FORM NP

NEW PROGRAM PROPOSAL FORM

Sponsoring Institutions: University of Missouri – Columbia

Program Title: Clinical and Translational Science

Degree/Certificate: Master's in Clinical and Translational Science
Doctor of Philosophy in Clinical and Translational Science

Options: Emphasis areas:

1. Translational Biomedicine
2. Clinical Research
3. Health Services Research

Delivery Site: University of Missouri – Columbia

CIP Classification: 26.0102

Implementation Date: Fall Semester, 2008 – Fall Semester, 2010

Expected Date of First Graduation: May, 2011 for Master's 2013 for PhD

AUTHORIZATION

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INTRODUCTION

The United States is facing an enormous healthcare crisis (National Coalition on Health Care). In 2004 (the latest year data are available), total national health expenditures rose 7.9 percent - over three times the rate of inflation. Total spending was $1.9 trillion in 2004, or $6,280 per person. Total health care spending represented 16 percent of the gross domestic product (GDP), and US health care spending is expected to increase at similar rates for the next decade reaching $4 trillion in 2015, or 20 percent of GDP; health care spending is currently 4.3 times the amount spent on national defense. Accordingly, health care is becoming increasingly unaffordable for millions of Americans. Since 2000, employment-based health insurance premiums have increased 87 percent, compared to a cumulative inflation rate of 18 percent and a cumulative wage growth of 20 percent during the same period. In 2006, employer health insurance premiums increased by 7.7 percent which is two times the rate of inflation. In addition, the annual premium in 2006 for an employer health plan covering a family of four averaged nearly $11,500; the annual premium for single coverage averaged over $4,200.

The number of uninsured in the US increased by nearly 7 million people between 2000 and 2005. The number of uninsured children in 2004 was 8.3 million (11.2% of all children). The Census Bureau reported that in 2005, the number of uninsured Americans rose 1.3 million to 46.6 million (15.9% of the population). The healthcare conundrum is even more challenging as a result of the increase in the average age of Americans due to longer life spans and lower birth rates. For these reasons, healthcare expenditures are projected to be extraordinarily high for decades to come.

In FY 2006, the total budget of the National Institutes of Health (NIH) was $30 billion. Increasingly, government leaders, advocacy groups, and the general public are expecting to see tangible solutions to the nation’s enormous healthcare problems as a return on the substantive NIH investment. This is especially the case when many other industrial nations can document better health outcomes for their citizens than can the US, even though their health care expenditures are much lower per citizen. To begin to address concerns surrounding the NIH return on investment, an NIH Leadership forum was charged with developing recommendations for future NIH strategies. Out of this effort, the NIH Roadmap for Medical Research (Zerhouni, 2007) was conceptualized with three major themes as follows:

1. Development of new pathways to discovery
2. Development of research teams of the future
3. Re-engineering of the clinical research enterprise

In concert with these key NIH Roadmap themes, specific requests for proposals (RFPs) have been published with the intent to facilitate the translation of promising basic science discoveries (in areas such as genomics, proteomics, and imaging technologies, among numerous others) to the clinical environment and, eventually, to applications within the healthcare system.

However, this process of translation is not easy. Most current scientists have been trained in highly specialized fields; they are able to work effectively in a narrow sphere of scientific inquiry (i.e., within their disciplines), but they are not typically able to conceptualize how their work might be applied in a broader context. For example, basic scientists are not generally capable of conducting clinical trials. Similarly, clinical trials researchers are typically not experts in health services research applications. Lastly, health services researchers are rarely able to fully comprehend how their research results might be translated and applied in healthcare environments. As a result, the average time from basic science discovery to healthcare application has been shown to be approximately 17 years (Balas and Boren, 2000). This surprising statistic provides evidence that greater scientific efficiency is needed and that specialized research, by itself, fails to generate the desired return on NIH investments. One of the absolute requirements for institutions competing for Clinical and Translational Science Awards is that there be an advanced degree program within the institution that directly addresses the training of a new generation of students to function within the arena of clinical and translational science. Therefore, this newly proposed advanced degree program in clinical and translational science will permit MU to apply for a Clinical and Translational Science Award.

The NIH strategy for speeding the pace of clinical and translational research is multi-faceted, but a key aspect is represented by an RFA for Clinical and Translational Science Awards (CTSAs). Approximately 60 CTSAs will be awarded by NIH, and many universities are beginning to re-align their research and educational programs as recommended in the NIH Roadmap in order to improve their ability to translate basic science discoveries into tangible products and services for their constituencies. A key strategy adopted by many universities is to develop advanced training programs in clinical and translational science that can prepare a new generation of researchers to be well-prepared in areas such as translational biomedicine, clinical research, and health services research.

What is Clinical and Translational Science? As the name implies, “clinical and translational science” describes a nexus of related spheres of research that cuts across traditional disciplines. Therefore, clinical and translational science is inherently interdisciplinary in nature. In “traditional” research, the focus is typically on narrow areas of scientific inquiry. As a result, discipline-specific researchers in the basic sciences often focus on isolated molecules, pathways, or compounds; the resulting discoveries have been remarkable. However, these same researchers typically are not trained to fully appreciate the implications of their basic discoveries for disease pathophysiology or for improvements in health care delivery systems. As a result, the enormous national investment in life sciences research often does not translate into the types of health-related benefits that would be desirable.

In contrast, clinical and translational scientists will be trained in a manner that prepares them to understand the scientific foundations of basic discoveries, but also to be able to move those discoveries into clinical environments (e.g. human studies) and, eventually, into practical applications in health care systems. In essence, clinical and translational science includes three broad spheres of expertise as follows:

1. Translational Biomedicine, which refers to the development and application of promising pre-clinical discoveries to specific human disease and medical problems.
2. Clinical Research, which refers to the design, implementation, or analysis of clinical trials or other data in the context of diagnosis or treatment of medical conditions.
3. Health Services Research, which refers to the translation of clinically relevant science into improved systems for health care delivery and evidence-based practice.

With regard to "translation," there are two broad components as follows: (a) translation of basic biomedical research into the clinical trials (T1), and (b) translation of clinical data into applications within the healthcare system (T2). Therefore, the breadth of skills that must be mastered for an effective clinical and translational scientist are, indeed, extremely diverse. A clinical and translational scientist must be able to evaluate new biomedical discoveries, to understand the implication of those basic discoveries for clinical disease, and to conceptualize services, products, and delivery systems that will be viable within complex healthcare environments.

MU has the collective expertise, programs, and resources to train a new generation of clinical and translational scientists who will be able to quicken the pace of translation of basic science discoveries into improved health outcomes.

I. PROGRAM NEED

A. Student Demand

According to the NIH Roadmap initiative, our nation faces a critical demand for graduates of clinical and translational science programs. Even though NIH expends 30 billion dollars per year in health-related research, the United States ranks only 10th in healthcare outcomes for our citizens. Of the 50 states, Missouri ranks 35th on health-related outcome measures. Therefore, the training of clinical and translational scientists to move basic research discoveries into practice is a high priority for both the nation and the State of Missouri. Specifically, for Missouri, enhanced capability in the area of clinical and translational science is important for the University of Missouri to expand the development of intellectual property. Clinical and translational scientists are able to readily identify scientific discoveries that are ready for development and to conceptualize business strategies that can lead to entrepreneurship, technology start-up companies, and state-wide economic development.

At present, an advanced degree program in clinical and translational science does not exist anywhere within the University of Missouri system.
Indeed, few universities are capable of offering a degree program in clinical and translational science due to the extensive resources that are required from the health-related disciplines of medicine, nursing, and health professions, among others. In addition to the required health-related disciplines, a strong research infrastructure must exist within the basic sciences and engineering.

For the initiation of a new degree program, there needs to be evidence that there is a demand in the field for graduates. Obtaining empirical evidence for student demand is challenging in a new field such as clinical and translational science. However, an article published in Nature by Kreeger (2003) described the growing interest on the part of both physicians and PhD scientists in obtaining training that effectively combines knowledge from both clinical and basic research. In the article, Professor Irwin Arias stated that "the clinical setting is becoming a popular occupational route for PhDs, in addition to MDs doing basic-science post docs, and notes that the demand for MDs/PhDs has been high." In addition, student demand in clinical and translational science was demonstrated in a survey by the Association of American Medical Colleges (AAMC) which conveyed that 72% of member institutions have introduced new clinical research training programs or enhanced the rigor of existing programs. This widespread shift toward the clinical and translational science training programs effectively demonstrates that students wish to pursue careers in this rapidly emerging area. As a result of the NIH Roadmap initiative, a select number of other universities in the United States that have the necessary basic sciences and health care infrastructure are actively working on the development of advanced degree programs in clinical and translational science in order to maximize research funding opportunities and to improve economic development within their regions. Knowledge translation and technology transfer (which are an inherent part of clinical and translational science) are highly valued by university stakeholders. For these reasons, the student demand for clinical and translational science training opportunities is expected to be extremely high for the foreseeable future.

In addition, there is a need to demonstrate that there is a demand on the part of students for the program and that students will actually enroll. In this regard, a survey was conducted of University of Missouri undergraduates with majors in scientific fields (e.g., chemistry, physics, biology, and biochemistry). In the summer of 2007, a Survey Monkey was distributed to 1,224 students that included a brief description of the new degree program in clinical and translational science; 170 students responded to the questionnaire. For the question "As an undergraduate science major, are you interested in pursuing graduate training in a scientific discipline?", 88% responded "yes." For the question "Is the new program in clinical and translational science of interest to you?" 65% of the respondents indicated "yes." In terms of MS versus PhD degrees, 15% indicated they would be more interested in the MS degree; 58% indicated that they would be more interested in the PhD degree, and 27% indicated that they were unsure which degree might be of most interest. Overall, the student survey indicates that a degree program in clinical and translational science would be highly competitive in terms of attracting undergraduate students with science backgrounds and that doctoral level training would be appealing to a sizable percentage of these students (see Figures 1 and 2).

