This proposal was developed by an ad hoc group of faculty from the Department of Radiology and Biomedical Imaging, with faculty representation from QB3, Bioengineering Graduate Group.

Committee Members
Ella Jones, PhD  Assist Adj Prof in Radiology & Biomedical Imaging
Sharmila Majumdar, PhD (Chair)  Prof in Res in Radiology & Biomedical Imaging
Tracy Richmond McKnight, PhD  Assoc Prof in Res in Radiology & Biomedical Imaging
Susan Noworolski, PhD  Assist Adj Prof in Radiology & Biomedical Imaging
David Saloner, PhD (Co-Chair)  Prof in Res in Radiology & Biomedical Imaging
Youngho Seo, PhD  Assist Adj Prof in Radiology & Biomedical Imaging
Henry VanBroicklin, PhD  Prof in Res in Radiology & Biomedical Imaging

Home Department: Department of Radiology and Biomedical Imaging

Contact:
Sharmila Majumdar, Ph.D.
Sharmila_Majumdar@radiology.ucsf.edu
Campus Box  2520
QB3 Building, 2nd Floor, Suite 203
1700 - 4th Street,
University of California, San Francisco
San Francisco, CA 94158

David Saloner, Ph.D.
David_Saloner@radiology.ucsf.edu
Radiology (114D)
VAMC
4150 Clement St
San Francisco, CA 94121
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SECTION 1: INTRODUCTION

1.A. Aims and Objectives

The Master’s Degree Program “MS in Imaging Sciences” (MSIS) is a course of study intended for advanced pre-doctoral students, post-doctoral fellows, residents and faculty members who wish to master imaging sciences and research methods to enhance their research designs and broaden their investigative projects. The course can be completed in one year of full time study or completed on a part time schedule but in an interval not to exceed three years. Course work includes instruction in core theory drawn from imaging physics, engineering and mathematics, linked to physiology and disease processes, providing a foundation in interdisciplinary scholarship. In addition to introduction to the fundamentals underlying image formation, hands-on laboratory courses with experiments relevant for characterizing pathologies, monitoring response to therapy and assessing the underlying mechanisms and etiologies will be introduced. Specialized topics such as quantitative imaging research design, biostatistical image analysis, and technology assessment, are available through electives. The masters program will provide a field of interdisciplinary academic investigation that will form the cornerstone for understanding and utilizing imaging to solve problems of biomedical relevance. Requirements include course work and presentation of a plan, including a comprehensive review of the literature, for an original work project at an end-of-year symposium.

The master’s program will establish new courses and a framework for concentrated study that can be pursued by non-medical students in the graduate division, medical students at UCSF (“Medical Student’s Option”, see 2.D.6, below), UC Berkeley graduate students, residents, fellows, and faculty. This plan complements broader curriculum changes occurring at UCSF under the “Pathways to Discovery” initiative which facilitates a MD with Thesis option for medical students.

1.B. Historical Development of the Field and Institutional Strengths

The University of California San Francisco (UCSF) has been a major center of imaging research. The research has spanned basic biology, engineering and clinical areas. The collaboration between the faculty at each of the campuses and between campuses has spanned a period of several years, with successful programs evolving as a result of such interactions. The development of Magnetic Resonance Imaging under the auspices of Alexander Margulis, Chair of Radiology, the development of Quantitative Computed Tomography, the combined Computed Tomography and SPECT systems were all initiated at UCSF in the Department of Radiology. Medical students, residents, clinical fellows, graduate students and post-doctoral researchers have played a pivotal role in the success of these interactions. The research has been multi-disciplinary and students and post-doctoral researchers have come from varied backgrounds, starting from Mathematics, Engineering, Biology, Physical Sciences and Medicine, all of which has contributed to the overall success of several leading programs in the San Francisco Bay Area.
The emergence of engineering tools such as complex imaging modalities, molecular biology probes, tissue and nano-engineering have been applied in pre-clinical and clinical studies. Today, imaging plays a pivotal role in many areas including oncology, cardiology, neurology, orthopedics, neurosurgery, and goes beyond diagnosis to monitoring therapy, exploring underlying pathophysiology, and even targeting and monitoring therapy.

The diversity of background and multi-disciplinary nature of imaging research has also brought with it a tremendous need for focused multi-disciplinary training. Although students and post-doctoral researchers have acquired inter-disciplinary skills as part of their training or during the course of their research program, the learning curve has often been steep. Besides imaging scientists, training is required for medical students, residents, fellows, corporate workers, and this training should be broad-based, diverse, detailed yet, not at the level of doctoral pedagogy. It is within this context that a multi-disciplinary Masters in Imaging Sciences program for undergraduate, graduate students after degree, post-doctoral researchers, fellows and others would provide a valuable link to clinical and translational areas, once a broad-based general training in areas such as bioengineering, physics, biology, medicine etc. is established. The close link between the engineering and biological and medical arenas is essential at this point, to ensure a cohesive development and appropriate application of such tools.

1.B.1. Interdisciplinary Background

The proposed master’s degree is in the rapidly growing academic field of Biomedical Imaging. The field was created through interdisciplinary collaboration and pioneering analytical scholarship.

The imaging sciences are in the midst of a profound revolution that stems from new and fundamental advances in imaging, tissue engineering, molecular and cellular biology. This is due in large part to the new technology and quantitative approaches developed in the disciplines of chemistry, physics and engineering. These advances, along with the aging of the population and the focus on health issues will increase the demand for better medical devices, techniques, and equipment.

Areas of rapid growth include non-invasive tissue characterization, computer-assisted surgery, molecular, cellular and tissue engineering, as well as rehabilitation and orthopaedic engineering. To keep pace with this anticipated growth, there is a critical need to expand training programs for individuals to serve as instructors and researchers in clinical and basic sciences departments in institutions of higher learning as well as to work in the growing industrial sector, which supports imaging research.

Traditional curricula in the life sciences have not included quantitative methods and the technology that is required in many areas of the current biological enterprise. An academic and intellectual environment that fosters seamless interaction between imaging
and life sciences and that trains students to solve complex biological and clinical problems using modern imaging tools is emerging.

The field has over 50 national and international associations and specialized journals dedicated to its scholarship. The National Institutes of Health has formed an independent institution, the National Institute of Biomedical Imaging and BioEngineering (NIBIB), largely to promote these imaging developments. These institutions and journals help to provide national educational standards for course development, opportunities for employment, peer review, publication in this area, and funding. In sum, the interdisciplinarity of the field has provided innovative analytic tools to investigate disease, and has proven to be an attractive field of study at the intersection between physical, chemical and biological science.

1.B.2 Institutional Strengths

The vision for the degree program at UCSF is to adapt the approach referred to above to teach fundamentals of imaging with hands on laboratory courses, preparing the Masters graduate with a deeper understanding of the imaging sciences.

We believe UCSF is well positioned in several ways for developing such a training program. As a health-science campus with no undergraduates, our teaching focus is on graduate students and post-doctoral researchers. UCSF’s historically strong biological focus and its biomedical community provide the advantage of a deep understanding of the problems that will continue to drive future clinical and research areas. Our location within the San Francisco Bay area provides us unequaled opportunities for interactions with Biotech and high-tech communities, UC Berkeley and Stanford, the new California Institute for Regenerative Medicine, and is in an environment that attracts outstanding students and faculty, as well as allows for placement of our Masters graduates. We already have significant experience in interdisciplinary training. The Joint Bio-engineering Graduate Group between UCSF and UCB, the Biophysics, Biological and Medical Informatics (BMI) and Chemistry and Chemical Biology (CCB) graduate programs at UCSF are all excellent examples. Thus from the very beginning we have had to work to bring these engineering-based approaches into a biological environment.

Students may be drawn from a number of undergraduate UC, Cal State programs, or graduate programs at UCSF, joint UCSF and UCB programs, fellows and researchers in areas utilizing imaging as a major tool, medical students, commercial companies, and others.

There are numerous faculty and PhD programs in place at UCSF that provide the structural integrity of the proposed one-year master’s program (see below, 1.C. for relationship to existing programs). There is also increasing support for interdisciplinary programs that foster social, cultural and other forms of non-biological social science and humanities perspectives on health, illness and disease. The Area of Concentration program for fourth year medical students provides an example. This program has allowed students to pursue a concentrated area of study and research in basic science, community
health, global health, humanities, social science, medical education, and the health care system. Many of these areas of concentration have faculty and students who work between different areas, with advice and input, mentoring and teaching, working between different ‘tracks.’ Recently, the Dean of the School of Medicine has approved plans for curricular reform to develop a “Pathways to Discovery” program for medical students to pursue a Thesis and possibly a master’s degree in an area of concentration. As explained below (see section 3.A), there is strong reason to believe that the nature of instruction and research offered by a program in Imaging Sciences would be appealing to students who elect to pursue a master’s degree.

UCSF has been a leader in taking quantitative sciences into the field of medicine. At UCSF, to further foster the application of the “hard sciences” to biology, an umbrella organization, the Program in Quantitative Biology (PQB) was formed. PQB sought to enhance enrollment of physicists, mathematicians and engineers at UCSF. Graduate groups in Biochemistry and Molecular Biology, Cell Biology, Genetics, Developmental Biology, Biophysics, Chemistry and Chemical Biology, Immunology and Neuroscience all come under the PQB umbrella.

The Integrated Program on Complex Biological Systems has recently been set up and its goal is to concentrate on cross-training, and to integrate the UCSF component of the joint UCSF-UCB graduate group in Bioengineering into the PQB umbrella. The Joint Bioengineering Graduate Group (JGGB) has been a focus for collaboration between the University of California at San Francisco (UCSF) and the University of California at Berkeley (UCB) for over 20 years. During that period it has stimulated numerous interactions between the two campuses and has enriched the opportunities for graduate students to experience how engineering principles can be brought to bear upon important problems in biology and medicine. The current NIH training grant, now in its 18th year, has been critical to the program’s past and present successes and its renewal is crucial for the future. The recent increase in the number of students who are seeking to enter the discipline has led to the assignment of major new resources for bioengineering research and education. At UCSF this need is being met by the formation of a multi-disciplinary Department of Bioengineering and Therapeutic Sciences. In addition, other programs such as the Program in Craniofacial and Mesenchymal Biology (CMB), Molecular Medicine and others bring together faculty, research labs and investigators, many of whom have laboratories extensively using imaging methodologies and whose students and fellows may benefit from a one year didactic, hands-on course of imaging sciences.

