional professional experience. In 2010, generous stipend support was offered to all admitted applicants, and 80% of those admitted enrolled. In 2011, stipend and fellowship support was offered only to 14% of admitted students, and still more than 63% of those admitted enrolled. This yield demonstrates strong demand for the program, even when students are responsible for paying the costs.

3.3. Opportunities for Placement of Graduates

Most graduates of the MTM program are expected to take positions in industries that deliver healthcare products or patient care, for which they will be well compensated. The MTM Advisory Board, comprising primarily representatives from industry and venture capital firms that fund new biotechnology enterprises, has affirmed the need for graduates with a solid understanding of translational medicine. A common career path for MTM students is through the pharmaceutical and health industry, where one would be involved in developing devices and carrying out pre-clinical and clinical trials. We expect to see an increase in these roles due to changes in market demand and the industry’s need to speed up the systems and increase the
efficiency of the “drug discovery to market” process. Many graduates will be poised for entrepreneurship opportunities, where they translate academic discoveries to start-up companies. Our students may also work for government labs (including environmental and public health agencies), contract research organizations (CROs), academic departments in universities, charity-funded research organizations, and other research institutes.

For the field of bioengineering in particular, the Bureau of Labor Statistics estimates that bioengineers are expected to have employment growth of 72 percent over 2008-18, much faster than the average for all occupations. (To view this report, visit: http://www.bls.gov/oco/ocos027.htm). This employment growth in the field of bioengineering is very likely to occur in the industrial sector. It is clear that we have both the opportunity and obligation to provide a pipeline of strong, leadership-ready bioengineers to fuel industry in California and beyond in the coming decades. For further details on employment prospects for bioengineering graduates (and a summary of the Bureau of Labor Statistics report), see Appendix B.

One measure of the earning potential of MTM graduates — and thus their ability to repay any student-loan debt that they may accrue during their MTM education — is a comparison between the average starting salaries for engineering graduates in the United States (shown in Chart 7) and the relatively higher salaries earned by engineers who play supervisory roles (Chart 8). With our program’s emphasis on engineering leadership, those MTM graduates who take jobs in industry will likely be in the latter group.

### Chart 7  Engineering Graduates — Average Starting Salaries by Highest Engineering Degree Earned [Source: American Association of Engineering Societies — Engineering Workforce Commission (AAES-EWC) 2009]

<table>
<thead>
<tr>
<th>Engineering Degree Earned</th>
<th>Starting Salary (as of 2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelor’s degree</td>
<td>$61,197</td>
</tr>
<tr>
<td>Master’s degree</td>
<td>$76,428</td>
</tr>
<tr>
<td>Ph.D. degree</td>
<td>$90,388</td>
</tr>
</tbody>
</table>

### Chart 8  Engineering Graduates — Average Salaries for Supervisors with Master’s Degrees [Source: American Association of Engineering Societies — Engineering Workforce Commission (AAES-EWC) 2009]

<table>
<thead>
<tr>
<th>Number of Years Since Baccalaureate Degree</th>
<th>Average Salary (as of 2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 years</td>
<td>$114,494</td>
</tr>
<tr>
<td>9-10 years</td>
<td>$122,102</td>
</tr>
</tbody>
</table>

### 3.4. Importance to the Discipline

Our proposal for the development of an MTM degree is driven by the mounting demand for engineers, physicians, scientists, and other professionals who can successfully move our abundant science and technology innovations into actual advances in patient care. We have all heard news reports about medical
breakthroughs in laboratories around the globe that might unlock the answers we need to combat cancers, Alzheimer’s and Parkinson’s disease, HIV/AIDS, and a host of other enigmatic diseases that affect people we know. We have also all known the disappointment when these reports conclude with a caveat: these advances will not be available to patients for 10 to 15 years. People with the skills and understanding to translate breakthroughs from “bench to bedside” are critical to breaking this barrier to patient care.

The National Institutes of Health, the nation’s leading arbiter of medical research directions, has given translational medicine a high priority and recently established a new National Center for Advancing Translational Sciences (NCATS). Announcing the center, NIH director Francis S. Collins laid out the problems that would be addressed by an intensified national focus on translation (“Reengineering Translational Science: The Time is Right,” Science Translational Medicine, July 6, 2011):

“Despite dramatic advances in the molecular pathogenesis of disease, translation of basic biomedical research into safe and effective clinical applications remains a slow, expensive, and failure-prone endeavor…” The new NIH focus on translational medicine and science, like our proposed MTM program, aims “to pursue opportunities for disruptive translational innovation.” Director Collins goes on to say, “The medical benefits of the current revolution in biology clearly cannot be achieved without vigorous and effective translation. Yet the triple frustrations of long timelines, steep costs, and high failure rates bedevil the translational pathway. The average length of time from target discovery to approval of a new drug currently averages ~13 years, the failure rate exceeds 95%, and the cost per successful drug exceeds $1 billion…”

The Obama Administration has underlined the importance of expediting translation by backing the new NIH effort with an unusual degree of support, trimming funding for some 27 other medical research centers in order to shift the discipline’s focus to advancing translational medicine (according to a report in the New York Times, “Federal research center will help develop medicines,” January 22, 2011). “Concerned about the slowing pace of new drugs coming out of the pharmaceutical industry,” the report says, the administration has invested in the billion-dollar NIH translational science center.

To help lead the way in providing graduates with the skills to capitalize on medical research and translate it to meaningful and timely advances for patients, both UCSF and UC Berkeley have made translational medicine a priority for their biomedical disciplines. At Berkeley, the bioengineering faculty have begun organizing their ongoing translational work into a coherent focus on the field, with hopes that the new MTM degree will be the critical educational piece in that effort. At UCSF, the campus web site makes its statement emphatically: “The pursuit of translational medicine — the process of applying ideas, insights and discoveries generated through basic science research to improving human health — is one of UCSF’s priorities as it advances into the next decade of the 21st century.”

As the result of their studies, our MTM students will be equipped to address the pressing healthcare issues identified by the NIH, the federal government, and their two universities, putting them in an excellent position to make a significant impact on the discipline.

3.5. Ways in Which the Program Will Meet the Needs of Society

The MTM program will prepare students to lead the way in strengthening and widening the pipeline from medical-innovation to patient care, an urgent need to meet the healthcare needs of society and people around the world. The curriculum encourages students to think about how to develop technologies for medical treatments “that are better, faster, cheaper” and to overcome the challenges inherent in new
technology adoption. Through courses and the hands-on capstone project, students will gain the well-rounded technical, clinical, business, and regulatory understanding and address real-world needs.