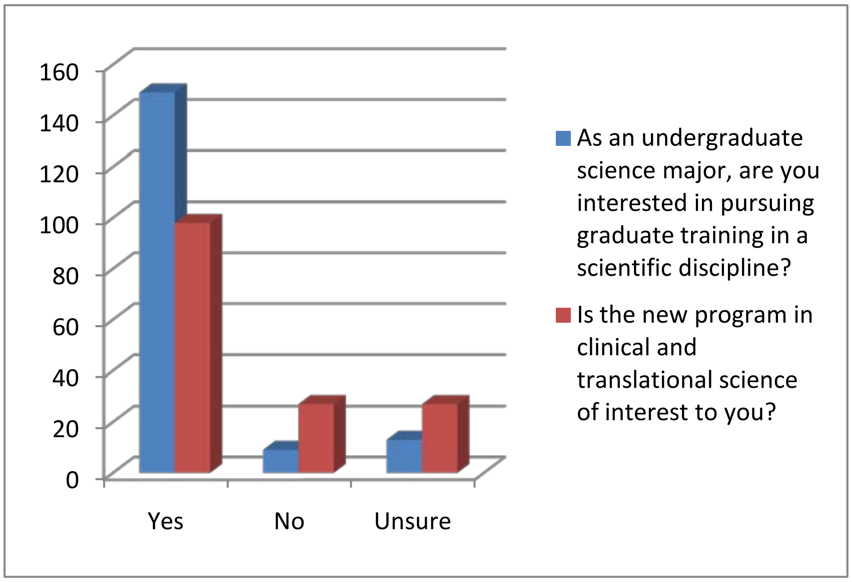

Figure 1.

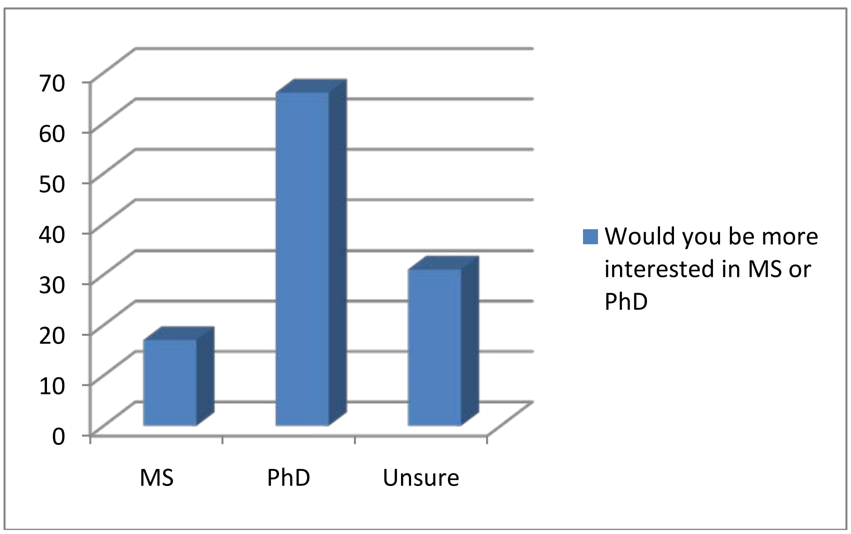

Figure 2.

Given the need nationally for scientists who are able to translate basic, life science discoveries into health-related applications, a strong possibility exists that Washington University also will pursue a new advanced degree program in some aspect of clinical and translational science. Indeed, most medical schools will likely perceive the need to implement new clinical and translational science programs due to both the NIH Roadmap priorities and the new Liaison Committee on Medical Education (LCME) guidelines (effective July, 2008), which require that all medical students be exposed to the principles of clinical and translational science.

Therefore, this proposal to synchronize the clinical and translational science curriculum with the medical school curriculum will permit the School of Medicine to efficiently meet the new LCME requirement. Lastly, as a land-grant university, MU has an outreach mission which is quite different from that of Washington University. Specifically, the new advanced degree programs in clinical and translational science at MU will lead to the preparation of a new type of scientist who will be able to translate the basic, life science discoveries on the MU campus into health-care applications and improved health-related outcomes for Missourians.

The proposed degree program in clinical and translational science is inherently collaborative. Indeed, the key objective of the proposed degree program will be to more effectively integrate existing clinical and translational science resources across the campus and to facilitate collaboration between MU schools/colleges/departments. The competencies required for clinical and translational science students will demand (and facilitate) a highly collaborative educational environment for the proposed degree program.

Estimated enrollment each year for the first five years for full-time and part-time students:

Enrollment projections are based on the number of student who can be appropriately managed by the faculty identified to provide the training and the space (within the School of Medicine and University of Missouri Health Care) that has been identified to house the new degree program in clinical and translational science. Planned enrollment for the initial class is 10 full-time students (4 Master's and 6 doctoral); the Survey Monkey questionnaire indicates that student interest in the program will be substantial. Therefore, there is reason to believe that the recruitment of 4 Master's and 6 doctoral students during Year 1 will be attainable. The Master's students are expected to require 2 years for degree completion, so the Master's students would be capped at a total of 8 in Year 2. The doctoral students are expected to require 4 years for degree completion, so the doctoral students would be capped at a total of 24 in Year 4; part-time student are not anticipated due to the nature of the problem-based curriculum. The student enrollment projections (including both Master's and doctoral students) are shown in Form SE below:

Form SE--STUDENT ENROLLMENT PROJECTIONS

Based on market/student demand

Year	**1**	**2**	**3**	**4**	**5**
Full-Time	10	20	26	32	32
Part-Time	0	0	0	0	0
Total	10	20	26	32	32

Enrollment at the end of year 5 for the program to be financially and academically viable:

Given that only a select number of universities (i.e., those with the necessary basic sciences and healthcare infrastructure) will be able to offer an advanced degree in clinical and translational science, the expectation is that the entering class will consistently be full and that the steady-state projection of 32 enrolled students will be achieved.

Some drop-outs for various reasons will occur, but additional students to fill vacancies are expected to be readily available due to the anticipated high student demand. However, the advanced degree program in clinical and translational science will be expected to be financially and academically viable with a total Year 5 enrollment of 20 full-time students.

Form SE--STUDENT ENROLLMENT PROJECTIONS:
Enrollment at the end of Year 5 for the program to be financially and academically viable

Year	**5**
Full-time	20
Part-time	0
TOTAL	20

Will enrollment be capped in the future?

The primary focus of the advanced degree programs in clinical and translational science is to train a future generation of researchers. However, a secondary goal is to facilitate close interaction between students in the clinical and translational science program and medical students; this close interaction will be effectively promoted by the physical proximity of the students in the two educational programs. In addition, some of the medical students may wish to pursue combined MD/PhD degrees (with the PhD in clinical and translational science), so these additional medical students (up to a maximum of 4) will be accommodated within the doctoral program. Therefore, students from all sources would be capped at 36 (32 clinical and translational science students and a maximum of 4 additional MD/PhD students). Within these enrollment parameters, faculty mentors will be able to facilitate training and research opportunities as appropriate for students in the clinical and translational science degree program.

B. Market Demand

The national, state, regional, and local demand for scientists with advanced training in clinical and translational science is expected to be high for the foreseeable future. This inference is predicated on the recommendations of the Clinical Research Task Force II (CRTF-II) of the Association of American Medical Colleges (AAMC); the CRTF-II Final Report was published in 2006. The CRTF-II Report entitled “Promoting Translational and Clinical Science: The Critical Role of Medical Schools and Teaching Hospitals” conveyed that the development and nurturance of clinical and translational scientists should be a major national priority. Indeed, evidence that the transformation of scientific training is actively underway was reflected by a survey of the research deans at AAMC institutions in August, 2006; the survey revealed that 72% of medical schools have introduced new clinical research training programs for fellows and/or junior faculty or have enhanced the rigor of existing programs since 2000. In addition, 52% of AAMC institutions reported that additional investments have been made in research aimed at improving healthcare delivery systems, and such investments increase the demand for clinical and translational scientists. Another key CRTF-II recommendation was that "training for translational and clinical research should comprise completion of an advanced degree with a thesis project (or equivalent educational experience), tutelage by an experienced mentor, and a substantive post-doctoral training experience." Hence, AAMC-affiliated institutions are in the process of actively mobilizing to meet the need to train a generation of future investigators who will have strong backgrounds in clinical and translational science.

Similarly, the NIH leadership has been actively engaged in the development of strategies to promote research that will be capable of meeting the public health challenges of the future. Specifically, NIH has concluded that research will need to address compelling health-related challenges as follows:

1. The increasing prevalence of chronic medical conditions
2. The increasing age of the population
3. The existence of health-related disparities within the population
4. The emergence of new diseases
5. The need to develop strategies for biodefense

To address these major public health challenges, the NIH has developed the Roadmap for Medical Research and has conveyed that a new type of scientist will be needed. Specifically, a critical need will exist for scientists who will be able to bring a broad perspective to bear on the nation's research agenda. These new scientists will conduct research and create new knowledge in the new academic discipline of clinical and translational sciences, studying the translation of scientific advances into improved health outcomes. These scientists will need to be able to grasp the emerging complexity of biology, understand biological "systems," be capable of accessing national data repositories, and be able to promote multi- and interdisciplinary research. In short, these new scientists will need to understand how scientific advances result in improved patient outcomes, what obstacles prevent the rapid transition of these advances into clinical sciences, and how these obstacles are overcome. They will participate in research, be capable of assembling the research teams of the future and be capable of conducting programmatic research across the spectrum of biomedicine, clinical trials, and health system applications. Data from the Missouri Economic Research and Information Center (MERIC) indicates that the high-tech industry in Missouri is substantial and, indeed, that 4% of the Missouri workforce is currently engaged in high-tech employment; the advanced degree program in clinical and translational science will contribute to the skills of this workforce. Specifically, jobs within the high-tech industry have a large influence on the Missouri economy (both direct and indirect) and account for over $17 billion of the Gross State Product (Missouri Economic Impact Brief: High-tech Industries, 2006).