Finally, UCSF has institutional strength for this master’s degree program with regard to the spirit of inquiry and cultivation of cultures of curiosity that make it a leading center for the study of health and illness. Interdisciplinarity is a valued approach to academic inquiry at UCSF. This is evident foremost in its encouragement of translational research. The meaning of this predominately relates to the promotion of communication and collaboration between bench scientists and clinicians (delivery of care from ‘bench to bedside’), but the methodology for facilitating such communication and ‘paradigm sharing’ draws on insights and evidence regarding social networks, intellectual traditions, and institutional conditions provided from research in the social sciences and humanities.
Following the example of advocating reflection on ethical, legal and social implications (ELSI) as part of the human genome project, virtually all major biomedical interventions or research endeavors occur with some dimension of integrated research that fosters such reflexivity. This master’s degree program at UCSF will be the first to institutionalize such critical reflection and analysis in a higher degree program geared to the examination of medical science and technology research.

In summary, UCSF is a premier research and teaching institution in basic science, clinical research, epidemiology, and health policy. The proposed master’s degree program draws on the legacy of these unique programs, the expertise of the faculty at UCSF and the moment of curricular re-conceptualization occurring within the School of Medicine to define its form and function as a new and innovative graduate program.

1.C. Relationship of the Proposed Program to Existing Programs at UCSF

Whereas the establishment of masters programs often acts as a building block toward creating a PhD program, the proposed program finds a niche under the umbrella of other successful PhD programs already active at UCSF. However, the proposed program serves the interests of a number of prospective students who either do not want to commit to a PhD program, or are under-qualified for admission to a PhD program and would benefit from a transitional MS degree.

The following list reflects the most closely related forms of intellectual inquiry to the activities of the proposed MS in Imaging Sciences degree at UCSF.

1.C.1. Department of Radiology and Biomedical Imaging

The host department does not currently offer graduate degrees. Establishing this degree program gives a new definition to Radiology and Biomedical Imaging as a discipline at UCSF. The faculty engaging in biomedical imaging research will be available for mentoring master’s research projects.

1.C.2. UCSF/UCB Graduate Group in Bioengineering

UCSF and UC Berkeley offer a joint graduate program in Bioengineering. This program admits students for a PhD though may grant terminal MS degrees to some students. While there may be overlap in coursework between the proposed MS program and Bioengineering, Bioengineering is a more broad discipline and is focused on independent research to be completed with a PhD dissertation.

The program has over 150 active graduate students, and offers a range of elective courses of relevance to the proposed MS in Imaging Sciences which can be cross-listed (see below, Section 2.E.2). The faculty engaging in biomedical imaging research within the Joint Graduate Group in Bioengineering (JGGB) will be available for mentoring master’s research projects.
The terminal MS in Bioengineering is offered via Plan I defined in the Graduate Handbook which requires a thesis and formal coursework as outlined below.

Plan I Requirements:

1. Completion of 20 semester units, eight of which are graded graduate level courses in the major field of study, not including seminars. Of the remaining 12 units, up to three may be individual research, while the remaining must be advanced undergraduate or graduate courses in the major or other fields of study.
2. Completion of a Masters Thesis. The Masters Thesis must be read and approved by at least two Group faculty members who may come from either or both campuses.

1.C.3. Department of Bioengineering and Therapeutic Sciences

This department administers three multidisciplinary PhD programs, including the Graduate Group in Bioengineering, and does not offer an MS degree. Research disciplines for the PhD programs in this department are much broader than the proposed MS in Imaging Sciences. The Department also has a Memorandum of Understanding with the Department of Radiology and Biomedical Imaging which outlines that major Biomedical Imaging related activities are carried out under the auspices of DRBI as home department.

1.C.4. Master of Advanced Study in Clinical Research

Department of Epidemiology and Biostatistics runs an MS program in Clinical Research. This program provides a two-year course of study for advanced pre-doctoral students, post-doctoral fellows, and faculty members. Although this program has a similar target population for the student enrollment, the proposed MS in Imaging Sciences program does not have any overlap with this MS program because of the difference in disciplines.

1.D. Relationship of the Proposed Program with Other UC Institutions

This program will be the only Masters with specific focus on biomedical imaging within the UC system. Of the programs and areas of study at other UC institutions, the following list reflects the most closely related forms of intellectual inquiry to the activities of the proposed MS in Imaging Sciences degree at UCSF.

Other UC Institutions (Berkeley, Davis, Irvine, Los Angeles, Merced, Riverside, San Diego, Santa Barbara, and Santa Cruz) offer traditional Bioengineering, Biomedical Engineering, Biological Sciences, Bioinformatics and/or Electrical Engineering programs. While the proposed coursework and research could fall under the scope of these umbrella programs, these traditional programs are much more broad, often requiring coursework beyond medical imaging and admit students into PhD programs as opposed to the proposed program designed to provide one year of study focused on medical imaging.
UC Berkeley runs a joint PhD program in Bioengineering with UCSF. Berkeley also runs a separate, traditional bioengineering program at an undergraduate level leading to a BS degree. The focused group of faculty with their research emphasis in medical imaging whose main affiliation is the host department of the proposed MS program at UCSF (Radiology and Biomedical Imaging) will have close relationship to the proposed core courses and elective courses.

UC Davis runs a graduate program in Biomedical Engineering. The Davis program currently has active biomedical imaging research components. This program, however, does not provide critical experience necessary to learn practical medical imaging implementations and applications because the Davis Medical Center is not actually in Davis (but in Sacramento). In addition, this traditional MS/PhD program lacks flexibility in course selections and a concentrated master’s coursework in medical imaging as found in the proposed MSIS program.

UC Irvine offers MS/PhD programs in Biomedical Engineering. Imaging is not one of the focus areas for these degrees.

UC Los Angeles offers traditional graduate degrees (MS/PhD) through Biomedical Physics Interdepartmental Graduate Program. In addition, the Biomedical Engineering Interdepartmental Program offers additional graduate degrees. Both programs are broad in their disciplines, and may not be suitable for the target population that the proposed MSIS program would like to attract because these programs are usually a part of, or on the way to, respective PhD programs.

Both interdepartmental programs offer MS degrees with emphasis in medical imaging of various forms (molecular imaging, instrumentation, informatics, etc.). These are the most closely related program in the UC system to the proposed MS in Imaging Sciences. The differences are that the UCLA programs are a traditional MS program, spanning 2 years typically, with 48 credits of coursework and a thesis or comprehensive exam. The proposed program is different in being a MS degree program, with less time and coursework required.

UC Merced runs graduate degree programs (MS and PhD) in Bioengineering through School of Engineering. These degree programs are not yet formed within a home department because of the status of UC Merced as a new campus with new graduate programs. The Merced Bioengineering graduate programs do not have a medical imaging focus yet.

UC Riverside offers MS and PhD programs in Bioengineering and a PhD in Biomedical Sciences. These programs do not offer graduate degrees with emphasis in medical imaging.

UC Santa Cruz runs traditional MS/PhD programs in Bioinformatics and in Electrical Engineering. Neither focus on medical imaging.
UC San Diego offers the MS, MEng, and PhD degrees in Bioengineering and the MS and PhD degrees in the area of Signal and Imaging Processing within the Electrical and Computer Engineering department and a PhD in Bioinformatics. These two programs are traditional bioengineering and electrical engineering graduate programs that do not offer degrees with focus on medical imaging although some specific applications in medical imaging are part of the curriculum.

UC Santa Barbara offers PhD 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 medical imaging from this graduate program at Santa Barbara.

1.E. Administration and Governance of the MS Program

The master’s degree program in Imaging Sciences will be administered through the Department of Radiology and Biomedical Imaging (DRBI) at UCSF. The Department has administrative space and staffing support, shared cubicle workspace for student access to computers, and access to conference and meeting rooms for seminars and classes at China Basin Landing, and at the Mission Bay and Parnassus campuses of UCSF.

The administration of student applications, funding issues, and curricular affairs will be overseen by the staff of the Postgraduate education office in DRBI.

The students’ academic and community affairs will be overseen by the MS Committee, Chaired by the Director of Graduate Studies in Radiology and Biomedical Imaging. The MS Committee will be comprised of a minimum of four faculty with primary appointments or affiliations with Radiology and Biomedical Imaging (see 4.A List of Faculty Members for initial committee structure), with the Chair of DRBI a fifth, ex officio, member. The Chair of the MS Committee will be responsible for committee membership, record keeping, and ensuring proper evaluation of each student’s performance. The Chair of the MS Committee (Director of Graduate Studies in Radiology and Biomedical Imaging) will also ensure that each master’s student is assigned an appropriate mentor as a liaison for curricular or personal concerns.

Membership of the MS Committee shall be reviewed every second year by the Director of Graduate Studies in Radiology and Biomedical Imaging (Chair of the Committee). Inactive members may be removed from the membership by a majority vote of the MS Committee or the Executive Committee of the DRBI. Criteria to be considered when reviewing the faculty membership to the MS Committee shall include:

1. Willingness, expertise and experience in serving on graduate student qualifying exams and/or dissertation committees.
2. Established record of scholarly, peer-reviewed publications.
3. Willingness and expertise to teach at least one course, seminar, or tutorial at the graduate level in Imaging Sciences.
4. Attendance and participation in MS Committee meetings and regular communications.
5. An associate or affiliate in good standing with the DRBI.

The Chair of the MS Committee will report to and liaise with the Executive Committee of DRBI and the Graduate Division.

The MS Committee will oversee the development and implementation of all new master’s degree courses, maintain the coherency of the course catalog and ensure the maintenance of the online course materials and course evaluation procedures.

The MS Committee will also be responsible for overseeing the recruitment, applications, and admissions to the master’s degree program. The Director of Graduate Studies in Biomedical Engineering will be invited to participate in the admissions process.

1.F. Plan for the Evaluation of the Program

Each course taught as part of the MS in Imaging Sciences Program (core and elective courses that count toward the master’s degree) will be evaluated by the students who will fill out a course evaluation questionnaire (see Appendix 1). A longitudinal study will be developed to assess regularly the impact of the MS program on career development, productivity, and placement of graduates. Learning portfolios (“ePortfolio”) will be used to showcase student learning, provide a framework for assessing academic progress, and demonstrate how skills have developed over time.