Advances in bioengineering and biotechnology are transforming the future of healthcare, but ensuring that these technologies are put in place to meet the healthcare needs of our growing population requires a new way of thinking — and the new kind of biotechnology professional the MTM will produce. Examples of the projects these students will address (in their capstone projects and in their careers) are the development of diagnostic devices and processes for quicker, more accurate results, whether in a hospital or in a remote area; new surgical procedures that improve patient care, integrating advances in technology that offer new capabilities for surgeons; or new biomaterials that can, for example, aid in the survival of transplanted stem cells to restore heart function in cardiac patients.

Through this program, academic and health industry specialists from a variety of disciplines, including the sciences, engineering, clinical science, and business, will educate the next generation of leaders, empowering them to develop and implement appropriate solutions that integrate scientific, engineering, health, policy, economic, and ethical perspectives. This degree culminates in a project in which students participate in design challenges aimed at solving real-world health problems.

This is the ideal time to establish such a program. Despite the nearly $32 billion annual investment in federal research funding, advances in cures and treatments for life-threatening diseases have slowed. It now takes 14 years on average to move from “molecule to medicine.” The health sciences have been slow in adopting best practices from the most innovative sectors of the economy, such as information technology, which focuses on being “better, faster, and cheaper” in everything. Healthcare is rapidly becoming more expensive, with only modest improvements in health. As a joint venture between UCSF and UC Berkeley, the new MTM program will draw on the collective strengths of two extraordinary campuses and attract the best students nationwide to meet global and societal health needs.

3.6. Relationship of the Program to Research and/or Professional Interests of Faculty

The pursuit of translational medicine — the conversion of scientific discovery into patient care — has largely defined UCSF’s mission in the 21st century, and is driving its ongoing efforts to create a work environment where clinicians, research scientists, and industry leaders interact on a daily basis. UC Berkeley faculty in the Department of Bioengineering have put a growing emphasis on translational research, backed by their strong translational foundation, including research that has generated technological innovations in tissue engineering, medical imaging, implantable devices, and more. The core MTM faculty (engineers and clinicians) are already engaged in translational research projects (see Appendix H for examples) and would greatly benefit from students interested in pursuing projects that address translational needs.

Additionally, UCSF’s focus on translational medicine has intensified over the past several years, thanks in part to a $100 million, five-year grant awarded by the National Institutes of Health in 2006, under its Clinical and Translational Science Award program. The funding led to the creation of the cross-campus UCSF Clinical and Translational Science Institute (CTSI). CTSI aims to promote research and education in translational and clinical science at UCSF, in partnership with its various training hospitals and other affiliated institutions, as well as the larger Bay Area healthcare community.

A joint degree program in translational medicine at UCSF and UC Berkeley would complement the efforts (and aspirations) of both campuses, augment faculty research programs with the infusion of new multidisciplinary graduates students, and catalyze the development of new technology to improve medical treatment.
3.7. Program Differentiation

The students currently enrolled in our existing degree programs indicate that they desire and need more relevant education to bridge the gap between basic engineering and clinical translation (See Section 1.5 for complete descriptions of related UC programs), and there are currently no UC or California independent university programs offering a Master of Translational Medicine.

Stanford University does offer a Master’s of Medicine (MOM) program, however, which has certain similarities. The MOM program exposes Ph.D. candidates to clinical medicine with a view to fostering translational research. The goal of the program is to train a new generation of Ph.D. students about human biology and disease, making them more able to translate new scientific discoveries into useful medical advances. Students admitted to any of the Ph.D. programs offered at Stanford may apply for admission to this program on a competitive basis. In practice, the program extends the total time of training by about one year beyond the usual length of the Ph.D. program. During their first two years, MOM participants will take basic biomedical science courses with the School of Medicine’s M.D. students, as well as seminar series dedicated to issues in translational medicine. This course schedule allows MOM students to concurrently undertake Ph.D. course requirements and lab rotations. By early in the second year, students will choose labs for thesis research and elect clinical mentors. The MOM degree is conferred with the Ph.D. upon a student’s successful completion of the doctoral program.

In comparison to the proposed MTM program, Stanford’s MOM program lacks both the technical/engineering and business/leadership components present in the MTM curriculum, and is only open to Stanford students enrolled in a Ph.D. program. The MTM program addresses a much broader need for professional training in both the clinical needs finding and industrial design and development of new medical technology.

Students seeking a professional degree in bioengineering (with an engineering rather than a clinical focus) can pursue the proposed M.Eng. in Bioengineering at UC Berkeley or they can seek an M.Eng. in Bioengineering at UC San Diego (which is aimed at design and project engineers). Professionals seeking careers in clinical research in academic medicine, or the biotechnology or pharmaceutical industry will choose UCSF’s Master of Advanced Study in Clinical Research.

Section 4. Faculty

UCSF and UC Berkeley have exceptionally large and experienced faculties for teaching courses at the graduate level. The clinical scientists and engineers who will serve as faculty for this program collectively have extraordinary depth and breadth of experience in teaching and conducting translational medical research.