Traditional discipline-specific research training programs do not produce scientists with the skills that are needed to pursue the clinical and translational science agenda of the future. Therefore, new advanced degree programs to train clinical and translational scientists are beginning to emerge at major research institutions across the nation. These new scientists will be uniquely capable of assembling the research teams of the future, so they are expected to be in very high demand within both the public and private sectors. Market demand also can be demonstrated by job postings in electronic databases. The term "clinical science" yielded 3,463 open searches (Monster.com); the term "clinical research" yielded >5,000 open searches (Monster.com). The term "clinical scientist" yielded 1,461 open searches (CareerBuilder.com); the term "clinical and life sciences" yielded 1,203 open searches (CareerBuilder.com). The available evidence indicates strong market demand for the type of graduate who will be prepared by the advanced degree programs in clinical and translational science.

C. Societal Need

From a state and regional perspective, a clinical and translational scientist workforce is exceedingly important. For Missouri, "life sciences" research conducted at state universities represents an opportunity for economic development, jobs, and growth in all sectors of the economy. Indeed, universities have been the source of most key biotechnology and life sciences discoveries over the past 30 years; a full two-thirds of all basic research and discovery now derive from work conducted at US universities (Report of Rural Biotechnology Committee).

The challenge for both Missouri and the nation is to translate the knowledge, techniques, and technology produced by the scientific community into products and services for constituents. In the case of health-related research, the objective is improvements in the health of the citizenry. Therefore, strategies are needed to speed the pathways to discovery, apply new findings to the problems of human disease, and deliver new treatments in the context of a complex health care system. The clinical and translational science enterprise is capable of initiating a process of economic development that includes patents/licensing, business incubators, start-up companies, research parks, and a range of related businesses and industries that materialize to support the scientific enterprise. This chain reaction of business activity is extremely beneficial for economic, social, and cultural development within communities (Report of Rural Biotechnology Commission).

Currently, Missouri devotes 80% of its academic research dollars to life sciences research (Missouri Biotechnology Association). Therefore, a major opportunity exists for the state to translate this engine of basic discovery into health-related and economic benefits. However, on the basis of national studies, the pace of innovation has been found to be exceedingly slow, and NIH has concluded that a major obstacle to the pace of health-related innovation is a lack of scientists with advanced training in clinical and translational science. Therefore, an important societal need can be addressed by the preparation of clinical and translational scientists within the state of Missouri. Specifically, clinical and translational researchers are critically important for enabling the citizenry to reap the rewards of Missouri's strong commitment to life sciences research.

Innovative Master's and doctoral degree programs in clinical and translational science at MU will produce high-quality graduates. These graduates will populate the clinical facilities, research institutions, and private companies of Missouri and, thereby, drive a "new life sciences economy." A principal reason for locating a company in a particular location is the availability of an educated and skilled workforce. University degree programs are able to produce the graduates that form such workforces.

D. Methodology

The analyses of student demand, market demand, and societal need have been based on NIH Roadmap documents, AAMC reports, documents of the Missouri Biotechnology Association, a review of the scientific literature, and searches of electronic job search databases.

II. DUPLICATION AND COLLABORATRATION

A. Avoidance of Duplication

A key concept in the proposal is the development of a Master's-level curriculum to be delivered in a problem-based learning (PBL) format on the MU campus in order to synchronize the training of clinical and translational science students with the medical student curriculum. Although the curricula for training clinical and translational students and the medical students are quite different, the core content domains (e.g., biochemistry, physiology, metabolism, microbiology, and immunology) overlap. Therefore, by synchronizing the core content (blocks), the students in each separate program will be able to expand and enrich their PBL activities. Specifically, students in the clinical and translational sciences program will work on research problems with compatible themes as those being studied by the medical students in order to permit students in each separate program to expand their learning through access to the other curriculum. Synchronization of the first two years of the clinical and translational science and the medical school curricula will be highly advantageous for several reasons. First, the PBL curriculum has proven to be a highly successful educational model due, in part, to the appeal of classical, case-based learning; the learning process is able to achieve exceptional relevance when placed in the context of real-life medical cases and problems. Secondly, the synchronization will facilitate collaborative learning strategies and will contribute to the acculturation of young scientists and clinicians into each other's professional language and worldviews. The final two years of the CTS curriculum will involve advanced research mentoring and dissertation and, therefore, can occur within the framework of existing MU research facilities.

A. Collaboration

On an annual basis, MU awards 277 doctoral degrees, but none of these advanced degrees address the training of clinical and translational sciences. Faculty input has indicated that the clinical and translational science curriculum would be exceedingly valuable as a complement to traditional, discipline-specific degree programs. Indeed, some doctoral students in traditional scientific disciplines are expected to be attracted to the Master's degree in clinical and translational science because they are likely to view the degree as a way to improve their ability to apply basic science discoveries and to prepare themselves to work more effectively within interdisciplinary teams. In addition, traditional departments at major universities are expected to increasingly seek to recruit faculty with clinical and translational science backgrounds in order to enhance their educational and research competitiveness. Since the advanced degree program in clinical and translational science is completely unique to the MU campus (and there are limited number of other programs of this type across the nation), there is expected to be a high demand from new students who are not already on the MU campus. In the event that the clinical and translational science program pulls students from other MU graduate degree programs in basic sciences, those programs are likely to backfill with other students with the resulting effect being that the total number of graduate students on the MU campus is, indeed, increased by the clinical and translational science program.

III. PROGRAM STRUCTURE

A. Summary of the Program

1. University of Missouri Institute for Clinical and Translational Sciences (MU-ICTS): The advanced degree program in clinical and translational science will be managed through the University of Missouri-Columbia Institute for Clinical and Translational Science (MU-ICTS), which will serve as both the academic home for the advanced degrees and the interdisciplinary structure for facilitating clinical and translational research across the MU campus. The MU-ICTS will be the vehicle through which the MU faculty build a strong, effective collaboration within both the educational and research arenas. Under the leadership of the Director of MU-ICTS, the organizational structure for the administration of the advanced degree program in clinical and translational science will be developed in a manner that will maximize faculty involvement. For example, the process of recruiting and selecting graduate students will be accomplished by an Admissions Committee. Similarly, the oversight of the integrity and effectiveness of the educational program will be managed by a Curriculum Committee. Indeed, all required functional components and committee structures as required for the advanced degree program in clinical and translational science will be based within the academic home of the MU-ICTS. In all of these functional activities, the collaborative involvement of the interdisciplinary faculty will be facilitated.

An organizational chart for the MU-ICTS is shown in Figure 3. The MU-ICTS will serve as both the academic home for the new advanced degree program in clinical and translational science and as the key organizational entity for the consolidation and facilitation of the interdisciplinary research enterprise in clinical and translational science on the MU campus. For purposes of research activities, the Director, MU-ICTS will report to the Vice Chancellor for Research. For purposes of administration of the new degrees in clinical and translational science, the Director, MU-ICTS, will report to the Vice Provost for Advanced Studies (Dean, Graduate School). In all respects, the MU-ICTS will be implemented as an organizational structure which will be consistent with the structure, policies, and procedures of the MU Graduate School; the organizational structure was approved by the campus prior to forwarding the proposal to the University of Missouri System office. The Vice Chancellor for Health Sciences will play an important advisory role in the MU-iCATS, but the campus-wide nature of a clinical and translational program requires a direct line of authority to MU officers that are responsible for oversight and integration of all MU schools/colleges/centers.

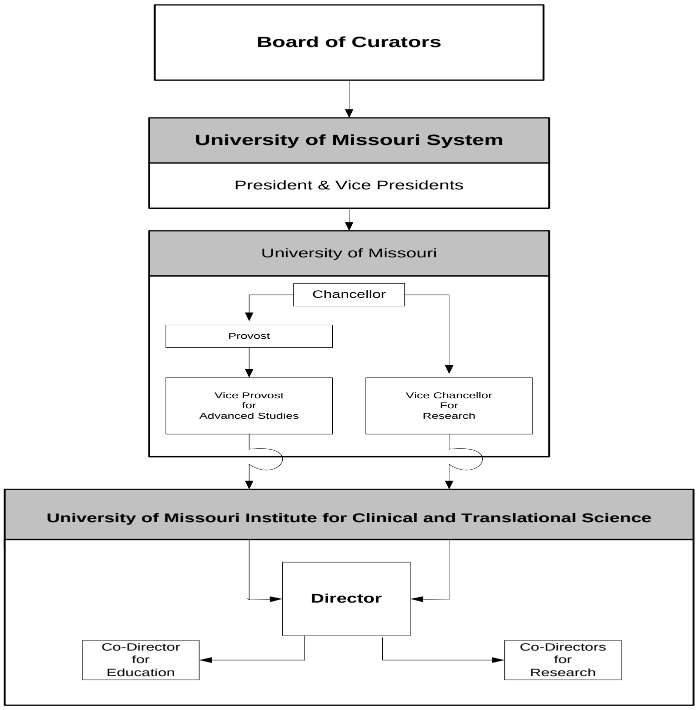

Figure 3. Organizational Structure for University of Missouri Institute for Clinical and Translational Science

2. <u>Vision of Institute</u>: The vision of the MU-ICTS is to transform clinical and translational science opportunities at the University of Missouri into an effective, competitive, well-funded enterprise that is capable of making a substantive contribution to the improvement of healthcare for the people of Missouri, the nation, and the world.