The Director of Graduate Studies for the MS in Imaging Sciences degree program will be responsible for keeping records and data that will provide the basis for annual reports on the performance of the master’s program presented to the MS Committee. This information will also be used to facilitate an ACADEMIC PROGRAM REVIEW every 5 years coordinated by the Graduate Division and the Graduate Council.

The ACADEMIC PROGRAM REVIEW COMMITTEE will be comprised of a minimum of three experts from outside UCSF who are faculty in existing academic programs in Imaging Sciences, Medical Physics, and/or Bioengineering or any related academic fields that would provide familiarity with current scholarship and professional standards (the list of programs listed in 1.D. above provides a pool of colleagues who could participate in a five-year review).

1.G. Timetable of Development of MS in Imaging Sciences Program

Table 1 shows the proposed timeline to develop the MS in Imaging Sciences from proposal preparation through course development to admission of the first cohort. We estimate approximately one year of proposal refinement until final approval from University of California Office of the President (July 2009 first draft of Full Proposal, Aug 2009 final approval). We plan to advertise the program in the fall of 2010, with an application deadline of Jan 2011. We aim to have the first cohort of MS students admitted in Fall 2011.
Table 1: Proposed timeline of development of MS in Imaging Sciences

<table>
<thead>
<tr>
<th>Date</th>
<th>Proposal status</th>
<th>MS Committee</th>
<th>Faculty/Courses</th>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/09</td>
<td>Submission of Proposed Action to Department Executive Committees</td>
<td>Recruit MS Proposal Committee</td>
<td></td>
<td></td>
</tr>
<tr>
<td>02-06/09</td>
<td>Draft full MS Proposal</td>
<td>Regular meetings of MS committee</td>
<td>Collection of existing course materials</td>
<td></td>
</tr>
<tr>
<td>07/09</td>
<td>Submit draft MS Proposal to Graduate Dean’s Office</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>08/09</td>
<td>Graduate Dean’s Office forwards to Graduate Council</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>01/10</td>
<td>Resubmit any revisions of MS Proposal to Graduate Council</td>
<td>Budget submission</td>
<td>Submit course forms for proposed new courses</td>
<td></td>
</tr>
<tr>
<td>02/10</td>
<td>Submit to Academic Senate</td>
<td>Meetings to coordinate admissions procedures</td>
<td>Development of new courses</td>
<td></td>
</tr>
<tr>
<td>04/10</td>
<td>Submit to Chancellor for approval</td>
<td></td>
<td>Website and e-Portfolio design</td>
<td></td>
</tr>
<tr>
<td>05/10</td>
<td>Submit to Academic Senate Coordinating Committee</td>
<td>iRocket course materials online for core courses</td>
<td></td>
<td></td>
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<tr>
<td>08/10</td>
<td>UCOP approval</td>
<td></td>
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<tr>
<td>08/10</td>
<td>Advertise for 2011/12</td>
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<tr>
<td>09/10</td>
<td></td>
<td>Continued course development; curriculum posted</td>
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<tr>
<td>10/10</td>
<td>Applications open</td>
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<tr>
<td>01/11</td>
<td>Application deadline</td>
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<tr>
<td>01-02/11</td>
<td>Review applications</td>
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<tr>
<td>02/11</td>
<td>Admissions offers</td>
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<tr>
<td>08/11</td>
<td></td>
<td></td>
<td>First cohort admitted</td>
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</tbody>
</table>
SECTION 2: MS PROGRAM IN IMAGING SCIENCE

2.A. Candidates for the Master’s Degree in Imaging Sciences

Medical students at UCSF who pursue the Medical Student’s Option for the MS (see 2.C.6, below), residents and fellows who are permitted time to pursue a professional degree, and professionals who wish to pursue the MS will be considered for admission to the program. A background in the health sciences, clinical or basic science training, will be a prerequisite for admission to the program. Students who graduate with an undergraduate degree in the basic sciences will be considered for admission to the master’s degree program.

Applicants who have been admitted to medical school or a fellowship program can submit their MCAT scores in lieu of GRE scores. Applicants with advanced professional degrees or in advanced degree programs do not need to take the GRE. Applicants to the program with a bachelor’s degree who have not been admitted to, or completed, an advanced degree program can submit either MCAT or GRE scores.

Foreign applicants will be eligible under the same conditions, but they must take the Test of English as a Foreign Language (TOEFL) with a minimum acceptable score of 550 (paper version) or 213 (computer version), or the IELTS exam with a minimum score of 7, or who have demonstrated proficiency in English by completing one year of full-time study with a minimum GPA of 3.2 in an accredited university in the United States.

2.B. Foreign Language

There will be no requirement for any foreign language proficiency in this program. The lingua franca of Imaging Science is English and has been since the inception of the field so there is currently little literature that is pertinent to the field that is not available in English. Virtually all scientific meetings of relevance are conducted in English.

2.C. Program of Study

The MS in Imaging Sciences will conform to the Masters of Science Plan I as outlined by the UCSF Graduate Council Regulations and Procedures.

2.C.1 Unit Requirements

i. Thirty six units are required.
ii. A minimum of twelve units must be taken in graduate (200 series) courses in the major subject. Of these, no more than eight units numbered 250 may be applied toward the degree.
2.C.2 Residency Requirements

Three quarters of academic residence are required for the Master’s degree. A student who wishes a leave of absence must submit a written request to the Director of Graduate Studies of Imaging Sciences for initial approval and then to the graduate dean or departmental chair for final approval. The granting of a leave of absence does not automatically change the time limit for advancement to candidacy or completion of degree.

2.C.3. Advancement to Candidacy

Advancement to Candidacy must take place not later than the first day of the last quarter during which the student will be registered.

i. At least one quarter in registered student status must elapse between advancement to candidacy and conferral of the degree.

ii. Candidacy for the Master’s degree lapses if a student has not completed requirements for the degree within five quarters after advancement to candidacy.

2.C.4. Transfer Credits

Up to six quarter units of credit for work taken elsewhere may be applied towards a master’s degree. For course work completed at another campus of the University of California, up to one-half of the program (15 units) may be accepted for transfer. Otherwise, all course work for the Master’s degree must be done in residence.

i. A student must be registered as a graduate student for at least one quarter before petitioning for transfer of credit.

ii. Units accepted for transfer must have been earned in graduate status.

iii. Students enrolled in an articulated BS-MS program may transfer up to six units of 200 series course work taken during the quarter immediately prior to graduate standing for credit toward the master's degree.

iv. Work that formed part of the program for a degree previously conferred may not be applied toward a current degree program.

v. Courses taken in a university extension division may not be accepted for transfer.

2.C.5. Medical Student’s Option

Pursuant to regulations already approved by the Graduate Council and documented elsewhere, students who hold a bachelor's degree and who are pursuing the M.D. degree in the UCSF School of Medicine may earn a Master's degree under the following conditions, known as the Medical Student's Option:

i. Besides the work for the M.D. degree, 15 units of graduate courses must be completed in addition to the thesis.
ii. Medical students who wish to pursue the Master’s degree must gain admission to the program of their choice and obtain permission of the Associate Dean of the School of Medicine.

2.C.6. Required Courses

All students enrolled for the master’s degree in Imaging Sciences will be required to complete the five-part Core Course in Imaging Sciences (i.e., IS 201 through IS 206). See 2.E below for description of Core Course.

The Imaging Sciences master’s degree program will consist of up to three quarters of didactic instruction and one quarter of independent research experience. MS coursework will consist of elective interdisciplinary courses relevant to the major content areas in addition to a two-part longitudinal core course.

Courses will be selected from an approved catalog of courses for major subject concentration. New course development in the major subject concentration will be reviewed by the MS Committee and follow the New Course proposal procedures (“General Course Form”) for UCSF approval.

   Calculation of Course Units:
   1 unit = 1 lecture hour per week
   1 unit = 3 hours per week of:
   Independent study; Conference; Seminar; Project; Web-Based Course Work
Table 2: MS Goals, Outcomes, Learning Methods, Assessment, Competencies

<table>
<thead>
<tr>
<th>Goals</th>
<th>Outcomes</th>
<th>Learning Methods</th>
<th>Assessment</th>
<th>Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graduates will understand the role of imaging in clinical and research applications, and understand the capabilities and limitations of different modalities.</td>
<td>For each imaging modality graduates will:  - Learn the underlying physical mechanisms used  - Understand determinants of signal strength and image contrast  - Learn the hardware and software requirements  - Learn fundamentals of image data structure, data analysis, and postprocessing</td>
<td>- Lectures reviewing principles and theory  - Small group projects requiring image acquisition  - Small group projects on data analysis and postprocessing  - Individual presentations reviewing current literature</td>
<td>Student assessment is based on:  - Class participation  - Completion of weekly assignments / presentations  - Evaluation of participation in hands-on imaging sessions  - Committee evaluation of presentation at Annual Symposium</td>
<td>Graduates will be able to:  - Demonstrate a critical understanding of primary source material  - Critically analyze imaging requirements in different physiological scenarios  - Demonstrate familiarity with principles and practical components of use of a wide variety of imaging modalities  - Identify research questions, formulate hypotheses, assess evidence, and present evidence using methodologies learned in the course</td>
</tr>
</tbody>
</table>

With our focused MS curriculum, students will gain multiple new perspectives on issues, modalities, and methodologies relevant to imaging studies in research, clinical, and industrial settings. Students will acquire new skills in image acquisition and postprocessing, quantitative and qualitative research, and gain insight into considerations that drive the commercialization of developments in Imaging Sciences.
2.D. Proposed Core Course and Existing Courses to be Cross-Listed

All students enrolled in the master’s degree program in Imaging Sciences will be required to take six Core Courses IS 201 through IS 206 which cover the fundamentals of imaging sciences (Fall, Winter, and Spring quarters), and a certain amount of elective courses as described below.

The master’s degree program is interdisciplinary, and therefore it is appropriate for students to be able to supplement the new “core courses” with existing courses offered through the Bioengineering program. The merits of including these as part of the available options for these students are that they already exist and they provide a useful range of elective course content (which is true for students in any of the degree programs), and it gives students an opportunity to engage with research topics and students coming from slightly different perspectives. It is customary for “core courses” to be distinct to the particular degree program, which is what we have proposed to offer by way of new courses. These have not yet been submitted to the Committee on Courses but are now in development. New elective courses are continually being developed within the other graduate programs and will also be available for Imaging Sciences students.