The faculty guiding the program and teaching the courses are primarily ladder-rank faculty (8 of the 9 core required and recommended courses are taught by ladder-rank faculty). The faculty participating in the program are listed here, and their curriculum vitae are in Appendix I:
<table>
<thead>
<tr>
<th>Faculty Member</th>
<th>Faculty Position</th>
<th>Department / Campus</th>
<th>Highest Degree (Granting Institution)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kirsten Bibbins-Domingo</td>
<td>Assoc. Professor in Residence</td>
<td>Medicine, Epi. &amp; Biostat./UCSF</td>
<td>Ph.D./M.D. (UCSF)</td>
</tr>
<tr>
<td>Tejal Desai</td>
<td>Professor</td>
<td>BTS &amp; Physiol./UCSF</td>
<td>Ph.D. (UC Berkeley/UCSF)</td>
</tr>
<tr>
<td>Dan Fletcher</td>
<td>Professor</td>
<td>BioE/UC Berkeley</td>
<td>Ph.D. (Stanford)</td>
</tr>
<tr>
<td>Kathy Giacomini</td>
<td>Professor</td>
<td>BTS &amp; Physiol./UCSF</td>
<td>Ph.D. (State University of New York at Buffalo)</td>
</tr>
<tr>
<td>Deborah Grady</td>
<td>Professor</td>
<td>Medicine/UCSF</td>
<td>M.D. (Virginia)</td>
</tr>
<tr>
<td>Kevin Healy</td>
<td>Professor</td>
<td>BioE/UC Berkeley</td>
<td>Ph.D. (Pennsylvania)</td>
</tr>
<tr>
<td>Terry Johnson</td>
<td>Lecturer</td>
<td>BioE/UC Berkeley</td>
<td>M.S. (MIT)</td>
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<td>Clay Johnston</td>
<td>Professor</td>
<td>Neuro., Epi./UCSF</td>
<td>Ph.D. (UC Berkeley)</td>
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<td>Song Li</td>
<td>Professor</td>
<td>BioE/UC Berkeley</td>
<td>Ph.D. (UC San Diego)</td>
</tr>
<tr>
<td>Sarah Nelson</td>
<td>Professor</td>
<td>BTS &amp; Physiol./UCSF</td>
<td>Ph.D. (University of Heidelberg)</td>
</tr>
<tr>
<td>Shuvo Roy</td>
<td>Associate Professor</td>
<td>BTS &amp; Physiol./UCSF</td>
<td>Ph.D. (Case Western)</td>
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<td>Marc Shuman</td>
<td>Professor</td>
<td>Medicine &amp; Urology/UCSF</td>
<td>M.D. (Thomas Jefferson)</td>
</tr>
<tr>
<td>Ikhlaq Sidhu</td>
<td>Adjunct Professor</td>
<td>Industrial Engineering &amp; Operations Research</td>
<td>Ph.D. (Northwestern)</td>
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</table>

### Section 5. Courses

Course descriptions for all core required and recommended courses for the MTM degree are listed below, along with a list of approved electives. All of these courses are already approved, with the exception of the new capstone project courses, to be offered through UC Berkeley and UCSF. Full descriptions for those courses are included in Appendix G.

With the guidance of the appointed Academic Advisers (and Assistant Graduate Advisers) — who will be knowledgeable about the courses available on both campuses — coursework will be tailored, via electives, for educating students from varying technical, clinical, and academic backgrounds. For example, students with engineering backgrounds may elect additional courses related to fundamentals of physiology, anatomy, biochemistry, and clinical medicine. Students with biomedical professional degrees may elect specific courses in basic bioengineering principles and product design and development. All students will take courses in clinical research methods, clinical trials design, research ethics, regulatory issues and FDA approval, and the business and economics of product development in healthcare. The goal of the coursework is to educate individuals who are: (1) capable of having an important role in the discovery and implementation of significant health innovations, and (2) are prepared to take a leadership role in their organizations.
Required Courses

**BIOENGINEERING (at least 10 semester units or equivalent)**

A total of 6 units of Bioengineering 296 must be applied to the degree, apportioned between Bioengineering and Clinical R&D, as needed. Students will enroll in the version of 296 that corresponds to their home campus. Additional BioE 296 units may be taken (in order to meet enrollment requirements on each campus), but only 6 total units may be applied to the degree.

**Bioengineering 296 (UC Berkeley) – Capstone Project**
The objective of the one-year professional MTM program is to develop engineering leaders who can synthesize the technical, environmental, economic, and social issues involved in the design and operation of complex engineering devices, systems, and organizations. Students will develop and demonstrate this skill at synthesis through the capstone project. Projects will provide practical instruction and experience in solving real problems in translational medicine, and it is anticipated that some will lead to innovations with commercial potential. This experience, undertaken as a team member and marked by extensive interaction with faculty, peers, and industry partners, enables the student to integrate the leadership and technical dimensions of the professional MTM curriculum. MTM capstone projects will be designed in accordance with the set of general guidelines included in Section 2.3.b. (F, Sp) Li (or future UC Berkeley Faculty-Co-Director)

**Bioengineering 296 (UCSF) – Capstone Project**
The objective of the one-year professional MTM program is to develop engineering leaders who can synthesize the technical, environmental, economic, and social issues involved in the design and operation of complex engineering devices, systems, and organizations. Students will develop and demonstrate this skill at synthesis through the capstone project. Projects will provide practical instruction and experience in solving real problems in translational medicine, and it is anticipated that some will lead to innovations with commercial potential. This experience, undertaken as a team member and marked by extensive interaction with faculty, peers, and industry partners, enables the student to integrate the leadership and technical dimensions of the professional MTM curriculum. MTM capstone projects will be designed in accordance with the set of general guidelines included in Section 2.3.b. (F, W, Sp) Desai (or future UCSF Faculty-Co-Director)

See lists of recommended and elective courses from UC Berkeley and UCSF below

**CLINICAL R&D (at least 6 semester units or equivalent)**

A total of 6 semester units (or 9 quarter units) of Bioengineering 296 must be applied to the degree, apportioned between Bioengineering and Clinical R&D, as needed. Students will enroll in the version of 296 that corresponds to their home campus. Additional BioE 296 units may be taken (in order to meet enrollment requirements on each campus), but only 6 total semester units (or 9 total quarter units) may be applied to the degree.

**Bioengineering 296 (UC Berkeley) – Capstone Project**
The objective of the one-year professional MTM program is to develop engineering leaders who can synthesize the technical, environmental, economic, and social issues involved in the design and operation of complex engineering devices, systems, and organizations. Students will develop and demonstrate this skill at synthesis through the capstone project. Projects will provide practical instruction and experience in solving real problems in translational medicine, and it is anticipated that some will lead to innovations with
commercial potential. This experience, undertaken as a team member and marked by extensive interaction with faculty, peers, and industry partners, enables the student to integrate the leadership and technical dimensions of the professional MTM curriculum. MTM capstone projects will be designed in accordance with the set of general guidelines included in Section 2.3.b (F, Sp) Li (or future UC Berkeley Faculty-Co-Director)

**Bioengineering 296 (UCSF) – Capstone Project**

The objective of the one-year professional MTM program is to develop engineering leaders who can synthesize the technical, environmental, economic, and social issues involved in the design and operation of complex engineering devices, systems, and organizations. Students will develop and demonstrate this skill at synthesis through the capstone project. Projects will provide practical instruction and experience in solving real problems in translational medicine, and it is anticipated that some will lead to innovations with commercial potential. This experience, undertaken as a team member and marked by extensive interaction with faculty, peers, and industry partners, enables the student to integrate the leadership and technical dimensions of the professional MTM curriculum. MTM capstone projects will be designed in accordance with the set of general guidelines included in Section 2.3.b (F, W, Sp) Desai (or future UCSF Faculty-Co-Director)