3. <u>Goals</u>: The key goal of the MU-ICTS will be to provide an organizational structure that can facilitate educational and research accomplishments across MU departments/schools/colleges. The NIH Roadmap report has conveyed that productivity in clinical and translational science is impeded by traditional, discipline-specific organizational structures. Generally, traditional academic disciplines are organized to promote teaching and research in highly specialized areas, and funding agencies have typically relied upon RFAs that use criteria that favor a high degree of specialization. In contrast, clinical and translational science is inherently interdisciplinary in nature and requires the assembly of faculty teams that will cut across traditional departments/ schools/ colleges and even campuses. Hence, the primary goal of the MU-ICTS will be to create a trans-campus (i.e., bridging schools and colleges) organizational structure that will be in a strong position to effectively manage resources in support of outstanding educational and research programs in clinical and translational science.

4. **<u>Interdisciplinary Support</u>.** Following discussions at the Council of Deans and a series of follow-up meetings with deans of schools and colleges on the MU campus, commitments have been obtained for MU-ICTS faculty participation from Human Environmental Sciences, Nursing, Arts and Science, Agriculture/Food and Natural Resources, Law, Health Professions, Veterinary Medicine, Engineering, Journalism,

Business, and Medicine (see Appendix C: Letters of Support). A consensus exists that the MU-ICTS will be highly advantageous for MU schools and colleges in terms of research opportunities, educational opportunities, and competitiveness for extramural funding.

5. **Degree Program Objectives:** The proposed Master's and doctoral degrees are intended to train professionals who will be capable of generating new knowledge in the context of "clinical" (applicable to humans) and "translational" science (application of basic research and/or development of improved healthcare practices). Competencies will include skills that span molecular, cellular, and tissue systems (and their integration) in the context of health, disease, and health care systems.

Graduates will possess competencies as follows:

(a) Ability to take advantage of rapid and fundamental scientific advances as they occur in fields such as genomics, proteomics, informatics, and other novel methodologies.

(b) Ability to function effectively in the complex regulatory, organizational, and cultural/sociological environments where clinical and translational research takes place.

(c) Ability to function effectively in multi-disciplinary and interdisciplinary research settings and to be capable of propelling scientific findings along the applied continuum (from bench, to clinical trials, to healthcare applications).

Master's-level graduates will be able to function effectively as members of clinical and translational science teams and/or to augment their core professional training with a clinical and translational science perspective. As the field of clinical and translational science develops over time, a need will exist for Master's-level trained professionals to support the work of doctoral-level investigators; these individuals will need to be able to function effectively within the interdisciplinary environment of clinical and translational science. The pool of applicants for the Master's program is expected to be similar to the pool of applicants for more discipline-specific research areas, but they will be trained to fulfill supportive and technical roles as required by teams of clinical and translational scientists.

Doctoral-level graduates will possess the skills needed to pursue careers as independent clinical and translational scientists, and they will be capable of conducting original research. Doctoral-level graduates will be capable of leading interdisciplinary research teams, analyzing the research literature across multiple fields, and identifying opportunities to translate new findings into products and services that can improve health outcomes.

Due to the extraordinary scope of clinical and translational science, doctoral-level specialization in one of the three following areas will be appropriate:

(a) Translational biomedicine

(b) Clinical research

(c) Health services research

In summary, graduates of the clinical and translational science program will possess uniquely integrative skills that permit them to view health care problems from a broad perspective and to address translational challenges across multiple research domains.

The new advanced degree program in clinical and translational science at MU will be unique and is expected to contribute to national distinction for the MU-ICTS. Many other universities that emphasize clinical and translational science and which also are competing for CTSAs already have established degree programs in place that meet the CTSA criteria, but MU does not. Therefore, the utilization of the problem-based learning approach and the synergy with medical education has the potential to place MU at the leading edge of innovative advanced degree programs for clinical and translational scientists.

B. General Prerequisites and Admission

Students will be accepted into the program with different backgrounds and varying degrees of experience, but prerequisites will be expected. A bachelor's degree is required, and specific prerequisite course requirements must be met. Acceptance into the program will not be precluded by minor deficiencies in background, but will be conditional upon such deficiencies being remedied before or during the first year of study.

Specific prerequisite courses/competencies are as follows:

Biology	6 credit hours
Biochemistry	6 credit hours
Chemistry	6 credit hours
Calculus	6 credit hours
Physics	6 credit hours

B. Form PS Requirements

Program	**Master's**	**PhD**
Total credits required for graduation:	**44**	**78**
Residency requirements:	44	**78**

1. MS Program Requirements: The Master's degree in clinical and translational science requires the completion of Year 1 and Year 2 of the clinical and translational sciences curriculum (Figure 4), except that the summer institute internships are not required. Instead, a Master's thesis must be completed, and the summer sessions typically will be devoted to thesis work. Because the MS degree in clinical and translational science is designed as a research degree, the experience of preparing and defending a thesis is viewed as central to the master training program. A final oral examination by the Graduate Committee also will be required in conjunction with the thesis defense.

2. PhD Program Requirements: Students in the doctoral program in clinical and translational science must complete Years 1-4 of the clinical and translational science curriculum (Figure 3), including summer sessions. Year 4 of the curriculum includes the original research component, and this may take longer than one calendar year. Indeed, an additional (5^{th}) year may be needed in many (if not most) cases in order to fully develop independent research skills and to prepare a doctoral dissertation, which will be a requirement. For doctoral students, the dissertation will constitute the demonstration of competency as an individual researcher; doctoral students will be required to complete the summer practica which also are viewed as requisite training for advanced work in the field of clinical and translational science. Although some doctoral students may elect also to complete a thesis related to the summer practica, it is not a requirement for the doctoral degree.

3. Overview of Content Domains: In order to achieve the objectives of the advanced degree in clinical and translational science, the requisite content domains have been identified; these key content areas span the multiple domains of translational biomedicine, clinical research, and health services research. Training in these three broad scientific domains is necessary to provide a translational perspective and to permit graduates to conceptualize the movement of knowledge from the realm of basic science, to human studies, and to applications within health care systems. In addition, training in scientific methods, techniques, ethics, and other aspects of research fundamentals will be required. Additional content domains will include topics such as experimental design, statistics, biologic systems, clinical disease, research ethics, health care systems, neurobiologic systems, proteomics, genomics, epidemiology, translational technologies, bioinformatics, research entrepreneurship, regulatory environments, and translational research practica. A central component for the education of students in clinical and translational science is strong preparation in research theory, hypothesis development, and critical thinking.

4. Problem-based Learning Model: Following the identification of the requisite content domains, several educational models are possible for the delivery of a training experience. For several reasons, an innovative problem-based learning (PBL) model has been selected. First, the PBL model for medical education (Figure 4) has proven to be extremely effective at the University of Missouri-Columbia. Following a 10-year experience with the PBL approach to medical education at MU, Hoffman et al (2006) found that mean scores on six of ten comparisons from the United States Medical Licensing Examination (USMLE) Step 1 and six of nine comparisons from USMLE Step 2 were significantly higher ($p < .01$) for MU medical students than for first-time examinees nationally; the authors also demonstrated that the high performance by MU medical students was not attributable to pre-selection of academically advantaged students, increased time on tasks, or reduced class size. Second, Parker and colleagues (Webster et al, 2003) have demonstrated that advanced research training strategies that place learning in the context of active research participation are highly effective. Specifically, participation in an Advanced Rehabilitation Research Training Program resulted in a high level of academic achievement as measured by the amount of extramural funding that was subsequently obtained (Webster et al, 2003).

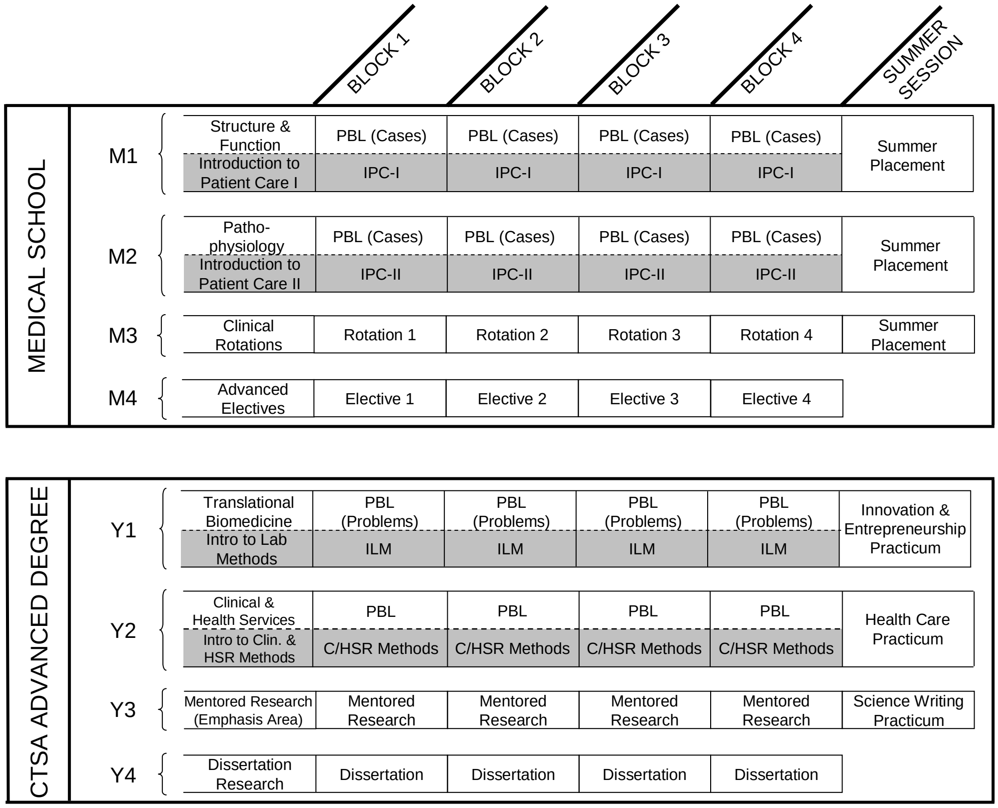

Figure 4: Synchronized Structure for Clinical and Translational Science and Medical School Curricula