2.D.1. Proposed Core Courses

All courses that will be offered are described in greater detail in SECTION 5, below. There will be six core courses:

a) IS 201. § Fa. Principles of Magnetic Resonance Imaging (4 units); 4 hours/week lecture;

b) IS 202. § Fa. Principles of X-Ray Imaging and CT (4 units); 4 hours/week lecture;

c) IS 203. § Wi. Principles of Radionuclide Imaging and SPECT/PET (4 units); 4 hours/week lecture;

d) IS 204. § Wi. Introduction to Optical Imaging (3 units); 3 hours/week lecture;

e) IS 205. §Sp. Principles of Ultrasound Imaging (3 units); 3 hours/week lecture;

f) IS 206. §Sp. Research Methodology (3 units); 3 hours/week lecture.

2.D.2 Existing Courses (for Elective Credit) to be Cross-Listed

The following courses offered in Bioengineering will be cross-listed with the MS in Imaging Sciences program as elective options.

a) BioE 240 (cross-listed with IS 201). § Fa. Physics of MRI

c) BioE 230B (cross-listed with IS 203). § Wi. Physics of Medical Imaging (Radionuclide Imaging)

e) BioE 244 (cross-listed with IS 207). § Wi. Image Processing and Analysis.
2.D.3. Proposed New Courses for MS in Imaging Sciences

a) Proposed IS 207. §Wi. Imaging Agents – Radiopharmaceuticals and Contrast Media (4 units). Restrictions: None. Lecture 4 hours/week.
b) Proposed IS 220. § Fa. Introduction to Cancer Imaging (3 units). Restrictions: None. Lecture 3 hours/week.
c) Proposed IS 230. §Sp. Introduction to Vascular Imaging (3 units). Restrictions: None. Lecture 3 hours/week.
d) Proposed IS 240. § Wi. Introduction to Musculoskeletal Imaging (3 units). Restrictions: None. Lecture 3 hours/week.
e) Proposed IS 250. § Fa, Wi, Sp. Supervised Research (4 units). Laboratory (12 hours/week).
h) Proposed IS 280. §Wi. Current Topics in Image Analysis/Data Mining/Biostatistics (2 units). Lecture (1 hour/week). Library (1 hour/week).

Table 3-1: Example Curricular Structure for a MS Candidate (one-year full time program without research)

<table>
<thead>
<tr>
<th>FALL (units)</th>
<th>WINTER (units)</th>
<th>SPRING (units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS 201 (4) [Required]</td>
<td>IS 203 (4) [Required]</td>
<td>IS 205 (3) [Required]</td>
</tr>
<tr>
<td>IS 202 (4) [Required]</td>
<td>IS 204 (3) [Required]</td>
<td>IS 206 (3) [Required]</td>
</tr>
<tr>
<td>Elective (e.g., IS 220 (4))</td>
<td>Elective (e.g., IS 207 (4))</td>
<td>Electives (e.g., IS 230 (3), IS260 (2) &amp; IS 270 (2))</td>
</tr>
<tr>
<td>TOTAL 36 units</td>
<td></td>
<td></td>
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</tbody>
</table>

Table 3-2: Example Curricular Structure for a MS Candidate (one-year full time program with research)

<table>
<thead>
<tr>
<th>FALL (units)</th>
<th>WINTER (units)</th>
<th>SPRING (units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS 201 (4) [Required]</td>
<td>IS 203 (4) [Required]</td>
<td>IS 205 (3) [Required]</td>
</tr>
<tr>
<td>IS 202 (4) [Required]</td>
<td>IS 204 (3) [Required]</td>
<td>IS 206 (3) [Required]</td>
</tr>
<tr>
<td>Elective (e.g., IS 220 (4))</td>
<td>Electives (e.g., IS 240 (3) &amp; IS 280 (2))</td>
<td>IS 250 (4) and Elective (e.g. IS 260)</td>
</tr>
<tr>
<td>TOTAL 36 units</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3-3: Example Curricular Structure for a MS Candidate (two-year part time program without research)

Year 1

<table>
<thead>
<tr>
<th>FALL (units)</th>
<th>WINTER (units)</th>
<th>SPRING (units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS 201 (4)</td>
<td>IS 203 (4)</td>
<td>IS 205 (3)</td>
</tr>
<tr>
<td>[Required]</td>
<td>[Required]</td>
<td>[Required]</td>
</tr>
<tr>
<td>Elective (e.g., IS 230 (3))</td>
<td>Elective (e.g., IS 280 (2))</td>
<td>Elective (e.g., IS 260 (2))</td>
</tr>
</tbody>
</table>

TOTAL 18 units

Year 2

<table>
<thead>
<tr>
<th>FALL (units)</th>
<th>WINTER (units)</th>
<th>SPRING (units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS 202 (4)</td>
<td>IS 204 (3)</td>
<td>IS 206 (3)</td>
</tr>
<tr>
<td>[Required]</td>
<td>[Required]</td>
<td>[Required]</td>
</tr>
<tr>
<td>Elective (e.g., IS 210 (4))</td>
<td>Elective (e.g., IS 240 (3))</td>
<td>Elective (e.g., IS 270 (2))</td>
</tr>
</tbody>
</table>

TOTAL 18 units

Table 3-4: Example Curricular Structure for a MS Candidate (two-year part time program with research)

Year 1

<table>
<thead>
<tr>
<th>FALL (units)</th>
<th>WINTER (units)</th>
<th>SPRING (units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS 201 (4)</td>
<td>IS 203 (4)</td>
<td>IS 205 (3)</td>
</tr>
<tr>
<td>[Required]</td>
<td>[Required]</td>
<td>[Required]</td>
</tr>
<tr>
<td>Elective (e.g., IS 250 (4))</td>
<td>Elective (e.g., IS 240 (4))</td>
<td></td>
</tr>
</tbody>
</table>

TOTAL 19 units

Year 2

<table>
<thead>
<tr>
<th>FALL (units)</th>
<th>WINTER (units)</th>
<th>SPRING (units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS 202 (4)</td>
<td>IS 204 (3)</td>
<td>IS 206 (3)</td>
</tr>
<tr>
<td>[Required]</td>
<td>[Required]</td>
<td>[Required]</td>
</tr>
<tr>
<td>Elective (e.g., IS 230 (3))</td>
<td>IS 250 (4)</td>
<td></td>
</tr>
</tbody>
</table>

TOTAL 17 units

In the above illustration, the six required courses (IS 201 through 206) are scheduled over three quarters, for 19 units. Supervised research is an option for MS candidates who elect to take the research option as the final requirement for the degree. The courses are spread so that either one-year full-time students or two-year part-time students can take required courses and selected electives to fulfill 36-unit requirement for the MS degree.
The following courses are offered in each quarter:

**Fall:** IS 201, IS 202, IS 210, IS 220, IS 230, IS 250  
**Winter:** IS 203, IS 204, IS 207, IS 240, IS 250, IS 280  
**Spring:** IS 205, IS 206, IS 230, IS 250, IS 260, IS 270

2.D.4. Grading

Letter grades will be assigned for the Core Courses and for any elective courses according to how the course was approved by UCSF academic senate committee, in accordance with Graduate Division requirements for a specified number of courses needing such grades. Supervised Research credits and Seminar credits will be issued on a S/U basis.

Graduate students must maintain a cumulative grade point average of 3.0 or better and must make satisfactory progress toward the requirements of the degree program. Students who fail to maintain a 3.0 GPA or fail to make satisfactory progress toward the degree are subject to dismissal by the Graduate Division Dean after consultation with the MS Committee and the Director of Graduate Studies.

The graduate program will establish a regular mechanism for reviewing students’ satisfactory progress toward the degree. Completion of specific program requirements will be documented and maintained in the graduate program’s student files. Any deficiency or failure to meet the standards of the program should be discussed with the student and confirmed in writing.

2.E. Research

As the Core Courses for Imaging Sciences demonstrate, the theoretical framework and methodological approaches to investigating these subjects are interdisciplinary. It is anticipated that a high percentage of the students will not have previous training in biomedical imaging research, though it is anticipated that many will have training in medicine, basic science, health policy and/or epidemiology. The acquisition of skills to identify appropriate imaging modality for disease detection, imaging probe design, imaging assisted drug development, image reconstructions and analyses and present a written argument according to scholarly conventions defined in the basic and clinical science is a major outcome of this MS program. Therefore, much emphasis is placed on techniques and procedures for acquiring these skills, both through core courses, electives, and hands-on research.

The capstone for the course will be a final project. The rigor of the projects will be similar for all students but the format will differ depending on the student’s background and the amount of hands-on research they are able to accomplish during the course year. The particular kind of research project a student may wish to pursue can vary. Some projects may be more oriented toward imaging hardware or software, but some may focus on chemistry or biology of imaging agents and their interaction with disease targets.
Students may choose an appropriate research project under the supervision of participating investigators. Examples of project formats are:

- a review article on a particular topic that is suitable for publication
- a grant proposal based on preliminary data obtained during the course
- a journal article suitable for publication
- an invention disclosure describing the design of imaging hardware or software

Although the projects will be formatted in a practical manner for communication to the scientific community, formal submissions of the work will not be required for acceptance by the MSIS graduate committee.

2.F. Symposium and Presentation

At the end of the academic year, each MS candidate who elected to choose a research option will present a final paper (20 minute oral presentation, followed by 15 minute Q&A) at a day-long Medical Imaging Science Research Symposium, sponsored by the Department of Radiology and Biomedical Imaging. This event acts as a mechanism to gauge students’ understanding of the research topic and their ability to present their original research with a scientifically sound rationale and in a logical manner.

2.G. Normative Time from Matriculation to Degree

The time from Matriculation to degree for full-time students will be one year. Generally, students will complete all course unit requirements by the end of the spring quarter. The degree will be awarded only after successful completion of the coursework (full unit requirements) and acceptance of the final project. The final project should be undertaken after consultation and following approval by the MSIS Committee, or a designated academic advisor appointed by the MSIS Committee prior to the spring quarter. For the two-year part-time students, this final project should be initiated prior to the spring quarter of the second year. This is a rigorous master’s degree program, but not so difficult as to be overly challenging to complete in a single year of full-time study.