See lists of recommended and elective courses from UC Berkeley and UCSF below

**BUSINESS, ENTREPRENEURSHIP, AND TECHNOLOGY (at least 8 semester units or equivalent)**

*No specific courses are explicitly required.*

See lists of recommended and elective courses from UC Berkeley and UCSF below

**Strongly Recommended Courses**

*While these courses are not explicitly required, students will be strongly encouraged to take them whenever possible. Exceptions can be made (at the discretion of the Academic Advisers) to retain flexibility in the curriculum for more personalized education.*

**BIOENGINEERING (at least 10 semester units or equivalent)**

**Bioengineering 260 (UCSF) – Anti-Medical School: Translational Challenges in Medicine**

(1 qtr unit)

**Course Format:** One hour of lecture per week.

**Description:** We have many opportunities to advance medical care by solving significant problems that have defied conventional solutions. But there has been an invisible barrier between scientists working at the level of discovery and invention and physicians who provide health care. Many of the former have the potential to make major advances in the diagnosis, prevention and treatment of disease, but are unaware of specific needs in medicine. Physicians on the other hand frequently meet with frustration in being able to deal with medical problems for which they have suboptimal equipment, testing, and therapies. The Anti-Medical School course provides an understanding of the nature of some of the technical and scientific limitations in treating people with serious diseases. Neurosurgeons, pediatric, orthopedic, and ophthalmologic surgeons, and medical, surgical, and neuro-oncologists will discuss the challenges they encounter in their practice, and opportunities for advancing their fields by new inventions and discoveries. Students will actively participate in organizing the lectures, and in discussing potential experimental solutions to these problems. It is expected that students will acquire a new appreciation of how their
research has the potential for overcoming significant problems in medicine.

**Course objectives:**

A. Provide the context for human disease processes that present significant obstacles for clinicians
B. Describe opportunities for discovery of novel inventions and agents that will significantly advance screening, diagnosis, and treatment of human diseases
C. Develop plans in a group setting for solutions to challenges presented during the course
D. Develop a framework of thought processes involved in research related to human disease

(F) Shuman/Desai (UCSF)

**Bioengineering 270 (UCSF) - Translational Challenges in Diagnostics, Devices, and Therapeutics (2 qtr units)**

This course will introduce key concepts of the product development process as it relates to medical diagnostics, devices, and therapeutics. Topics will include strategies for concept generation, prototyping approaches to demonstrate feasibility, and translation pathways for “real-world” adoption. The course will comprise of didactic lectures and interactive discussions around specific projects that will serve as “case-study” illustrations to step the students through the medical technology development process. Material will be presented by regular faculty as well as scientist/physician entrepreneurs, corporate executives, device manufacturers, regulatory experts, health policy specialists, intellectual property attorneys, and venture capitalists. (W) Roy

**Bioengineering 290X (UCB) – Ethical and Social Issues in Translational Medicine (1 sem unit)**

**Course Format:** One hour of lecture per week.
**Description:** This course is designed to acquaint students with the ethical and social issues inherent in the translation of laboratory research into clinical innovations. Members of the MTM program will, through a combination of lectures and guest speakers, learn about ethical challenges in translational medicine. Through a series of assignments they will learn to recognize ethical issues in their work and construct appropriate guidelines for conducting that work in an ethical manner. (F) Johnson.

**CLINICAL R&D (at least 6 semester units or equivalent)**

**Epidemiology (EPID & BIO) 150.03 (UCSF) - Designing Clinical Research for Residents and Students (2q units)**

**Course format:** Project, 2 hours of lecture a week. **Prerequisites:** None. **Restrictions:** Must be a student in Dentistry, Medicine, Nursing, Pharmacy, or a Resident at UCSF (*MTM students have been granted special permission to take this class*). **Description:** This course guides residents and students through the essential components for writing a clinical research protocol, developed around their own clinical research question. Students attend lectures and small group seminars as well as a peer review session in the last week of the course. The course will cover research questions, hypotheses, specific aims, study types, sample size estimation, power calculations, and data analysis. (Su, F) Bibbins-Domingo

**Epidemiology 205 (UCSF) - Clinical Trials (1.5 qtr units)**

**Course format:** One and a half hours of lecture per week for 11 weeks. **Prerequisites:** Possession of M.D., Ph.D., D.D.S. or Pharm.D. degree or permission of course director and Epidemiology 180.04. **Restrictions:** This course is part of the Advanced Training in Clinical Research (ATCR) Certificate Program and the Master’s Degree Program in Clinical Research. Space permitting, the course is open to a
limited number of other individuals but has special fees attached. **Description:** Instruction in experimental design options in clinical research; methods of randomization; blinding; interventions and controls; measuring outcomes and adverse effects; follow-up, compliance and post-randomization problems; ethical issues; and working with pharmaceutical companies. (W) Grady

**BUSINESS, ENTREPRENEURSHIP, AND TECHNOLOGY (at least 8 semester units or equivalent)**

**Engineering 271 (UCB) – Engineering Leadership I (3 sem units)**

**Course Format:** Three hours of lecture per week. **Prerequisites:** Admission to the M.Eng. Program.  
**Description:** Designed for professionally-oriented engineering graduate students, this course explores key management and leadership concepts relevant to technology-dependent enterprises. Topics include opportunity recognition, strategies for effective R and D, marketing innovation, disruption, cognitive inertia, product management, market selection, standards wars, two-sided markets, attracting stakeholders, business models, pricing strategies (F) Sidhu, Staff

**Engineering 272 (UCB) - Engineering Leadership II (3 sem units)**  
**Course Format:** Three hours of lecture per week. **Prerequisites:** Admission to M.Eng. Program and 271.  
**Description:** Designed for professionally-oriented engineering graduate level students, this course explores key operational, leadership, and financial concepts relevant to technology-dependent enterprises. Topics include methods to go to market, direct and indirect sales, logistics, talent management, managing creativity, project management, leadership styles, CFO-style interpretation of financial statements, funding sources, budgeting, and valuation methods. (SP) Sidhu, Staff

**Approved Electives**

*This list comprises the currently approved elective courses for the proposed Master of Translational Medicine program. Additional courses may be added to this list in future years as approved by the MTM Program Committee.*