For these reasons, the advanced degree programs in clinical and translational science will use the PBL model which does not emphasize traditional courses within a semester format. Instead, the learning activities will be delivered in four, 10-week blocks during the academic year; summer placements/institutes also will be utilized. As shown in Figure 4, the PBL activities for medical students and clinical and translational science students are delivered in parallel formats. Furthermore, the themes for blocks 1-4 over the first two years are synchronized from a content standpoint for students in both programs. For example, while medical students are studying "structure and function" involving biochemistry and molecular biology during Block 1, the clinical and translational science students will be studying "translational biomedical research" as related to biochemistry and molecular biology. Although the curricula for the two programs are independent, they are synchronized in a manner that permits clinical and translational science students to draw upon the medical student curriculum during their PBL activities. For example, medical school coverage of pathophysiology will greatly expand learning opportunities for clinical and translational science students. Similarly, medical students will be able to draw upon the clinical and translational science curriculum during their PBL activities. For example, the clinical and translational science coverage of research methodologies will greatly expand the opportunities for medical students to learn to evaluate the scientific literature. Specifically, the medical students and the clinical and translational science students will be able to share "cases" and "problems." In the medical student PBL curriculum, teaching activities revolve around cases that present complex sets of problems to be solved (diagnosed). An example might be “a 64 year old male who presents to clinic with a sore throat.” As the case unfolds, more detailed information (e.g., smoker, weight loss, diet, co-morbidities) is presented in a way that requires increasingly diverse material to be researched, synthesized, and applied in support of the learning objectives. For students in the clinical and translational science program, the same case can serve as the foundation for a PBL approach for teaching scientific thinking and research methods. Students would examine the scientific literature as it pertains to the various facets of the case; they would identify the translational biomedical questions that remain unanswered, and they would design potential experiments. They also would learn about the principals of epidemiology and clinical trial design that might be used to test new treatments. Equally important, a common frame of reference would facilitate interaction and discussion between medical students and clinical and translational science students as they work on the various facets of the same case. Students in both programs would be able to attend some of the same lectures, as appropriate, for their learning objectives, and they would gain an understanding of each others’ worldviews and be able to acculturate with respect to shared values (i.e., improving healthcare outcomes). In particular, for clinical and translational science students, there will be a need to understand the pathophysiology of disease and the barriers to improved health outcomes, and learning in these areas can be most effectively provided within a healthcare environment where close proximity to clinicians is possible.

Sharing cases with medical students provides an opportunity for the CTS students to join the medical students and learn “first hand” about the human disease. The CTS degree program would provide a parallel PBL experience designed for CTS students and tutored by CTS faculty with emphasis on CTS content domains. A parallel medical and CTS PBL training using the same case should provide opportunities for interaction between the medical and the CTS students in a manner that will enhance the educational experience of both.

As shown in Figure 4, the medical school curriculum is divided into four (4) “structure and function” blocks (M1 year) and four (4) “pathophysiology” blocks (M2 year). Each of these eight (total) blocks has a specific content theme (e.g., cardiovascular system, pulmonary system, immune system, and nutrition, among others). In the M1 and M2 years, these content domains are taught in a manner that is optimal for the training of physicians (e.g., through the lens of structure/function, pathophysiology, and principles of patient care). With regard to the advanced degree in clinical and translational science, the synchronization with the medical school curriculum occurs through the use of the same framework of the eight content domains during Y1 and Y2 years. However, in the clinical and translational science program, the content domains (e.g., cardiovascular system, pulmonary system, immune system, and nutrition, among others) will be taught in a manner that will be optimal for the training of clinical and translational scientists (e.g., through the lens of translational biomedicine, clinical/health service research, and principles of research methodology). This synchronized approach to the training of clinical and translational science students and medical students is highly innovative and permits the sharing of curriculum resources between the two programs. Although the curricula are independent and different in focus, the use of the same sequence of content domains will enhance the learning environment for students in both programs because there will be complementary resources, lectures, “cases”, and “problems” for students to utilize during the learning process.

In the PBL model, students are required to be active learners. They are presented with “cases” or “problems” and are required to search for solutions; the search for solutions requires didactic components (e.g., lectures by CTS core and affiliated faculty), independent reading, group activities, and active exploration across interdisciplinary content domains. Therefore, the synchronization of a clinical and translational science curriculum with a medical school curriculum provides a rich expansion of PBL opportunities for both programs. Equally important, the clinical and translational science students will be able to acculturate into the worldview of physicians and into the challenges of the health care system; this is precisely the type of understanding that they will need to effectively translate basic science discoveries into clinical applications, and eventually, into improvements within the health care system. Indeed, for this reason, selected components of the medical student curriculum will be required for clinical and translational science students in order to ensure an in-depth understanding of clinical and health care environments. Specifically, interactions with medical students and physicians during the Health Care Practicum will be a core experience for all clinical and translational science students. Finally, the PBL model will facilitate the development of learning experiences that facilitate progression through the program, including selection of advisors, identification of emphasis areas, preparation for comprehensive examinations, and conceptualization of dissertation proposals.

From a cost perspective, the PBL approach to training in clinical and translational science can be expected to be somewhat higher than for a traditional coursework approach. Whereas in the traditional coursework model, existing courses on the campus could be used in support of the new curriculum, the PBL model will require the development of an original curriculum in all respects (i.e., “problems” for which “solutions” by students will cover the necessary content domains for the program). However, one of the essential components of training in clinical and translational science is the acculturation of scientists into the worldview of practitioners and the exposure of scientists to the operation of healthcare facilities; these aspects of the program would be much more difficult to accomplish within the traditional classroom environment. In addition, the new LCME requirements for medical students to receive training in clinical and translational science will require additional expenditures within the School of Medicine if the proposed model were not used. Overall, the cost of the PBL approach to training in clinical and translational science does not appear to be notably more expensive than the traditional alternative.

5. General Description of Program

(a) Description of Year 1 Blocks: During Year 1, students in the advanced degree program in clinical and translational science will rotate through four, 10-week blocks. Each 10-week block will involve the presentation of research “problems” in a PBL format. In Block 1, the research problems will involve translational biomedicine issues in molecular biology, biochemistry, kinetics, embryology, and histology; students also will spend time in a supervised laboratory environment (see listing of core and affiliated faculty) where they can learn the research methods and techniques which pertain to the PBL research problems they are exploring. In Block 2, the focus of the PBL research problems will pertain to metabolism, pulmonary, cardiovascular, gastrointestinal, renal, and respiratory systems; the laboratory experiences in translational biomedicine, likewise, will be designed to provide instruction in the methods and techniques which are pertinent to these research domains. In Block 3, the focus of the PBL research problems will pertain to neurophysiology and endocrine systems; the laboratory components will be designed to facilitate the learning of the methods and techniques involved in these translational biomedicine research domains. In Block 4, the focus of the PBL research problems will pertain to hematology, reproductive systems, microorganisms, immune responses, and pharmacokinetics; the laboratory components will provide exposure to methods and techniques appropriate to translational biomedicine research within these areas. In each of the blocks of the first year (Blocks 1 – 4), the students will spend time in the laboratories of core and affiliated faculty who conduct research in basic biomedical sciences. The rotations are arranged by the curricular core faculty at the beginning of the year, with scheduled rotations throughout the 4 blocks. Research among these faculty is being conducted in all of the biological, cellular, and molecular sciences across campus, and each student's rotation schedule will be designed to provide breadth of exposure to research methodologies in biomedical sciences, but with some individualization related to student career plans. Students will receive five course credits upon completion of each 10-week block. Therefore, across Blocks 1-4 during the first year, students will receive a total of 20 course credits.

(b) Description of Year 1 Summer Practicum on Innovation and Entrepreneurship: At the end of Year 1 (first summer session), students in the clinical and translational science program will participate in a five-week Practicum on Innovation and Entrepreneurship. The Practicum will not require rotations to diverse sites, but instead will involve closely mentored, small group experiences in which student/faculty teams will provide direct assistance to MU faculty entrepreneurs who desire assistance. When useful, simulated projects also may be used for teaching purposes. The Practicum will provide in-depth training experiences which pertain to intellectual property, licensing, sources of capital, business incubation, and business start-up. Using the PBL educational format, students will analyze business "problems," write business plans, and learn to read financial reports. Students will receive two course credits at the completion of the summer Innovation and Entrepreneurship/Practicum. For doctoral students, participation in innovation/entrepreneurship projects that begin during the Summer Practicum on Innovation and Entrepreneurship may continue into other parts of the curriculum (Year 2 laboratory rotations; Year 3 supervised experiences; Year 4 projects). These opportunities will provide students with exposure to commercial partners, especially in the form of faculty start-ups.

(c) Description of Year 2 Blocks: During Year 2, students will continue to rotate through four additional 10-week blocks. In Block 5, the research problems for the PBL component will involve human dynamic disturbances, genetic disorders, autoimmune diseases, immune deficiency, and hypersensitivity. However, the research methods components during Year 2 will focus on clinical and health services research methodologies. Therefore, the level of analysis for the clinical and translational science students will shift from research methods pertaining to translational biomedicine to research methods involving human participants, which will add a new dimension to the clinical and translational science curriculum. In Block 6, the research problems will involve cardiovascular, respiratory, blood disorders, and nutritional disease; the research methods component will involve exposure to clinical and epidemiologic research design and statistics. In Block 7, the research problems will involve gastrointestinal, liver, endocrine, renal, and genitourinary disorders; the research methods component will provide exposure to clinical trials design and related statistical analyses. In Block 8, the research problems will involve clinical microbiology, antibiotics, musculoskeletal, skin, and nervous system disorders; the research methods component will emphasize population-based studies and advanced biostatistics. In each of the blocks of the second year (Blocks 5 – 8), the students will rotate in the research laboratories of core and affiliated faculty who conduct research in clinical and health services sciences. The rotations are arranged by the curricular core faculty at the beginning of the year, with scheduled rotations throughout the 4 blocks. Research among these faculty is being conducted in all of the clinical and health services research areas across campus, and each student's rotation schedule will be designed to provide breadth of exposure to research methodologies in clinical and health services research sciences, but with some individualization related to student career plans. Students will receive five course credits upon completion of each 10-week block for a total of 20 course credits across Blocks 5-8 of Year 2.