SECTION 3: PROJECTED NEED

3.A. Student Demand for the Program

As suggested in sections 1.B.1 and 1.B.2 above, the interdisciplinary academic field of Medical Imaging has rapidly emerged as a vibrant field over the last twenty years. Growth is indicated institutionally, marked by increasing academic undergraduate and graduate degree programs across the country (including UCLA, UC Berkeley, UC Davis, Stanford, Washington University St. Louis, Harvard/Mass General Hospital, Duke, Wisconsin, University of Washington, Johns Hopkins, etc.), by growth in membership to its scholarly societies and the establishment of two new societies this decade (particularly SNM – Society of Nuclear Medicine, International Society for Magnetic Resonance in Medicine – ISMRM, Academy of Molecular Imaging – est. ~2000 and the Society of
Molecular Imaging – est. ~ 2000), and publication in its specialized journals (Journal of Nuclear Medicine, Molecular Imaging, Molecular Imaging and Biology, Magnetic Resonance in Medicine and Journal of Magnetic Resonance Imaging). Additionally, a growing number of biotechnology companies, small drug companies and large pharmaceutical companies (Merck, Lilly, Pfizer, etc.) have purchased imaging devices for preclinical drug development or have incorporated imaging applications into their core drug development schema.

Several major imaging centers have been established over the last decade that offer access to multiple imaging modalities including UCSF and many of those listed above. While these centers are offering undergraduate courses and increasing numbers of graduate degree programs, typically related to a specific imaging modalities, probe/contrast agent development, medical physics, instrumentation development or clinical research, there are no known didactic/practical master’s programs specializing in imaging science in the United States. At least two programs are known in the UK (MSc Quantitative Cell and Molecular Imaging – University of Edinburgh) and Europe (European Master in Molecular Imaging program) The proposed master’s degree program at UCSF may be the first such formal Imaging Science course of study in the US.

Our target enrollees, outlined above (1.A), include medical students, residents and fellows interested in pursuing a master’s option and who wish to expand their research skills, pre-doctoral graduate students who wish to earn an Imaging Sciences Master’s degree prior to pursuing a Ph.D, post-baccalaureate students who wish to earn only a Masters’ degree, post-baccalaureate students and post-graduates who are currently working in the biotechnology or pharmaceutical industry requiring training to meet job expectations, and foreign students from countries where imaging programs are just emerging (Asia, India, South America, etc.). Many students enter medical school with backgrounds in a variety of non-physical science disciplines and are eager to have the opportunity to pursue a higher level of training in the field, but who are not intending to commit to a PhD program.

The existing Radiology and Bioengineering programs at UCSF provide the impetus for the establishment of this MSIS program. There are a few courses that already exist as part of the bioengineering curriculum that provide the foundation for the development of the Imaging Sciences curriculum.

In order to confirm if other Masters’ programs in Imaging Sciences or Molecular Imaging existed in the US as well as seek feedback on the concept and gauge the potential interest in graduates from this program we performed an informal survey of our colleagues in imaging programs at several academic institutions. No programs were identified with the specific purpose of providing a Masters degree. There are graduate programs in Medical Physics, generally with an emphasis on radiation planning, and engineering programs where imaging science courses are included as part of the curriculum. However, these programs do not offer a targeted Masters degree. A discussion of the opportunities for graduates of the UCSF MSIS program is provided in the following sections.
In summary, we have identified a broader range of potential applicants to this program, beyond the UCSF graduate and medical student body and anticipate up to a minimum of 10 students per year in course attendance (see section 6A). There may be some synergy with the UCSF “Pathways to Discovery” program in the areas of Clinical Translation or Molecular Medicine. The didactic/practical training provided as part of the Masters’ program may be attractive to the medical students in these courses of study. Undergraduate programs at universities throughout California (UCLA, UC Davis, UC Berkeley, etc), the United States (Washington University, Duke, Wisconsin, Harvard-MIT, Johns Hopkins, etc), pharmaceutical and biotech companies in the Bay Area and beyond (Genentech, Bayer Schering Pharmaceuticals, Amgen, Roche, Varian Biosynergy, etc) as well as emerging programs in foreign countries (Asia, India and South America, etc) define the pool of potential candidates for this program.

3.B. Opportunities for Placement of Graduates

Imaging science is a rapidly growing field of study with research opportunities ranging from basic science to clinical translational studies. Practical applications of the technological developments that have emerged over the last decade or two are being employed to develop new drugs and support the movement towards personalized medical care. There are many career paths emerging for individuals trained in Imaging Sciences, including director/coordinators of imaging facilities at academic and industrial institutions, research assistants in imaging laboratories, clinical study coordinators as well as opportunities in the State and Federal regulatory bodies such as the FDA.

We envision that the master’s program will provide essential training for students who wish to pursue PhD level research in Chemistry (contrast agent development), Physics (instrumentation development), Medical Physics, Bioengineering or one of the PhD programs offered in imaging programs elsewhere. However, not every student will intend to pursue a PhD, nor will every student wish this to provide a springboard to an academic career in this specified field. We envision a number of students with primary training in medicine or science who wish to expand the scope of their analytical skills and knowledge of Imaging Sciences to enhance their investigations and work in their primary professional field.

The placement depends on the student, and as stated above there is reason to believe that we will admit other than medical students. Graduates may go on to pursue a PhD in one of a number of PhD programs, with ultimate placement in an academic department or a pharmaceutical, biotechnology or technology (instrumentation) development company. There may be candidates who already are working in a corporate position with the desire or need to receive training that will enhance job performance. This program will provide the skills and knowledge that will allow the graduates to design and implement new research projects, apply for research funding and to implement new translation imaging paradigms to address delivery and efficacy of new therapeutics. The “value added” applies to all students, not only medical students. This program cultivates critical thinking on the infusion of imaging technologies to address intractable medical problems and the implementation of personalized medicine.
3.C. Importance and Impact of the MS in Imaging Sciences

The rapid expansion of Imaging Sciences over the past decade has created shortages of trained professionals to fill the positions available in academic institutions. The added application of molecular imaging in the pharmaceutical and biotechnology industry has placed even more pressure on the limited number of training programs to increase the numbers of trained professionals to meet the demand. The increased demand has created positions for trained post-Baccalaureate and Masters’ degree candidates. Additionally, MD candidates may wish to augment their medical school training with specialized training in Imaging Sciences that will create opportunities for future translational research in academia or the corporate sectors. These candidates may additionally benefit professionally from the Master’s in Imaging Sciences and be more marketable or enhance their current position. This specialized training will produce professionals that will have the skills and knowledge to immediately apply to their research and development efforts.

With the exception of two programs in Europe there are no Masters’ programs in Imaging Sciences. Therefore, establishment of a UCSF based program offering access to graduate students, medical students and pharmaceutical/ biotech scientists would have significant impact on the dearth of trained scientists. The Master’s program would also provide broad-based training with introduction of all students to the breadth of the field. This would be a perfect portal for students desiring to pursue a PhD as their ultimate goal as their thesis will more than likely be multimodality and multidisciplinary. The consensus from a poll of colleagues in the field is that this MSIS program is needed, would be welcome, and provide a means of increasing the numbers of competent individuals who will bear the torch of future imaging research and applications.

3.D Ways in which the program will meet the needs of society.

Students who receive an MS in Imaging Science will be knowledgeable and skilled in the safe and effective use of the broad range of imaging modalities that are routinely, and increasingly, used in the delivery of health care to the broad population in the United States and throughout the world. They will contribute to the ability to deliver safer, more reliable, and more cost effective methods of imaging diagnostics to evaluate health, disease, and efficacy of pharmacologic and interventional therapies. Not only will they understand the implementation of the most sophisticated imaging modalities, they will also understand when cheaper and more practical diagnostic systems should be implemented to meet the needs of the global community.

3.E Relationship of the program to research and/or professional interests of the faculty.

The MS in Imaging Science proposes a course of study that would train students in many of the approaches, tools, and methodology that are routinely used by faculty in the DRBI.
**3.F Program Differentiation.**

To our knowledge, there is no similar program on any of the campuses of the UC system.

**SECTION 4: LIST OF CORE FACULTY MEMBERS, RANKS AND HIGHEST DEGREES**

The following is a list of UCSF faculty members (in alphabetical order) who currently teach and/or mentor students in a related Department and degree program and who have agreed to contribute to the proposed master’s degree program as core faculty and committee members.

**Yanjun Fu, PhD, Course Instructor**  
Assistant Research Scientist in Radiology and Biomedical Imaging

Dr. Fu received his PhD from Wuhan University, China, in the field of Organic and Polymer Chemistry. His work has been focused on the field of Contrast Media research and molecular imaging. He has teaching experience on polymer chemistry and molecular imaging (particularly molecular design, synthesis and characterization of imaging contrast agents/probes) for graduates in the joint Bioengineering program between UCSF and UC Berkeley (as one of the instructors in 2008). He also has enthusiastically involved in informal laboratory teaching on chemistry for research fellows/postdocs, technologist staff and medical students in the contrast media lab at UCSF Radiology department.

**Ella Fung Jones, PhD, Faculty Mentor and Course Instructor**  
Adjunct Assistant Professor in Radiology and Biomedical Imaging

Dr. Jones obtained her PhD in Chemistry from University of California at Davis and completed two years of post-doctoral training at the Oxford University in UK. She has over 15 years of research experience in cancer imaging. At UCSF, Dr. Jones is a NIH funded Principal Investigator researching molecularly targeted probes to delineate diseases using nuclear and optical imaging. Dr. Jones teaches the chemistry and biology aspects of molecular imaging to graduate students and radiology residents. She currently serves as the Director of Preclinical Optical Imaging Laboratory at the Center for Molecular and Functional Imaging in the Department of Radiology. Dr. Jones will develop the new course IS 204 “Introduction to Optical Imaging”. She will also participate in IS 260, “Current Topics in Molecular Imaging”

**Jiang He, PhD, Course Instructor**  
Assistant Adjunct Professor of Radiology
Dr. He obtained a PhD in radiopharmaceutical chemistry from Peking University. He has been actively participating in teaching and mentoring students, postdoctoral fellows, research staff and junior faculty members in different settings by providing technical expertise and career development advice in molecular imaging and radiopharmaceutical research. He served as a counselor for students and postdoctoral fellows who were just starting their post-graduate careers in imaging science as well as for postdoctoral fellows and junior faculty member with many years experience in other fields who are interested in transitioning into imaging research. He has taught lectures in imaging probe development for medical residents and PhD students in the UCSF/UC Berkeley joint bioengineering program.

Roland Henry, PhD, Course Instructor  
Associate Professor in Residence Radiology and Biomedical Imaging.