**BIOENGINEERING**

*Berkeley (in semester units)*

Bioengineering (BIO ENG) C145L – Introductory Electronic Transducers Laboratory (3) F  
Bioengineering (BIO ENG) 210 – Cell Mechanics and the Cytoskeleton (3) Sp  
Bioengineering (BIO ENG) 211 – Tissue Mechanotransduction (3) F  
Bioengineering (BIO ENG) C214 – Advanced Tissue Mechanics (3) Sp  
Bioengineering (BIO ENG) 215 – Models of Cell Mechanics: Dynamics of the Cytoskeleton (3) F  
Bioengineering (BIO ENG) C216 – Macromolecular Science in Biotechnology and Medicine (4) Sp  
Bioengineering (BIO ENG) C217 – Biomimetic Engineering – Engineering from Biology (3) F  
Bioengineering (BIO ENG) C218 – Stem Cells and Directed Organogenesis (3) Sp  
Bioengineering (BIO ENG) 221 – Introduction to Micro and Nanobiotechnology: BioMEMS (4) F  
Bioengineering (BIO ENG) C223 – Polymer Engineering (3) F  
Bioengineering (BIO ENG) 231 – Intro to Computational Biology (4) F  
Bioengineering (BIO ENG) 251 – Micro/Nanofluidics for Bioengineering and Lab-On-A-Chip (4) Sp  
Bioengineering (BIO ENG) C265 – Principles of Magnetic Resonance Imaging (3) F, Sp
Bioengineering (BIO ENG) C279 – Occupational Biomechanics (4) Sp
Bioengineering (BIO ENG) C280 – Introduction to Nano-Science and Engineering (3) F, Sp
Electrical Engineering (EL ENG) C245 – Introduction to MEMS Design (4) F, Sp
Mechanical Engineering (MEC ENG) 132 – Dynamic Systems and Feedback (3) F, Sp
Neuroscience (NEUROSC) C217D – Biological and Public Health Aspects of Alzheimer’s Disease (3) Sp
Public Health (PB HLTH) 200C1 – Health Policy and Management Breadth Course (2) F*
Public Health (PB HLTH) 222A – Health Care Technology Policy (2) F
Public Health (PB HLTH) 260A – Principles of Infectious Diseases (4) F, Sp

**UCSF (in quarter units; one quarter unit = 2/3 semester unit)**

Bioengineering (BIOENG PRG) 221 – Tissue Mechanobiology (2) F
Bioengineering (BIO THERAP) 230A – Radiologic, Nuclear and Molecular Imaging Methods (3) F
Bioengineering (BIO THERAP) 230B – Physics of Medical Imaging (3) W
Bioengineering (BIO THERAP) 230C – Molecular Imaging (3) Sp
Bioengineering (BIO THERAP) 240 – Principles of Nuclear Magnetic Resonance Imaging (3) F
Bioengineering (BIO THERAP) 241 – Magnetic Resonance Spectroscopy (3) W
Bioengineering (BIO CELL & TISBI) 242 – Principles of Tissue Engineering (3) F, W, Sp
Bioengineering (BIO THERAP) 244 – Image Processing & Analysis (3) W, Sp
Bioengineering (BIO THERAP) 245 – Electromagnetic Neuroimaging (3) F, W, Sp
Bioengineering (BIO THERAP) 247 – Introduction to Magnetic Resonance Imaging System and Hardware (3) Sp
Bio Therapeutics (BIO THERAP) 280 – Clinical Aspects of Bioengineering (3) F, W, Sp
Pharmacology (PHARMACOL) 245A – Basic Principles of Pharmaceutical Sciences (3) F
Pharmacology (PHARMACOL) 245C – Principles of Pharmacogenomics (3) Sp

**CLINICAL R&D**

**UCSF (in quarter units; one quarter unit = 2/3 semester unit)**

Epidemiology (EPID & BIO) 213 – Decision and Cost-Effectiveness Analysis in Medicine (2) W, Sp
Epidemiology (EPID & BIO) 260 – Development and Approval of Drugs and Devices (1.5) Sp

**BUSINESS, ENTREPRENEURSHIP, AND TECHNOLOGY**

**Berkeley (in semester units)**

Chemical & Biomolecular Engineering (CHEM ENG) 295D – Development of Biopharmaceuticals (2), Sp
Chemical & Biomolecular Engineering (CHEM ENG) 295P – Introduction to New Product Development (3) F
Engineering (ENGIN) 290 – Special Topics in Management of Technology (2.3) F, Sp
Engineering (ENGIN) 290J – Entrepreneurship in Biotechnology (2) Sp
Engineering (ENGIN) 298A – Richard Newton Distinguished Innovator Lecture Series (1-6) F, Sp
Industrial Engineering (IND ENG) 171 – Introduction to Design of Human Work Systems and Organizations (3) F

Industrial Engineering (IND ENG) 191 – Technology Entrepreneurship (3) F

Law (LAW) 276.61 – Biotechnology Law (2) Sp

Master of Business Administration (MBA) 205 – Organizational Behavior (2) F, Sp

Master of Business Administration (MBA) 209F – Fundamentals of Business (3) F, Sp

Master of Business Administration (MBA) 290B – Biotechnology: Industry Perspectives and Business Development (2) F, Sp

Master of Business Administration (MBA) 296 – Innovation in Healthcare (2) F, Sp

Mechanical Engineering (MEC ENG) 290P – New Product Development: Design Theory and Methods (3) F

Public Health (PB HLTH) 200C1 – Health Policy and Management Breadth Course (2) F*

**USSF (in quarter units; one quarter unit = 2/3 semester unit)**

Biochemistry (BIOCHEM) 210 – A Life Scientist’s Guide to Intellectual Property. (1.5) Sp

Biochemistry (BIOCHEM) 241 – Idea to IPO & Beyond (3) W, Sp

Biochemistry (BIOCHEM) 247 – Corporate Finance Survival Skills. (1.5) Sp

*May be used either as a Bioengineering or Business elective

**Professional Outreach Courses**

The following UCSF-sponsored outreach courses are also potentially available to students in the Master of Translational Medicine program, at a reduced fee, as approved by the Academic Advisers.

American Course on Drug Development and Regulatory Sciences (ACDRS) – 23 sessions over 2 years

Pharmacokinetics for Pharmaceutical Scientists (PKPS) – 5 days in February

**Section 6. Resource Requirements**

The MTM program will be funded by a combination of state funds and student-paid professional degree supplemental tuition (PDST). During the first two years, when we do not anticipate enrolling the full complement of students (30 at steady state), the financial needs of the program will be supplemented by private gifts ($1.5 million from the Grove Foundation has been secured to support the development and implementation of this program).