(d) Description of Year 2 Summer Health Care Practicum: At the end of Year 2 (second summer session), students in the clinical and translational science program will participate in a 5-week summer Health Care Practicum. For a clinical and translational scientist, a keen understanding of the challenges facing practitioners and the operational dynamics of a health care facility are critically important. Accordingly, clinical and translational science students will be required to rotate with health care providers in both inpatient and outpatient settings. Students will observe direct interactions with patients (following required authorizations), round with healthcare teams, attend clinical conferences, and gain exposure to the numerous systems involved in comprehensive clinical care (e.g., medical records, diagnostic laboratories, pharmacy operations, and the functions of ancillary personnel). In addition, the Health Care Practicum will involve exposure to administrative and financial systems that are required for health care operations. The primary mentor for the Health Care Practicum will be a physician in order to maximize the breadth and depth of the practicum experience. Students will receive two upper-level (8000/9000) course credits at the completion of the summer Health Care Practicum.

(e) Description of Year 3 Advanced Mentored Research and Emphasis Area Coursework: During Year 3, clinical and translational science students will pursue a program of mentored research within their selected emphasis areas. This year-long experience will involve supervised work within the research program of a mentor and will help to prepare students for their dissertation requirement in Year 4. The advanced mentored research experience will focus specifically on one of the three "emphasis areas" within the clinical and translational science curriculum, and the mentoring will be provided by a supervisor with expertise in the student's area of specialization. The requirement for the emphasis area will involve the completion of an advanced mentored research experience over four, 10-week blocks; students will receive two upper-level course credits per block for a total of 8 hours of course credit across the four advanced mentored research blocks during Year 3. In addition to the advanced mentored research experience, students also will be required to take 12 additional hours of upper-level (8000/9000) course credit in their selected emphasis area; these courses will be taken in traditional semester format. Examples of emphasis area course electives are as follows:

<u>Electives for Translational Biomedicine Emphasis Area</u>

BIOCHM 8090	Research in Biochemistry
BIOCHM 8360	Nutritional Biochemistry of Carbohydrates
BIOCHM 8390	Molecular Biology of Mineral Nutrition
BIOCHM 8438	Nutrient Regulation of Gene Expression
BIOCHM 9090	Research in Biochemistry
BIOCHM 9430	Molecular Biology I
BIOCHM 9432	Molecular Biology II
BIOCHM 9460	Cancer Biology
BIO EN 8085	Problems in Biological Engineering
BIO EN 8170	Sensors and Biosensors
BIO EN 8270	Principles and Applications of Fluorescence
BIO SC 8340	Advanced Microscopy Techniques
BIO SC 8350	Advanced Cell Biology
BIO SC 8440	Integrative Neuroscience I
BIO SC 8442	Integrative Neuroscience II
BIO SC 8450	Development Neurobiology
BIO SC 8982	Advances in Human Genetic Disorders
BIO SC 9090	Research in Biological Sciences
MICROB 8404	Mechanisms of Microbial Pathogenesis
MICROB 9090	Research in Microbiology
MICROB 9403	Advanced Medical Microbiology
MICROB 9407	Advanced Immunology
MPP 8411	Mammalian Pharmacology and Physiology
MPP 9421	Neuropharmacology
MPP 9423	Oncological Pharmacology
MPP 9424	Principles of Drug Action
MPP 9425	Receptor Pharmacology
MPP 9426	Transmembrane Signaling
MPP 9427	Drug Metabolism
MPP 9430	Cardiovascular Physiology
MPP 9436	Renal Physiology
NUTR S 8310	Nutritional Biochemistry of Lipids

NUTR S 8340	Nutrition in Human Health
NUTR S 8850	Advanced Exercise Physiology
NUTR S 8870	Exercise Metabolism

Electives for Clinical Research Emphasis Area

F&CMD 8421	Clinical Epidemiology/Evidence-based Medicine
F&CMD 8422	Clinical Research Methods I
F&CMD 8423	Clinical Research Methods II
HMI 8435	Information Security and Policy
HMI 8441	Controlled Terminology Theory and Application
NURS 9410	Advanced Research Methods in Nursing
PSYCH 8730	Data Management and Analysis in Psychology
PSYCH 9330	Applied Research Methodology
PSYCH 9575	Clinical Research Methods
PSYCH 9710	Multivariate Statistics in Psychology
PSYCH 9720	Latent Variable Models in Statistical Analysis
PSYCH 9745	Small Sample-size Design and Analysis
STAT 8310	Data Analysis I
STAT 8320	Data Analysis II
STAT 9410	Reliability, Theory and Survival Analysis
STAT 9810	Advanced Probability
VPB 8421	Epidemiology
VMS 8431	Research Methods and Data Analysis

Electives for Health Services Emphasis Area

CS 8370	Data Mining and Knowledge Discovery
CS 8380	Database Management Systems II
F&CMD 8330	Statistical Aspects of Public Health
F&CMD 8430	Applications of Evidence-based Medicine I
F&CMD 8431	Applications of Evidence-based Medicine II
HDFS 8710	Children, Families, and Public Policy
HMI 8450	Methods of Health Service Research
JOURN 8006	Quantitative Research Methods in Journalism
JOURN 8008	Qualitative Research Methods in Journalism
JOURN 8010	Advanced Qualitative Methods in Journalism
JOURN 8016	Advanced Quantitative Research Methods
NURS 8100	Epidemiology for Public Health Practice
NURS 8120	Community-based Public Health Interventions
NURS 8130	Developing and Evaluating Public Health Programs
PUB AF 8180	Research Methods and Inquiry in Public Affairs I
PUB AF 8181	Research Methods and Inquiry in Public Affairs II

The prerequisites for admission to the MS and PhD programs in clinical and translational science will ensure a firm foundation for advanced studies in basic sciences, statistics, and research methodology. Similarly, the PBL curriculum Years 1 and 2 will be constructed to provide the required foundation for the upper-level coursework that will occur in Year 3. In combination, the completion of four, mentored research blocks (8 hours of upper-level course credit) and the 12 hours of upper-level coursework will exceed the requirements for the selected emphasis areas.

(f) Description of Year 3 Summer Practicum on Science Writing: At the end of Year 3 (third summer session), students in the clinical and translational science program will participate in a 5-week Science Writing Practicum. The purpose of the Science Writing Practicum will be to refine the writing skills of clinical and translational science students and to provide focused training in the area of grant-writing. Participation in the summer Practicum will facilitate the completion of multiple writing projects (e.g., manuscripts from mentored research activities, literature reviews, and early-career applications to funding agencies). The Science Writing Practicum also will facilitate the preparation of dissertation proposals. Students will receive two upper-level (8000/9000) course credits at the completion of the summer Science Writing Practicum.

(g) Description of Year 4 Dissertation: During Year 4, students in the clinical and translational science program will pursue dissertation research under the supervision of a faculty advisor and a dissertation committee. In combination, the PBL curriculum, the research laboratory exposure, the advanced mentored research experience, and the emphasis area coursework will effectively prepare students to engage in dissertation work; students will receive three course credits at the completion of each 10-week block of dissertation work for a total of 12 hours of course credit during Year 4.

(h) Description of Year 5: Although the PhD degree in clinical and translational science may be attained within 4 years in some cases, many students will require an additional year to fully develop independent research skills and to complete the dissertation requirement.

6. Emphasis Areas: By design, an advanced degree in clinical and translational science will require a breadth of knowledge that spans from pre-clinical science, to clinical application, to an in-depth understanding of health care systems. Accordingly, the core program in clinical and translational science will provide a basic foundation of knowledge in multiple areas. However, to prepare doctoral level students who are able to conduct original research, the advanced degree program also will require that an "emphasis area" be declared in one of three possible specialized areas: (a) translational biomedicine, (b) clinical research, or (c) health services research.

Within the emphasis area, clinical and translational science students will be required to develop specialized expertise that will permit them to identify the leading scientific edge of their selected research fields and to acquire a comprehensive understanding of the research methods and techniques that are required for original scientific work. Whereas the core program in clinical and translational science will help students develop a broad, translational context for their research, the emphasis area will facilitate the acquisition of skills needed to conduct cutting-edge science within a focused research domain. The emphasis area primarily will be developed through advanced mentored research activities that will occur during Year 3. Specifically, the advanced mentored research experiences will be supervised by faculty members who are experts in each student's selected emphasis area and, thereby, able to develop the specialized competencies that are required. Descriptions of the specific emphasis areas within the advanced degree program in clinical and translational science are as follows:

(a) Translational Biomedicine: PhD students who select the translational biomedicine emphasis area will develop specialized skills in the application of pre-clinical discoveries to human disease or medical problems. These students will develop the required competencies to evaluate the biomedical research literature, recognize potential clinical applications, and conduct original research in the area of translational biomedicine.

(b) Clinical Research: PhD students who select the clinical research area will develop specialized skills in the design, application, and analysis of clinical research pertaining to the diagnosis or treatment of medical conditions. These students will develop the required competencies to evaluate the clinical research literature, recognize potential health care applications, and conduct original investigations in the clinical research arena.