Dr. Henry has been a member of the Bioengineering Graduate Group for a number of years, and teaches the graduate level course in Magnetic Resonance Imaging. His research involves quantitative MRI measurements in the brain. These new and exciting techniques yield physiological information about normal and diseased brain. His focus is on the improvement and development of these techniques in order to understand the relevance of these measures and their potential for tissue characterization. In particular his group has been working on developing diffusion MRI techniques. Diffusion MRI is the only technique that can delineate white matter pathways in the brain. This relatively new technique is growing rapidly in its scope of application and utility in neurological studies.

Thomas Lang, PhD, Course Instructor  
Professor in Residence,  Department of Radiology and Biomedical Imaging

Thomas Lang, Ph.D., is a Professor in Residence in the UCSF Department of Radiology and the UCSF/UC Berkeley Joint Bioengineering Graduate Group, and the course instructor for a graduate level course in x-ray based imaging techniques. He received his B.A. in Chemistry from the University of Chicago in 1983 and a Ph.D. in Chemistry from UC Berkeley in 1990. After completing a postdoctoral fellowship with Professor Bruce Hasegawa in the UCSF Department of Radiology, Dr. Lang worked as a Nuclear Medicine Physicist at ADAC Laboratories in Milpitas, Calif. Dr. Lang joined the UCSF faculty as an Assistant Adjunct Professor in 1994. As a faculty member at UCSF, Dr. Lang's core interest is the use of quantitative computed technology and other clinically available imaging modalities in the study of human musculoskeletal biology. His group is currently funded by the National Institutes of Health, National Space Biomedical Research Institute and pharmaceutical industry. In addition to his position at UCSF, he is also Leader of the Musculoskeletal Alterations Team at the National Space Biomedical Research Institute, where he coordinates a research team comprising investigators from eight institutions.

Sharmila Majumdar, PhD, Faculty Mentor and Course Instructor  
Professor in Residence in Radiology and Biomedical Imaging with appointments in the
Tracy Richmond McKnight, PhD, Faculty Mentor and Course Instructor
Associate Professor in Residence in Radiology and Biomedical Imaging

She received her PhD in Biomedical Engineering from the University of California, Davis. She is currently an Associate Professor in the Department of Radiology and Biomedical Imaging and her research focus is magnetic resonance imaging and spectroscopy of brain tumors. Dr. McKnight is a member of the UCSF Brain Tumor Research Center, the UCSF Helen Diller Cancer Center, and the UCSF/UCB Joint Bioengineering Graduate Group. She is also actively involved in mentoring and advising students interested in science, particularly students that are underrepresented in the science and medical fields. In addition to teaching a Bioengineering course in Biomedical Image Processing and Analysis, she also sits on several UCSF committees that provide research opportunities for pre- and post-doctoral trainees.

Srikantan Nagarajan, PhD, Course Instructor
Professor in Residence of Radiology and Biomedical Imaging at the University of California San Francisco (UCSF)

Dr. Srikantan Nagarajan obtained his MS and PhD in Biomedical Engineering from Case Western Reserve University and a postdoctoral fellowship at the Keck Center for Integrative Neuroscience at the University of California, San Francisco (UCSF). Currently, he is a Professor in the Department of Radiology and Biomedical Imaging at UCSF, and a faculty member in the UCSF/UCB Joint Graduate Program in
Bioengineering. His research interests in the areas of Neural Engineering are to better understand brain dynamics in health and disease and its relationship to behavior, through the development of algorithms and tools for improved functional brain imaging and biomedical signal processing. His neuroscience interests include understanding neural mechanisms of brain plasticity associated with sensorimotor learning and of the role of sensory feedback in speech motor control.

Susan Noworolski, PhD, Faculty Mentor and Course Instructor
Assistant Adjunct Professor in Radiology and Biomedical Imaging
Affiliate Faculty Member, UCSF/UCB Joint Graduate Group in Bioengineering

Dr. Noworolski received her PhD from the Joint Graduate Group in Bioengineering from UC Berkeley and UC San Francisco. She has taught magnetic resonance imaging for the past thirteen years. She has organized the MR Discussion Series, the Seminars for Summer Students Series, and Cell Biology for Non-biologists all taught within the Department of Radiology and Biomedical Imaging Department. In addition to lecturing in these courses, she has lectured in a number of other MR courses at UCSF, UC Berkeley and SF State. Dr. Noworolski is also involved in science education from preschool to high school and beyond through her outreach programs and as part of the UCSF/San Francisco public schools’ Science Education Partnership, the Take our Daughters and Sons to Work Days and as chair of a Science Night at a local public elementary school. For the Masters in Medical Imaging Program, Dr. Noworolski will develop the new course IS 220 called “Introduction to Cancer Imaging” with an emphasis on magnetic resonance imaging in cancer detection, treatment planning, and evaluation of therapy.

David Saloner, PhD, Faculty Mentor and Course Instructor
Professor in Residence of Radiology and Biomedical Imaging with a joint appointment in the Department of Surgery, and is an Affiliate Faculty Member, UCSF/UCB Joint Graduate Group in Bioengineering

Dr. Saloner received his PhD in Nuclear Physics from the University of Heidelberg. Over the past 20 years, he has provided instruction on physical principles of medical imaging. He is Co-Director of the Departmental Neurovascular Research Interest Group. He chairs the Departmental Committee on Seminars and Presentations. He has taught a course on Imaging and Image Processing Techniques at UC Berkeley, and a course on Advanced Cardiovascular Imaging at UCSF. He provides regular instruction to residents and fellows on the principles of Medical Imaging. He has served on the Academic Senate Graduate Council and on the Academic Senate Committee on Research. His research interests are in the area of vascular disease, including atherosclerosis, aneurysmal disease, cardiovascular disorders, and hemodynamics. Dr. Saloner will develop the new course IS 230 “Introduction to Vascular Imaging” which will provide an overview of multi-modality imaging of vascular disease. He will also provide supervision for IS 250, “Supervised Research” and will participate in IS 270, “Current Topics in Cancer/Neuro/Vascular Imaging”
**Youngho Seo, PhD**, Faculty Mentor and Course Instructor  
Assistant Adjunct Professor, Department of Radiology and Biomedical Imaging; Faculty Member, UCSF/UCB Joint Graduate Group in Bioengineering

Dr. Seo obtained a PhD in Astroparticle Physics from UCLA. After his doctorate work and one year of postdoctoral training at UCLA, he came to UCSF to concentrate his efforts on research in the development of quantitative nuclear medicine imaging techniques. He teaches nuclear medicine physics to graduate students and both diagnostic radiology and nuclear medicine residents. He has once served the Faculty Council of School of Medicine at UCSF. He currently serves as a Group Leader to the renowned UCSF Physics Research Laboratory, a large group of nuclear medicine physics researchers at the Center for Molecular and Functional Imaging. Dr. Seo's main research interest in developing hardware and software to perform quantitative dynamic PET/CT and SPECT/CT imaging studies for cardiovascular and oncological applications in both human subjects and laboratory animals.  

**Colin Studholme, PhD**, Course Instructor  
Associate Professor in Residence of Radiology and Biomedical Imaging at the University of California San Francisco (UCSF)  

Dr. Studholme’s research interests are in the area of computational imaging methods which bridge the gap between in-vivo brain imaging and the areas of neuroscience and clinical research. His current work focuses on developing and applying novel methodology to study variations and changes in brain anatomy at a macroscopic level from human imaging data. At the most basic level he is seeking to develop physically meaningful mathematical representations of brain structure which capture properties useful in clinical diagnosis, progression monitoring and fundamental neuroscience. Such work falls under the emerging field of computational anatomy.

**Henry F. VanBrocklin, PhD**, Course Instructor  
Professor in Residence of Radiology and Biomedical Imaging at the University of California San Francisco (UCSF)  

Dr. VanBrocklin received his Ph.D. in Radiopharmaceutical Chemistry in 1990 from Washington University St. Louis. In 1992, following a DOE sponsored Alexander Hollander Postdoctoral Fellowship at the University of Illinois, Dr. VanBrocklin moved to Lawrence Berkeley National Laboratory where he was a Staff Scientist and Radiopharmaceutical Chemistry Group Leader in the Department of Functional Imaging for 13 years. He is currently Director of Radiopharmaceutical Research in the Center for Molecular and Functional Imaging (cmfi.ucsf.edu). His research in the field spans many disciplines from short-lived radioisotope production to the creation of fluorine-18 and carbon-11 labeling chemistry strategies for new radiotracer preparation and their application. Current interests include development of radiopharmaceutical probes for PET and SPECT cancer imaging, blood flow measurement and translational applications.
in drug development. Dr. VanBrooklin will participate in the new course IS 207 “Imaging Agents – Radiopharmaceuticals and Contrast Media” which will provide an overview of the use of contrast agents with different modalities. He will also participate in IS 260, “Current Topics in Molecular Imaging”

SECTION 5: COURSES

5. A Proposed Core Courses

a) IS 201. § Fa. Principles of Magnetic Resonance Imaging (4 units); 4 hours/week lecture.
Roland Henry (Cross-listed BioE240)
This course is designed to provide the basic knowledge base to understand the physical principles of magnetic resonance imaging. Through “real” examples of how MRI is used in medical diagnosis and disease management, we will combine physical science and mathematical foundations of MRI with practical applications for thorough understanding of the principles of MRI. We will emphasize how MRI and various MR-based imaging techniques have become so useful in everyday medicine.

b) IS 202. § Fa. Principles of X-Ray Imaging and CT (4 units); 4 hours/week lecture.
T. Lang (Cross listed BioE230A)
This course is designed to provide the basic knowledge base to understand the physical principles of x-ray imaging and x-ray computed tomography (CT). Through “real” examples of how radiography and x-ray CT are used in medical diagnosis and disease management, we will combine physical and mathematical foundations of x-ray imaging with actual applications for thorough understanding of the principles of these imaging techniques. In this course, we will also describe principles of x-ray based screening imaging examinations such as mammography for breast cancer screening.

c) IS 203. § Wi. Principles of Radionuclide Imaging and SPECT/PET (4 units); 4 hours/week lecture.
Y. Seo (Cross listed BioE 230B)
Radionuclide imaging namely planar scintigraphy and radionuclide computed tomography methods such as single photon emission computed tomography (SPECT) and positron emission tomography (PET) are discussed in this course. Principles and developments of advanced SPECT and PET imaging technologies will be emphasized. In addition, introduction to basic applications of functional and physiological imaging using SPECT and PET and radiopharmaceuticals will be presented in this course.

d) IS 204. § Wi. Introduction to Optical Imaging (3 units); 3 hours/week lecture.
E. Jones (Cross-listed BioE 230C)
Optical imaging techniques, particularly using bioluminescence and fluorescence signals are important imaging tools in biomedical research. We will introduce concepts and basic principles of optical imaging for laboratory biomedical research and its potential in clinical translations. Molecular imaging based on optical imaging techniques is also a focus on this course.

e) IS 205. §Sp. Principles of Ultrasound Imaging (3 units); 3 hours/week lecture.
David Saloner
Ultrasound imaging is one of major everyday imaging procedures in medical practices. In this course, we will provide the fundamental knowledge base to understanding of ultrasound imaging techniques. Physics of ultrasound imaging, and advanced high-frequency ultrasound techniques will be described. Ultrasound contrast enhancement media such as microbubbles are of important topics in this course.

f) IS 206. §Sp. Research Methodology (3 units); 3 hours/week lecture.
Program Faculty
Study design, data analysis, manuscript preparation, including the outline for a viable imaging research project to be presented at the end-of-year symposium. Options for this research project could be: design of a grant proposal including hypotheses, specific aims, and description of imaging methods; description of a proposal to commercialize new imaging instrumentation with consideration of patent and licensing issues; or detailed description of all the elements required in conducting an imaging trial including regulatory body approvals.