The estimated budget for the MTM professional degree supplemental tuition (PDST) over the first three years of the program will provide a sufficient level of revenue to give the program financial stability at steady state (*Appendix K*). Details of the MTM program-delivery needs are included throughout this section, and a thorough explanation of projected program costs and revenues and how PDST revenues would be distributed between the sponsoring departments follows the description of resource needs at the end of this section. A two-campus MOU is being prepared to outline the agreements by the two departments on allocation of revenues (see *Appendix E*).
6.1 FTE Faculty

Students in the MTM degree program will enroll in graduate courses taught by the ladder-rank faculty from the two bioengineering departments, adjuncts, lecturers, and other faculty in engineering, epidemiology, medicine, business, and other disciplines on both campuses. They will teach existing courses that are strongly recommended for the MTM curriculum, including Anti-Medical School: Translational Challenges in Medicine (Bioengineering 260) and two courses taught through CTSI (Epi 150.03 and Epi 205) on the UCSF campus, as well as the leadership series (Engineering 271 and 272) on the Berkeley campus. The number of course sections in these courses might need to increase to meet the needs of the small MTM cohort, and the frequency of offerings may be adjusted so that students will make normative progress towards their degrees. However, any increase in faculty workload metrics will be balanced by additional support for supplemental teaching assistance (lecturers or GSIs) as accounted for using the PDST (Appendix K). The MTM student count for the program is not expected to overtax our ability to provide adequate sections for our other graduate students. Any additional instructors necessary for providing the educational requirements of the MTM students will be paid for from the departments’ professional degree supplemental tuition (PDST) resources and College/School resources, as jointly determined by the leadership of the departments and their college or schools. Estimates concerning possible instructional backup are provided in the planning budget, discussed below.

6.2 Library Acquisitions

No additional resources are needed.

6.3 Computing Requirements and Cost Estimates

Funds from the PDST revenue will be allocated to both campuses for IT costs associated with program administration; $3,750 per campus is estimated to cover these needs in the first year of the program — $2,500 computing costs and $1,250 network charges (see also Appendix K, line items for “Computing costs” and “Network charges”).

Should specific IT needs arise in conjunction with a particular capstone project that cannot be covered by the project leader, these costs may be covered through the budgeted PDST revenue (at the discretion of the Faculty Co-Directors). An estimate of $12,860 per campus is devoted to project support in the first year of the program (see Appendix K, line item for “Instructional Lab/Capstone Project Support,” which includes such potential costs).

6.4 Equipment

Similarly to project-specific IT costs, project-specific laboratory equipment costs that cannot be covered by the project leader may be covered using the budgeted PDST revenue (at the discretion of the Faculty Co-Directors). This cost would also be covered in the $12,860 per campus that is devoted to project support in the first year of the program (see Appendix K, line item for “Instructional Lab/Capstone Project Support”).

6.5 Space and other capital facilities

We expect to comfortably accommodate the additional students for the MTM program in existing space on both campuses; any space modifications needed by the program in the future will be funded through the
PDST fees. Students will have access to shared student space in bioengineering departments on both campuses. The program’s needs for conference rooms, videoconferencing, and teleconferencing will also be met, as available, by the departments.

In the long term, MTM-specific lab- or work-space may be desired as the program expands to steady-state (30 students per year). In addition to the project-specific IT and equipment needs described in Section 6.3 and Section 6.4 above, the “Instructional Lab/Capstone Project Support” line item in the planning budget (Appendix K) is intended to cover the cost of future dedicated lab/work-space. For capital-intensive projects such as the addition of new rooms or facilities, the project-support revenue may need to be compiled over the course of several years.

6.6 Other Operating Costs

An Executive Director administers the MTM program; the cost of salary ($105,000 in 2013) and benefits (30%) for the position is shared by the two sponsoring departments, as indicated in the planning budget, Appendix K. The administrative infrastructures of the bioengineering departments at UC Berkeley and UCSF have the capacity to support other needs of the MTM program — with modest additional support from the PDST — including administering financial aid, website development, fundraising, and other financial and administrative services that pertain to this program. Specifically, the budget allocates $12,500 to each campus in the first year of the program for financial administrative support (line item “Financial Admin Support”), as well as $12,500 to each campus for web development, advertising, and other communications (line item “Web Development and Communications”). These amounts will be balanced between campuses annually depending on where the actual costs are incurred.

6.7 Course Delivery Costs

The core MTM curriculum consists of nine total courses — two of which are required (the capstone project courses) and seven of which are strongly recommended — as described in Section 5. To ensure that these courses are available to MTM students every year, a portion of the PDST is reserved for core-course delivery (Appendix K, line item “Core course delivery costs”). In addition to the $12,500 (in 2013) allocated for each Faculty Co-Director, $12,860 is allocated to each campus to support the capstone projects (as described above), which may also be used to supplement course instruction costs, if needed. For the seven highly recommended courses, approximately $130,000 will be allocated to each campus at steady-state to cover the cost of 30 students in each course (see Appendix K for full details). This amount will be adjusted annually depending on the fluctuations of the course costs over time and the number of students who actually enroll in each course.

6.7 PDST Details

To meet the financial needs of the program as detailed in the sections above, a professional degree supplemental tuition (PDST) fee will be charged to the students in addition to standard UC tuition and fees. The PDST will be charged to each student’s home campus, and each campus will receive 50% of the PDST revenue per year. However, money may be transferred between campuses as deemed appropriate by the Faculty Co-Directors in order to pay for specific costs on the campus where they are incurred.

The MTM program will charge all students (regardless of residency status) a PDST fee of $30,330 in 2013, and will increase this fee an estimated 8% annually as detailed in the projected budget (Appendix K). This PDST level falls within the levels projected for California-residents and non-residents in the UC Berkeley M.Eng. program in 2013: $35,000 and $25,660, respectively. Taking into account standard UC
tuition and fees, the total cost to students of the one-year MTM program in 2013 is estimated to be $47,808 for California-residents and $62,090 for non-residents; this is in line with the costs of the closest comparable programs (Appendix J), which have a projected range of $47,590-$66,580 total cost to students for both residents and non-residents in 2013.