(c) Health Services Research**:** PhD students who select the health services research emphasis area will develop specialized skills in the translation of clinically relevant science (including clinical trials) into improved methods for health care delivery and evidence-based practice. These students will develop the required competencies to evaluate the health services research literature, recognize potential opportunities for improvement in health care outcomes, and conduct original investigations in the area of health services research.

Note: The Master's degree program in clinical and translational science will not involve emphasis areas.

7. Preliminary Exams: In all respects, Graduate School policies will be followed with regard to preliminary exams. For the PhD program, a comprehensive examination will be given after the Master's-level course requirements are met (following Year 2), but no later than the end of Year 3. An examination committee, chaired by the major advisor, will conduct a non-public oral examination in which committee members will examine the candidate on knowledge and critical thinking based on the domain of clinical and translational science. A preliminary examination will include a written dissertation proposal prepared in the format of a federal research grant and will be submitted to the committee at least two weeks prior to that portion of the examination. A public, oral presentation of the research proposal and a non-public oral examination will be required in which committee members will examine the candidate on the research proposal, including knowledge deemed essential to proceed with dissertation research.

The outcome of the preliminary examination can be pass, fail, or resubmission; a student can pass the examination with one dissenting vote. In the event that the committee members unanimously fail the student, the policies for dismissal will be those of the Graduate School. In the event that the committee members decide to ask the student to revise the examination material, the student will be permitted to revise the material, according to the suggestions from the preliminary examination committee, and the student will be allowed to resubmit.

8. Graduate Committee, Thesis, and Dissertation: For both Master's and doctoral students, a graduate committee will be formed to manage the admission process, evaluate educational needs, and advise students before they identify thesis or dissertation advisors.

Students will be encouraged to choose a major advisor by the end of Year 1 (Form D1) and a graduate committee by the middle of Year 2 (Form D2). Each student's graduate committee will consist of at least four faculty members. This committee will represent at least three faculty members from the University of Missouri Institute for Clinical and Translational Science and at least one participating faculty member from another department. Co-advisement by faculty in different disciplines will be encouraged.
The Master's program will require students to complete and defend a thesis and to pass a final oral examination; the thesis will demonstrate the student's ability to conduct an independent research project.

The doctoral program will require each student to defend a dissertation and pass a final oral examination. Students will enroll for course credit while pursuing dissertation work. The doctoral dissertation will demonstrate a high level of scholarly achievement and represent a substantive, original contribution to the field. In addition to the dissertation, students will be encouraged to present their work at scientific conferences and publish in appropriate peer-reviewed journals. Students will present their dissertations publicly at their final defense. Academic oversight for the program will be provided by an interdisciplinary curriculum committee with broad faculty representation. This model of governance will be similar to MU's "Area" PhD degrees.

9. **Outcome Objectives and Quality Control**: The Curriculum Committee will be responsible for establishing specific learning objectives for each program component (e.g., PBL blocks, summer institutes, advanced mentored research experiences, and research projects). Evaluation methods will include quizzes, tests, performance on group projects, mastery of skills/techniques, direct observation of competencies, and completion of criterion-based assignments/projects. Ongoing review of all program elements will be conducted and will include solicitation of direct feedback from both faculty and students. Specifically, a system for long-term follow-up of graduates of both the Master's and doctoral degree programs will be established in order to gather information to respond to changing social, scientific, and educational circumstances.

C. Form FP – Financial Projections (deleted)

E. Form PG – Program Characteristics and Performance Goals

1. **<u>Student Preparation</u>:** Students entering the program will be expected to have a strong, yet diverse, background in terms of their undergraduate or graduate courses. Although students who have not completed all prerequisite courses will be considered for admission, they will be required to have strong basic science backgrounds.

The preferred candidate will have completed a bachelor's degree in any area of science. Students having an undergraduate degree will be considered if they are graduated from an accredited school with a cumulative GPA at the undergraduate level of 3.5 or higher and have taken the GRE and scored above the top 70^{th} percentile. A minimum score on the Test of English as a Foreign Language (TOEFL) of 550 on the paper version; or 213 on the computer version; or 80 on the iBT version will be required to enter the clinical and translational science program. Demonstrated English proficiency, as reflected by a minimum score on the TOEFL of 600 or higher (250 or higher on the computer version), or completion of a University proficiency exam will be required to serve as a teaching and/or research assistant. As an alternative, the International English Language Testing System (IELTS) Academic Score of at least 5.5 may be substituted for TOEFL. All enrolled students will be expected to maintain a GPA of 3.0 or higher.

Students will be expected to furnish two letters of recommendation from professors/teachers with whom they have had substantial contact. All students who enter the program will be expected to have a face-to-face interview. However, in cases where the cost or timing of an interview would be prohibitive, phone interviews may be conducted. This requirement is due to the personalized nature of the program and the need to ensure that students have a clear understanding of the requirements of the program and the rigorous nature of the training (see Recruitment Section).

<u>Characteristics of a specific population to be served, if applicable:</u> Given the nature of the University of Missouri, the first goal will be to serve the population of our state, including both students and the population at large. The advanced degree program is designed to produce highly skilled graduates who can occupy top slots in clinical and translational science at academic, industrial, and healthcare institutions. Therefore, the program is expected to attract the top students from the University of Missouri system, other top universities within the state, and universities from surrounding states. The goal of the program is to gain both national and international recognition that will attract students from a wide range of backgrounds and locations.

2. <u>Faculty Characteristics</u>: <u>Special requirements for assignment of teaching for this degree/certificate</u>: This doctoral degree in clinical and translational science is an interdisciplinary program, which will include participating faculty members from several academic units at MU; all faculty will hold appointments with the University of Missouri Institute for Clinical and Translational Science. The categories of faculty who will be needed to deliver the Master's and doctoral programs in clinical and translational science represent several disciplines and academic departments and reflects the interdisciplinary nature of clinical and translational science (see Letters of Support from MU Deans). Faculty will come from existing or approved lines; no new faculty will need to be hired specifically for the advanced degree program in clinical and translational science. As a new campus entity, the MU-ICTS is still in the process of coordinating with Deans and Department Chairs on the specific faculty who can best support the problem-based curriculum, but the campus-wide support is exceptionally strong as reflected in the Letters of Support.

Based on the specific faculty commitments from the deans of MU schools/colleges, the composition of the faculty for the advanced degree program in clinical and translational science will cover content areas as follows:

Unit/Department	**Number**	**Content Areas**
Nursing	1	Health care systems, patient interaction
Health Mgmt/Informatics	7	Decision-support, health care systems, health informatics
Law	1	Intellectual property, patents, contracts
Physical Therapy	1	Musculoskeletal issues, disability
Engineering	7	Bioengineering, nanotechnology, imaging
Veterinary Medicine	2	Animal models of disease, pre-clinical trials
Education	1	Information technology, problem-solving
Computer Science	3	Computational biology, informatics, social networking
Health Psychology	1	Health psychology, rehabilitation psychology, neuropsychology
Journalism	1	Communication, scientific writing
Statistics	2	General statistics, multivariate methods, surveys
Biochemistry	1	Biochemistry
Microbiology	1	Molecular microbiology and immunology
Medical Pharm/Physiology	1	Pharmacology, physiology
Medicine	2	Anatomy, pathobiology, clinical research
Nutrition	1	Obesity, exercise physiology, metabolism

Faculty members participating in the advanced degree program in clinical and translational science will be required to have a PhD, MD, or other terminal degree for their specialty; they must meet the status for Doctoral and Graduate faculty as specified by the appropriate academic units. Specific requirements will include a strong research program, a sufficient number of peer-reviewed publications to meet the requirements of the MU Graduate Faculty Senate, and experience in an educational environment also is required.

The specific faculty members for the advanced degree program may change slightly at the point of implementation due to the complex balance for faculty among teaching, research, service, and administration. If substitutions are required, the representation from disciplines and spheres of expertise will be maintained. The faculty list as submitted within the CTSA application is as follows:

(Faculty List Available on Request)

Estimated percentage of credit hours that will be assigned to full-time faculty. Please use the term "full-time faculty" (and not FTE) in your descriptions here: Full-time faculty members will be expected to devote 50% of their time to PBL instruction or other related educational activities.

Expectations for professional activities, special student contact, teaching/learning innovation: Faculty involved in the clinical and translational science degree program will be expected to teach PBL blocks and/or host seminars/institutes and other scholarly activities in clinical and translational science. Faculty also will be required to train students within laboratory settings, and they will be expected to serve as advisors and/or members of Master's/doctoral committees.

Given that clinical and translational science is a new area, faculty members are not likely to individually possess the full-range of competencies that will be expected of graduates of the advanced degree program. Therefore, faculty within the University of Missouri Institute for Clinical and Translational Science will be expected to lead program components in which they possess specific areas of expertise, but faculty also will be expected to teach and collaborate in other program components that reflect the broad range of competencies required of students in the clinical and translational science program.