5.B Existing Courses (for Core or Elective Credit) to be Cross-Listed

The following is a list of courses currently on offer under the aegis of a PhD program (UCSF/UCB Joint Graduate Group in Bioengineering) that will be cross-listed with the MS in Imaging Sciences program as core or elective.

f) BioE 240 (cross-listed with IS 201). Physics of MRI § Fa. Additional 1 hour/week will be required through an arrangement with the instructor for the 4-unit equivalency with IS 201.
R. Henry
This Bioengineering graduate course discusses physical foundations of nuclear magnetic resonance imaging.

g) BioE 230A (cross-listed with IS 202). Physics of Medical Imaging (X-Ray Imaging) § Fa. Additional 1 hour/week will be required through an arrangement with the instructor for the 4-unit equivalency with IS 202.
T. Lang
This Bioengineering graduate course provides the basic knowledge base of x-ray imaging and computed tomography techniques in biomedical research.

h) BioE 230B (cross-listed with IS 203). Physics of Medical Imaging (Radionuclide Imaging) § Wi. Additional 1 hour/week will be required through an arrangement with the instructor for the 4-unit equivalency with IS 203.
Y. Seo
This Bioengineering graduate course provides the basic knowledge base of physics in radionuclide imaging with a special focus on single photon emission computed tomography and positron emission tomography imaging techniques.
i) BioE 230C (cross-listed with IS 204). Introduction to Molecular Imaging. § Sp. Additional 1 hour/week will be required through an arrangement with the instructor for the 4-unit equivalency with IS 204.
E. Jones
This Bioengineering graduate course introduces molecular imaging in the context of imaging techniques such as optical imaging and radionuclide imaging with a special focus on small animal imaging applications.

j) BioE 244 (cross-listed with IS 207). Image Processing and Analysis. § Wi. Additional 1 hour/week will be required through arrangement with the instructor for the 4-unit equivalency with IS 207.
T. McKnight
This Bioengineering graduate course provides overview on digital biomedical imaging basics and the use of programming tools such as MATLAB to manipulate and analyze imaging data. Basics of image enhancement, restoration, filtering, segmentation, image object classification, and image registration will be introduced.

k) BioE 245 (cross-listed with IS 210). Electromagnetic Neuroimaging. § Fa, Wi, Sp. Additional 1 hour/week will be required through arrangement with the instructor for the 4-unit equivalency with IS 210.
S. Nagarajan
This Bioengineering course provides a mathematically rigorous introduction to human electromagnetic neuroimaging using electroencephalography (EEG) and magnetoencephalography (MEG). Topics include neuronal sources of EEG/MEG signals, electric head modeling, data acquisition, dynamical analysis and techniques for solving the ill-posed inverse problem.

5.C Proposed New Elective Courses for MS in Imaging Sciences

H. VanBrocklin/Y. Fu
This course introduces principles of developing radiopharmaceuticals for radionuclide imaging and contrast media for enhancing CT and MRI imaging.

m) Proposed IS 220. § Fa. Introduction to Cancer Imaging (4 units). Restrictions: None. Lecture 4 hours/week.
S. Noworolski
This course will introduce various imaging techniques in cancer research. Topics will include magnetic resonance imaging techniques in cancer detection and therapy monitoring, and other imaging modalities that are being utilized in cancer management.

D. Saloner
This course will describe physical principles of cardiovascular and cerebrovascular imaging using magnetic resonance imaging and computed tomography. Special topics can include vascular imaging techniques using radiopharmaceuticals.

o) Proposed IS 240. Introduction to Musculoskeletal Imaging (4 units). § Wi.
Restrictions: None. Lecture 4 hours/week.
S. Majumdar/X. Li
This course will elaborate imaging techniques in musculoskeletal research. Topics will include quantitative MR, CT, and SPECT/PET imaging methods in musculoskeletal investigations.

p) Proposed IS 250. § Fa, Wi, Sp. Supervised Research (4 units). Laboratory (12 hours/week).

E. Jones/J. He
This course is a weekly seminar series with speakers to present current topics in molecular imaging research. Registered students will be required to provide seminar review reports after literature search using the library resources after each presentation.

Y. Seo
This course is a weekly seminar series with speakers to present current topics in cancer, neuro, or vascular imaging research. Registered students will be required to provide seminar review reports after literature search using the library resources after each presentation.

s) Proposed IS 280. §Sp. Current Topics in Image Analysis/Data Mining/Biostatistics (2 units). Lecture (1 hour/week). Library (1 hour/week).
C. Studholme
This course is a weekly seminar series with speakers to present current topics in image analysis, data mining, and biostatistics. Registered students will be required to provide seminar review reports after literature search using the library resources after each presentation.

SECTION 6: RESOURCE REQUIREMENTS

6.A. Faculty and Staff Support

The Department has an administrative infrastructure that supports teaching programs for residents and for CME credit. There is also a comprehensive administrative program for visiting students, fellow, and postdocs, both from within the US and from abroad. In addition, there is an extensive administrative and financial office that provides support for all grant applications and other financial issues. While use of the existing
infrastructure will be available during the start-up period, it is planned that all administrative functions for the MS in Imaging Sciences will be supported by the MS program itself.

A Director of Graduate Studies for the MS in Imaging Sciences will be appointed to administer the program and will provide 10% effort to these duties.

The Program will provide support for instructors to teach the five required core courses and the elective courses. In total these courses will provide 36 units of instruction per year. Support is budgeted at approximately 10% annual effort to teach one 4 unit course during one quarter term. The total support for all instruction is therefore equivalent to 90% of an FTE.

We also budget for 100% effort for an administrative assistant II to support duties related to the management of the MS program. The Chair of DRBI has allocated a percentage of staff resources to support the administration of student affairs within DRBI for the start-up of the program. While one FTE will be supported by the program, it is anticipated that a pooling of administrative resources will occur within the Department in future years. This will permit, e.g., administration of applications from foreign applicants, which requires specialized knowledge, using the extensive experience that already exists within the Department for foreign students issues, such as visas, fees, etc. The MS program will then pick up a portion of that AA’s support with a commensurate transfer of effort of the program AA.

6.B. UCSF Program Costs for Self-Supporting Programs

6.B.1 Library Acquisitions

There will be no additional costs for library acquisitions, as the books and journals necessary for the graduate program are already available in the library or on-line.

6.B.2 Computing and Imaging Equipment Costs

DRBI has allocated access to computers within the Department in the research offices at China Basin Landing. These desktop computers are maintained by IT staff on a Departmental contract.

6.B.3 Equipment

Expenses are budgeted for the use of Radiological imaging equipment, including MRI, CT, Ultrasound, MEG, PET, SPECT, and small animal imaging equipment. Hands-on instruction on the use of this equipment is an essential component in this MS program. Each imaging resource is managed by a recharge operation at a rate that must conform with federal guidelines. That rate is the same as that charged to research users and is substantially less than charges associated with the use of equivalent clinical equipment owned by the hospital. Imaging sessions will be conducted in small groups (generally 3
students per session) to maximize practical learning opportunities while keeping costs manageable.

6.B.4 Space and Other Capital Facilities
Cubicle space for each of the students in the MS program will be provided using the usual rental agreement for such space in the research space at China Basin Landing. There are also other resources that are available for use by the MS program, including conference rooms, videoconferencing, and teleconferencing on an occasional basis. Classrooms are booked through the DRBI staff at no cost for rooms at China Basin Landing for seminar and class meetings.

6.C Method of Funding: Tuition and Fees
Projected Income (Scenario with ten students registered in MS program):

The chart on the following page provides budget information and is structured on the template provided by the UCSF Budget Office.

“Faculty salaries”: This line accounts for 10% effort for the MS Program Director and for the equivalent of 80% effort to support instructors. All the instructors combined will provide 36 units of courses. This is calculated based on an estimated 9% effort per calendar year to an instructor to teach one 4 unit course in this MS program (in other words, this does not pay for an instructor’s effort to teach an already existing elective course in another program which will be open for enrolment to these MS students). For all instructors together this amounts to approximately 80% effort per calendar year.

“Staff salaries”: This line budgets for an administrative assistant II to manage all program-related matters for the 10 students enrolled.

Sundry Expenses are detailed: This figure reflects anticipated costs for computer support, office supplies, space costs, and imaging equipment costs.

“Projected Revenue”: We have indicated above that we expect to enroll ten students a year to complete this one-year master’s program. We have set student fees at $30,966 per year for full-time study. Students may choose to spread the course load over two years and would pay an additional $5,743 to cover the costs of annual fees for items such as Health services and Milberry Union and Library rights, however that will be revenue neutral to the program. This program is intended to be entirely self supporting. Offerings and enrollment will be modified/limited if we do not meet projected revenues.