With the revenue from the PDST fees, the MTM program is expected to lose approximately $95,000 in 2013-14, break even in 2014-15, and generate a surplus of approximately $88,000 in 2015-16 at a steady-state of 30 students. For the first year of the program, the net financial loss will be offset by the Grove gift funds. At steady-state, any surplus revenue will be used for new course creation and unaccounted costs of elective course delivery, to improve the educational experience for students, and to modestly benefit the sponsoring departments, with surplus divided between the two campuses annually based upon the proportion of elective student-credit hours that were taken at each campus.

The two-campus MOU outlining these distributions, handling of shared costs for the program, and the agreement on home campus of students in the joint program is being prepared based on agreements made by the two departments (see Appendix E for details).

Section 7: Graduate Student Support

7.1. Student Financial Support and Earning Potential Post-Degree

Both the UC Berkeley and UCSF are dedicated to excellence in their educational programs, and also strongly committed to enrolling an exceptional and diverse student cohort. To this end and in compliance with Regental policy, a minimum of one-third of its professional degree supplemental tuition (PDST) revenues from the MTM program will be allocated to financial aid to help ensure that talented students who may not be able to afford the MTM program can indeed attend.

Financial aid will be offered to our MTM students in two categories: (1) need-based aid and (2) merit-based support. Consideration for need-based aid for MTM students will be based on the students’ submission of a modified version of the national financial aid form, the Free Application for Federal Student Aid (FAFSA). Both the bioengineering departments have established policies and procedures for financial aid, and these will be applied in granting aid to MTM students.

We anticipate offering partial fellowships to students who need financial support. As mentioned above and outlined in the planning budget (Appendix K), 33% of the PDST revenue will be used exclusively for student support. Students may also apply for GSI positions on the Berkeley campus (none are available at UCSF); because priority for these positions is given to Ph.D. students and to majors of the home department offering the course, MTM students will only receive a GSI position when there is an overabundance available, and so the MTM students will not have a negative impact on the overall availability of these GSI positions. Students in the current Bioengineering M.S. program who have secured GSI positions have balanced the teaching workload with their coursework with little difficulty.

In addition, the two campuses have established a high-level MTM Advisory Board, assembled through both UCSF and UC Berkeley. The Board will provide counsel and external advice to program faculty when examining the strategic directions of the program, but its fundamental purpose is to help raise funds to support student financial aid, capstone projects, and other program needs. A central, long-term goal of the Board is to create an endowment that will help to secure ongoing support of student aid.
Due to strong industry demand for bioengineers with advanced professional education, students who earn the MTM degree will have substantially improved employment opportunities and salaries, as illustrated above in Chart 7 and Chart 8. In addition, some MTM students may be supported partly or in full by their corporate or other sponsors. In this context, we believe that while some students may need to incur a level of debt to help finance their MTM education, their relative financial position after completion of the program will beneficially compensate them for this.

7.2. Ensuring Access, Affordability, and Diversity

Ensuring student access, affordability, and diversity is a paramount consideration in establishing any new UC Berkeley or UCSF degree program. These issues for the MTM will be addressed through 1) offering adequate need-based (and merit-based) financial aid to students (see Section 7.1), 2) factoring in the enhanced earning potential of graduates of the one-year program (see Section 3.3), and 3) utilizing the well-established outreach programs in the College of Engineering, School of Medicine, and School of Pharmacy to attract a diverse student body.

At Berkeley, each College of Engineering department has long experience in outreach to a culturally diverse pool of prospective students at all levels including underrepresented minorities. We have utilized this experience and supplemented outreach efforts with extensive marketing to attract underrepresented students for other professional master’s programs. We will employ similar marketing and outreach for the MTM, should it be approved. In addition, the College’s Engineering Student Services office is dedicated to broadening participation in engineering programs by students of diverse backgrounds; its Graduate Academic Diversity Program can also supplement outreach for prospective MTM students by encouraging current Berkeley students to pursue graduate studies.

At UCSF, there is a strong commitment to achieving excellence through diversity in the classroom, lab, and workplace. In keeping with this goal, the Graduate Division administers several diversity programs including the NIH/NIGMS-sponsored IRACDA Scholars in Science (ISIS) Fellowship Program for postdoctoral scholars and the Initiative to Maximize Student Diversity (IMSD) Fellowship for underrepresented minority graduate students; the NSF-sponsored Alliances for Graduate Education and the Professoriate (AGEP) “Postdoc Bootcamp” program; the UC Leadership Excellence through Advanced Degrees (LEADS) Program; and Summer Research Opportunities.

At UCSF, “Nurturing Diversity” is included as a key aspect of the campuses Strategic Plan. As such, several programs are also in place to support individuals with disabilities. For example, the Student Disability Service (SDS) coordinates services to students with permanent and temporary disabilities. On request and free of charge, SDS staff meet with students to evaluate how their disability may impair their academic performance. Services and accommodations are then provided to compensate for their limitation. The UCSF Committee on Educational Policy has an action plan to promote interdisciplinary/interprofessional education within existing campus structures. As part of that effort, websites for student academic affairs have been modified to provide students expanded access to accessibility information for students with disabilities.

UCSF is also committed to ensuring Access for Individuals with Financial Disadvantages. We will work with the School of Dentistry and School of Medicine’s Pipeline program that has been successful with increasing recruitment and retention of low-income students. One aspect of this program is the school’s Post Baccalaureate Program that is designed to help individuals increase their chances of gaining admission to graduate school by offering standardized test review, assistance with graduate school
application preparation, and academic skills workshops. Another aspect of the Pipeline initiative is the Recruitment by Alumni Program (RAP). This involves working with alumni that are working in areas near underserved communities to foster effective role modeling before, during, and after completion of graduate school. In addition, we will take advantage of UCSF’s strong tie to the San Francisco Public High Schools to introduce financially disadvantaged students (as well as other underrepresented students) to the research opportunities and graduate programs offered. Already, several of our MTM faculty have had San Francisco public high school students perform funded research in their laboratory over the summer.

Section 8: Governance

The program will be offered and jointly administered by the UC Berkeley Department of Bioengineering and the UCSF Department of Bioengineering and Therapeutic Sciences. Both departments have been heavily involved in graduate education in teaching, mentoring, and advising the large cohort of Ph.D. students enrolled through the Joint Graduate Group in Bioengineering (165 students in total on both campuses as of Spring 2011).