“Student and Other Central Services”, “Direct Services”, and “Other Direct Services”: The total amount of student service costs are estimates automatically generated by the Budget Office template and represent recharges from tuition income administered by UCSF Student Academic Affairs for master degree programs. All graduate students will be provided with a comprehensive health plan and other benefits in accordance with UCSF Graduate Division policies, paid for through the student service costs recharged to and administered by Student Academic Affairs.
### UCSF Cost of Education Model
Self-supporting Degree Programs

Program: MS in Imaging Science  
Department: Radiology and Biomedical Imaging

#### Projected FY 2010-11 Budget

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Number of Students (First year)</td>
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<td>10</td>
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<tr>
<td>Number of Students (Second year)</td>
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<tr>
<td>Total Enrollment</td>
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<td>Annual Fee Level (First year)</td>
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<td>30,966</td>
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<tr>
<td>Annual Fee Level (Second year)</td>
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#### Projected Revenue

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<tr>
<td>Fee Revenue (First year)</td>
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<td>309,660</td>
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<td>Fee Revenue (First year)</td>
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#### Total Annual Revenue:

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<tbody>
<tr>
<td>Fee Revenue (First year)</td>
<td>$</td>
<td>309,660</td>
</tr>
<tr>
<td>Fee Revenue (First year)</td>
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#### Projected Expenses

<table>
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<tr>
<th></th>
<th>FTE</th>
<th>Support Model Components $ Per Student</th>
<th>Support Model Components % of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty</td>
<td></td>
<td>$102,000</td>
<td>73%</td>
</tr>
<tr>
<td>Salaries</td>
<td>0.90</td>
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<tr>
<td>Staff Salaries</td>
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<tr>
<td>Benefits (faculty, staff and IAP)</td>
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<td>$32,400</td>
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<tr>
<td>GAEL</td>
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<td></td>
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</tr>
<tr>
<td>S &amp; E (Advertising, Brochures/Syllabus)</td>
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<td>$2,000</td>
<td></td>
</tr>
<tr>
<td>Travel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td></td>
<td>$32,000</td>
<td></td>
</tr>
<tr>
<td>Other-space rental/supplies for clinical training</td>
<td></td>
<td>$10,000</td>
<td></td>
</tr>
<tr>
<td>Subtotal Department Support:</td>
<td>$</td>
<td>226,400</td>
<td>73%</td>
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</table>

#### Student & Other Central Services (Estimates Only - Requires update from the SAA Office)

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<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Administration &amp; Program Review</td>
<td>$</td>
<td>2,160</td>
</tr>
<tr>
<td>Admission &amp; Registration</td>
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<td>$3,360</td>
</tr>
<tr>
<td>Student Information System</td>
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<td>3,030</td>
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<td>Graduate Division</td>
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<td>4,390</td>
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<td>International Students &amp; Scholars</td>
<td>$</td>
<td>800</td>
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<td>Office of Student Relations</td>
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<td>Other Student Services</td>
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<td>EMR (IRTS)</td>
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<tr>
<td>Student Financial Services</td>
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<td>5,990</td>
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<td>Subtotal Student Services:</td>
<td>$</td>
<td>25,830</td>
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#### Direct Services to Students (Estimates Only - Requires update from SHS)

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<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Student Health Services</td>
<td>$</td>
<td>7,720</td>
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<tr>
<td>Student Health Insurance Fee</td>
<td>$</td>
<td>37,380</td>
</tr>
<tr>
<td>Subtotal Direct Support Services:</td>
<td>$</td>
<td>45,100</td>
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</table>

#### Other Direct Services to Students (Estimates Only - Requires update from the SAA Office)

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<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Millberry Union Membership</td>
<td>$</td>
<td>1,380</td>
</tr>
<tr>
<td>UCSF Library</td>
<td>$</td>
<td>10,950</td>
</tr>
<tr>
<td>Subtotal Other Direct Sppt Services:</td>
<td>$</td>
<td>12,330</td>
</tr>
</tbody>
</table>

#### Total Costs:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Variance Revenue less Est. Expense:</td>
<td>$</td>
<td>-</td>
</tr>
</tbody>
</table>

MS in Imaging Sciences
SECTION 7: GRADUATE STUDENT SUPPORT

This program is intended to be an intensive course of instruction designed to lead to the MS degree. As such, there will be no opportunity for those students that are taking the course on a full-time basis to participate in teaching duties or to assume research duties. However, the situation would be different for students who choose to take the program on a part-time basis. There are a significant number of job opportunities within the DRBI for individuals with profiles similar to those of the intended student pool in the MS on Imaging Science. We also anticipate that some of the students in this program will come from local industry where they will have ongoing employment.

SECTION 8: CHANGES IN SENATE REGULATIONS

None.
Appendix

Appendix.1 GRADUATE COURSE TEACHING EVALUATION FORM

GRADUATE COURSE TEACHING EVALUATION FORM
Master of Advanced Study in Imaging Sciences
UCSF

Course name and number: ___________________________________________________________

Professor: __________________________

Date: ____________________________

This form will be made available to the instructor after final grades have been submitted. It will become part of the instructor’s dossier, and will be consulted when s/he is reviewed for reappointment, tenure, and promotion.

PART I: Please respond to these statements, with 5 indicating that you strongly agree and 1 indicating that you strongly disagree.

THE COURSE

<table>
<thead>
<tr>
<th>Agree</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The course was pitched at the appropriate level.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>2. The workload for the course was about right.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>3. The required materials (texts, etc.) were appropriate to this course.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>4. The assignments had instructional value and were related to the content.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>5. The course was well planned.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>6. The course was a valuable learning experience.</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

THE INSTRUCTOR

<table>
<thead>
<tr>
<th>Agree</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Established clear objectives for the course.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>8. Used class time effectively.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>9. Responded to questions adequately.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>10. Provided constructive feedback.</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>11. Communicated clearly and effectively.</td>
<td>1 2 3 4 5</td>
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<tr>
<td></td>
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<tr>
<td>---</td>
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</tr>
<tr>
<td>12. Encouraged and facilitated student participation and discussion.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td>13. Created a supportive learning environment.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td>14. Demonstrated enthusiasm for teaching this course.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td>15. Stimulated critical thinking about the subject.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td>16. Stimulated your interest in this subject.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td>17. Was available to meet outside of class.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>
PART II: Free response

CONTENT OF THE COURSE
Was the course content (topics, readings, assignments, etc.) what you would expect of a graduate-level curriculum, and appropriate to the particular curriculum of the department? Was it sufficiently challenging and up-to-date? Were you engaged by the material?

CONDUCT OF THE COURSE
Was the class handled well? Were the readings available and accessible? How were discussions facilitated? Did students make presentations and, if so, how were these incorporated into the learning dynamic of the class?

QUALITY OF INSTRUCTION
Where applicable, were you satisfied with comments on your oral presentations and written work, guidance given in developing your own research, other feedback?
PART III: Constructive criticism
Note: This page will not be included in the instructor’s dossier. It is intended to provide him/her with suggestions on how to improve the design and implementation of the course.

How many hours did you devote outside of class per week to course preparation?

What were the strongest aspects of this course?

What were the weakest aspects of this course?

What changes would you recommend in:
Topics covered?

Readings assigned?

Student participation?

Any other comments?
Appendix.2 Information Required by CPEC

This questionnaire is to be completed by sponsoring faculty (department or group). It will be used by Systemwide Administration to prepare a report to the California Postsecondary Education Commission. If more space is required, please attach as many additional sheets as necessary. Attach to full proposal.

1. Name of Program:
   Masters of Advanced Study (MAS) in Imaging Sciences

2. Campus:
   UCSF

3. Degree/Certificate:
   Master of Science

4. CIP Classification (to be completed by Office of the President):

5. Date to be started:
   September 2008  Is this the correct date?

6. If modification of existing program, identify that program and explain changes.
   N/A

7. Purpose (academic or professional training) and distinctive features (how does this program differ from others, if any, offered in California?):
   The “Master of Science in Imaging Sciences” Master's Degree Program is a one-year academic course of study for students who wish to master imaging-oriented research methods to enhance their research designs and broaden their investigative projects. Course work includes instruction in core theory and provides a foundation in interdisciplinary scholarship. The master’s program will provide a field of interdisciplinary academic investigation that examines the many facets of imaging, both at the molecular and cellular level and also translational aspects from the whole organ to clinical applications.

8. Type(s) of students to be served:
   Students with Bachelor’s degrees, medical students pursuing a master’s option, advanced pre-doctoral students, residents, and others who wish to augment their professional qualifications.
9. If program is not in current campus academic plan, give reason for proposing program now:

The program will be housed in the Department of Radiology and Biomedical Imaging at UCSF. The department has a total of 40 Ph.D. faculty specializing in Imaging Sciences, in addition there are 47 non-faculty academic appointees in the Researcher and Specialist series, all of whom can participate in course instruction.

10. If program requires approval of a licensure board, what is the status of such approval?

N/A

11. Please list special features of the program (credit for experience, internships, lab requirements, unit requirements, etc.)

N/A

12. List all new courses required: Department, Course Number, Title, Hours/Week Lecture Lab.

13. List all other required courses: Department, Course Number, Title, Hours/Week Lecture Lab.

14. List UC campuses and other California institutions, public or private, which now offer or plan to offer this program or closely related programs:

15. List any related program offered by the proposing institution and explain relationship.

16. Summarize employment prospects for graduates of the proposed program. Give results of job market survey if such has been made.

17. Give estimated enrollment for the first 5 years and state basis for estimate.

18. Give estimates of the additional cost of the program by year for 5 years in each of the following categories: FTE Faculty, Library Acquisitions, Computing, Other Facilities, Equipment, Provide brief explanation of any of the costs where necessary.

19. How and by what agencies will the program be evaluated.

Each course taught as part of the MSIS (core and elective courses that count toward the master’s degree) will be evaluated by the students who will fill out a course evaluation
questionnaire (see Appendix 1). A longitudinal study will be developed to assess regularly the impact of the MS program on career developments, productivity, and placement of graduates. Learning portfolios (“ePortfolio”) will be used to showcase student learning, provide a framework for assessing academic progress, and demonstrate how skills have developed over time.

The Director of Graduate Studies for the MSIS degree program will be responsible for keeping records and data that will provide the basis for annual reports on the performance of the master’s program presented to the MS Committee. This information will also be used to facilitate a quinquennial review performed by a peer review committee.

The peer review committee will be comprised of a minimum of four colleagues from outside UCSF who are faculty in existing academic programs in Imaging Sciences or any related academic fields that would provide familiarity with current scholarship and professional standards.