UC Berkeley and UCSF will each constitute a home campus for the MTM program, with approximately half of the MTM cohort (15 students at steady state) enrolled at each campus. Prospective students apply directly to the program, and admissions will be carried out by the MTM Program Committee, with faculty representatives from both campuses. Degrees will be conferred jointly by both campuses, but verification of degree requirement completion will be vetted by the student’s home campus. As described in Section 2.1, the Registrar’s Offices on both campuses are already familiar with the issues of joint enrollment — including admissions, registration, and degree conferral — for both the bioengineering Ph.D. program and the current bioengineering M.S. program. The MTM Co-Directors and staff will work closely with the both Registrar’s Offices to ensure similarly efficient joint operation of the proposed MTM program.

MTM Faculty Co-Directors, one from each campus, will be named by the two sponsoring bioengineering department chairs and will serve one-year appointments, subject to renewal at the discretion of each department chair. The Co-Directors will nominate Head Academic Advisers (one from each campus), for appointment by the respective department chairs. An Executive Director (staff) will coordinate administration and communications between the two campuses, and will manage program needs, including recruiting, admissions support, project solicitation, job placement, and the organization of meetings and events.

The Co-Directors, the two Academic Advisers, and the Executive Director will comprise the MTM Program Committee. As required for the efficient operation of the program, other faculty may also be asked to serve one-year terms on this committee, at the discretion of the Co-Directors. The Program Committee is charged to:

- Oversee program operations
- Manage program curriculum, including coursework and project selection
- Administer the admissions process (aided by department staff)
- Identify candidates for financial aid
- Ensure program diversity through broad outreach to prospective students.

To assist in early development and implementation of this unique two-campus degree program, the Co-Directors will be advised by an internal Steering Committee and an external MTM Advisory Board.
While the Program Committee handles operations and direct interaction with students, the Steering Committee is responsible for broad program development and outreach. It provides the high-level input and strategic guidance necessary to resolve the complexities of a dual-campus degree program, including working with campus leadership, helping navigate varying policies and processes on the two campuses, coordinating activities with the MTM Advisory Board, and assisting with philanthropy and industry outreach. Members of the Steering Committee will include a designate of the UCSF Provost, a designate of the UC Berkeley Dean of Engineering, the two Program Co-Directors, and the Executive Director. The chair is chosen from among current members in May/June for the following fiscal year; the chairmanship will rotate annually between the campuses. (If one of the Faculty Co-Directors is to be appointed as chair of the Steering Committee, his or her appointment as Co-Director would need to be renewed in advance for the following year by the corresponding department chair).

The external MTM Advisory Board will help to forge connections with clinicians, engineers, and industry. This group may also sponsor some capstone project work and advise on emerging industry needs. They will also be a resource to faculty in discussing future direction of the program and desired learning outcomes for graduates. The MTM Advisory Board will assist in fundraising for the program, and will support post-graduation job placement efforts. An influential and engaged group of industry leaders has already been identified and have agreed to serve:

- Hal Barron, Chair – Executive Vice President of Global Development, Genentech, and Chief Medical Officer, Roche
- Andy Grove, Ex-officio – Co-Founder and Former CEO, Intel Corporation
- Rebekah Saul Butler – Program Director, Grove Foundation
- Richard Chin – CEO, Institute for OneWorld Health
- Isaac Ciechanover – Partner, Kleiner Perkins Caufield & Byers
- Pierson Chiou – Assistant Clinical Professor of Radiology, UCSF
- Tony Chou – Partner, Vertical Group
- Luke Envin – Managing Director, Vertical Group
- Jan Fandrianto – CEO, Obihai Technology, Inc.
- Linda Grais – Partner, InterWest Partners
- Bevil Hogg – Founder, President, and CEO, EndoStim, Inc.
- Larry Lasky – Partner, U.S. Venture Partners
- Jack Lloyd – Founder and Former Chairman, Alere Medical, Inc.
- Walter Moos – Senior Vice President, Biosciences Division, SRI International
- Jonathan Schwartz – Founder and CEO, Informed Biometry Corporation
- Ajit Shah – Managing Partner, Ariva Partners

PDST revenues will be shared among the sponsoring departments and will be used exclusively to enhance program services and delivery (as detailed in Appendix K). The specific financial and administrative arrangements, including the registration status of students, are described in Section 6.

Section 9: Changes in Academic Senate Regulations

Additions to Academic Senate Regulations will be required on both campuses and will be proposed to the Rules and Elections Committee of the Berkeley Division and the Faculty Councils of the Schools of Medicine and Pharmacy of the San Francisco Division (the UCSF Department of Bioengineering and Therapeutic Sciences is part of both schools).
For the Berkeley Division, “Regulation 566: Master of Translational Medicine (MTM)” will be proposed for adoption by the Rules and Elections Committee (as a section of “Part II: Title V. College of Engineering”). A draft of the proposed language follows:

566. MASTER OF TRANSLATIONAL MEDICINE DEGREE (MTM)

E. Degree (MTM)

The candidate must:

1. Have completed requirements for the Bachelor’s degree in one of the Colleges or Schools of the University of California or at another college or university of approved standing;

2. Have completed at least two semesters of graduate study in residence at the University of California;
   - a program of at least 24 semester/36 quarter units of approved upper division and graduate courses pertinent to the field of translational medicine, with at least 12 units of the 24 being strictly graduate courses in the major subject;
   - at least 10 units of the 24 must be in courses oriented toward bioengineering (including designated capstone project units);
   - at least 6 units of the 24 must be in courses oriented toward clinical research and development (including designated capstone project units);
   - at least 8 units of the 24 must be in courses oriented toward business, entrepreneurship, and technology;
   - at least 6 of the 24 units must be in the capstone project work, and must be distributed between the “bioengineering” and “clinical R&D” components of the curriculum.

3. Maintain an average grade of at least B in all course work undertaken as a graduate student at the University of California.

F. Program

1. The program of work of each candidate is to be under the supervision of both an Academic Adviser and a Research Adviser on the student’s home campus, as appointed by the bioengineering department chair on each campus.

2. The program must include at least 6 units of team-based capstone project work, culminating in a written report and oral presentation. The student’s individual contribution to the project work will be assessed throughout the year by the Research Adviser, and the report and presentation will also be assessed by an additional Academic Senate faculty member in bioengineering. No more than 6 of the 24 specified units can be capstone project work.

3. Subject to approval of the Graduate Council, the program of study is determined and administered by the Faculty of the College of Engineering, in consultation with parallel bodies in the School of Medicine and School of Pharmacy at UCSF