In order for students to obtain research experience, they will need to rotate through the laboratories of senior investigators. Therefore, a list of interdisciplinary mentors who have expressed a willingness to supervise student research projects is provided as follows:

Selected Mentors (N=30)	**Discipline**	**Research Area**
Frank Booth, PhD	Biomedical Sci	Physical inactivity
Marybeth Brown, PT, PhD	Physical Therapy	Physical frailty in older adults
Linda Bullock, PhD, RN, FAAN	Nursing	Social support and stress
Vicki Conn, PhD	Nursing	Medication adherence/management
Nelson Cowan, PhD	Psychology	Brain imaging
Kevin Dellsperger, MD, PhD	Cardiology	Valvular heart disease
William Fay, MD	Cardiology	Thrombosis/vascular biology
William R. Folk, PhD	Biochemistry	Plant biotechnology/medical uses
Craig Franklin, DVM, PhD	Pathobiology	Intestinal mucosal inflammation
Shubhra Gangopadhyay, PhD	Bioengineering	Micro-fluidics and Biosensors
Mark Hannink, PhD	Biochemistry	Oncogenisis/neurodegeneration

Carolyn J. Henry, DVM, PhD	Veterinary Med	Animal models of cancer
Lanis L. Hicks, PhD	Health Mgmt	Health economics
Virginia Huxley, PhD	Physiology	Metabolic domains
Kattesh V. Katti, PhD	Physics	Radiopharmaceuticals, cancer therapy
M. Harold Laughlin, PhD	Biomedical Sci	Coronary circulation
Gerald A. Meininger, PhD	Physiology	Vascular physiology
Mark A. Milanick, PhD	Physiology	Membrane physiology/biophysics
Judith Miles, MD, PhD	Child Health	Autism
Randall S. Prather, PhD	Animal Science	Genetically-engineered swine
Marilyn Rantz, PhD	Nursing	Quality of nursing home care
Kenneth J. Sher, PhD	Psychology	Addictive behavior
Shivendra D. Shukla, PhD	Pharmacology	Molecular pharmacology of ethanol
Jinglu Tan, PhD	Bioengineering	Image-processing
Ronald L. Terjung, PhD	Biomedical Sci	Peripheral arterial insufficiency
Wynn A. Volkert, PhD	Chemistry	Radiolabeled peptides
Bonnie Wakefield, PhD, RN	Nursing	Medication administration errors
Deidre Wipke-Tevis, PhD, RN	Nursing	Nutrition and wound healing
Cuihua Zhang, MD, PhD	Cardiovascular Med	Metabolic syndrome in diabetes
Steven Zweig, MD, MSPH	Family Medicine	Aging

3. Enrollment Projections: Student FTE majoring in program by the end of five years: The planned enrollment for the initial class is 10 students (4 Master's and 6 doctoral), with 10 new students admitted each year to a steady-state of 32 students within 4 years. This figure represents a balance between achieving critical mass and ensuring excellence in the training of students.

Percent of full-time and part-time enrollment by the end of five years: Virtually all of the students enrolled in both the Master's and doctoral programs are expected to be full-time.

4. Student and Program Outcomes: Number of graduates per annum at three and five years after implementation: Master's students are expected to require two years to complete the MS degree; doctoral students are expected to require four years to complete the PhD degree. Therefore, at the end of three years, the expected graduation rate would be four MS students per year. At the end of Year 5, the expected graduation rate would be four MS students per year and six PhD students per year.

Special skills which are specific to the program: Master's-level graduates will be able to function effectively within clinical and translational science teams and/or to augment their core professional training with the clinical and translational science perspective. Doctoral-level graduates will possess the skills needed to pursue careers as independent clinical and translational scientists who are capable of conducting original research.

Proportion of students who will achieve licensing, certification, or registration: No specific licensing or registration programs exist for graduates of clinical and translational science programs.

Performance on national and/or local assessments, (e.g., percent of students scoring above the 50th percentile on normed tests; percent of students achieving minimal cut-scores on criterion-referenced tests. Include expected results on assessments of general education and on exit assessments in a particular discipline as well as the name of any nationally recognized assessments used). Since this is a doctoral degree program with no accreditation, students will not be expected to take further standardized tests during the program or after graduation.

Placement rates in related fields, in other fields, unemployed: Virtually all Master's degree students will be expected to find employment working within multidisciplinary or interdisciplinary research teams that are pursuing clinical and translational research. Virtually all doctoral students will be expected to find employment working as scientists within public or private research institutions.

Transfer rates, continuous study: A retention rate of 95% is anticipated based upon longitudinal statistics from the medical school, which also uses a PBL educational model.

5. Program Accreditation: Institutional plans for accreditation, if applicable, including accrediting agency and timeline. If there are no plans to seek specialized accreditation, please provide reasons. No accrediting body currently exists for clinical and translational science.

6. Alumni and Employer Survey: Expected satisfaction rates for alumni, including timing and method of surveys: Alumni will be surveyed as follows:

(a) One month post-graduation, to assess satisfaction with the program and employment status.
(b) One year post-graduation, to assess how the program helped them prepare for their current job.
(c) Three, six, and nine years post-graduation, to assess long-term satisfaction with the program, employment status, and opinions about content areas they believe are most applicable in the current environment.

Surveys will be mailed to alumni, either by physical mail or by e-mail. Alumni will be tracked by the University alumni office to ensure that their current addresses and contacts are on file. Surveys will consist of a 10-question "numeric" section, which will gauge alumni satisfaction with the program; there also will be a short 5-question section which will poll alumni about changes in the field and allow for feedback on changes needed within the program. In addition, the survey will clarify the employment status of alumni and reveal how many are working in industry or academic settings.

<u>Expected satisfaction rates for employers, including timing and method of surveys</u>: Employers will be polled yearly to find out if their employment needs have changed and to determine how satisfied they are with the quality of applications received from program graduates. If they have employed graduates, employers will receive the employment survey to assess their satisfaction with employee skills. Employers will be surveyed once every three years to determine their level of satisfaction with the quality of students from the program and, in particular, their level of satisfaction with those that have been employed within their workplace within the past three years. Surveys will be mailed to the Human Resource departments of identified institutions and will consist of a 15-question "numeric" survey with a section for open comments on contacts within the program and graduates.

IV. ACCREDITATION

There is no accreditation available for advanced degree programs in clinical and translational science.

V. INTSITUTIONAL CHARACTERISTICS

A. Overview

The mission of the University of Missouri, as a land-grant university and Missouri's only public research and doctoral-level institution, is to discover, disseminate, preserve, and apply knowledge. The University promotes learning by its students and lifelong learning by Missouri's citizens, fosters innovation to support economic development, and advances the health, cultural, and social interests of the people of Missouri, the nation, and the world. The University of Missouri has provided teaching, research and service to Missouri since 1839. The University, the first publicly supported institution of higher education to be established in the Louisiana Purchase territory, was shaped in accordance with the ideals of Thomas Jefferson, an early proponent of higher education. The University remained a single campus until the School of Mines and Metallurgy was established in Rolla in 1870. In the same year, the University assumed land-grant responsibilities of providing higher education opportunities for all citizens. In 1963, the University again expanded to better serve Missouri by founding a new campus in St. Louis and acquiring the University of Kansas City, creating the present four-campus system. Today, the University of Missouri is one of the nation's largest higher education institutions, with more than 63,000 students on four campuses and an Extension program with activities in every county of the state.

1. <u>Local Community</u>: The MU world-class research university serves a predominantly rural, agricultural state with a total population of ~6 million. An important advantage of MU's location is our ready access to racial/ethnic groups from a predominantly rural population. With a population of ~800,000 within a primary catchment area of 30 counties in central Missouri and more than 200,000 in the immediate Boone County area, we are well situated to recruit graduate students locally and nationally.

2. <u>Institution</u>: The University of Missouri-Columbia (MU), the flagship of a four-campus system, offers an extensive array of professional, graduate, and undergraduate programs, with nearly 250 degree programs in 13 schools and colleges, more than 25,000 students, and 5,000 faculty and staff. MU is one of only six universities nationwide with schools of medicine, veterinary medicine, agriculture, engineering, and law, and an outstanding healthcare environment including a nationally recognized cancer center, all on the same campus. Faculty from these disciplines and those from arts and science, human environmental sciences, nursing, and MU's Research Reactor comprise one of our biggest assets: a unique combination of resources that makes groundbreaking collaborative research and research training possible. MU is accredited by the North Central Association of Colleges and Secondary Schools. As a member of the American Association of Universities (AAU) and a university classified "Doctoral/Research Universities – Extensive" by the Carnegie Foundation for the Advancement of Teaching, MU is a premier provider of undergraduate, graduate and professional education and is perfectly suited to host the new advanced degree program in clinical and translational science. Approximately one-third of MU's budget comes from state appropriations. The sources of the remainder of the budget include private gifts, grants, contracts, student tuition and fees, auxiliary enterprises and University Hospitals and Clinics. In FY 2004, MU expenditures from externally sponsored grants and contracts totaled over $162 million.

MU's 25,000 select and diverse students include 5,527 graduate and 1,100 professional students from all 50 states and over 100 countries. Approximately 85% of MU's undergraduate students are Missouri residents. The number of MU students who are National Merit/Achievement Scholars places MU among the top 20 public institutions nationally. The Columbia campus has approximately 1,500 full-time faculty. It is unusual to find a major research university, rich in academic resources, in a rural, Midwestern setting. At MU, a nationally known Cancer Center, School of Medicine (SOM), College of Veterinary Medicine (CVM), College of Agriculture and Natural Resources (CAFNR), College of Engineering (COE), School of Public Policy, a world-class Research Reactor (MURR), perhaps the best Journalism School in the country, and basic sciences departments housed within a College of Arts and Science are all located at a single contiguous site. As a result, this campus houses numerous interdisciplinary research and training programs that heavily emphasize biomedical research and development that crosses many boundaries.

B. Interdisciplinary Life Sciences Culture

The University of Missouri-Columbia has a long and successful history of interdisciplinary research in the life sciences. Several of these interdisciplinary programs are particularly relevant as resources and infrastructure upon which the advanced degree program in clinical and translational science will be built. Examples of the interdisciplinary life sciences culture are as follows: (1) Life Sciences Mission Enhancement, (2) Bond Center, (3) Dalton Cardiovascular Research Center, (4) Health Activity Center, (5) Research Reactor, (6) Institute for Nuclear Science and Engineering, (7) International Institute for Nanotechnology and Molecular Medicine, (8) Interdisciplinary Center on Aging, (9) Center for Health Care Quality, and (10) Missouri Arthritis Rehabilitation Research and Training Center.

C. Health Care and Medical Training Environment

An advanced degree program in clinical and translational science requires the existence of excellent health care facilities/infrastructure and a strong medical training environment. Such resources exist on the MU campus and include the following: (1) Ellis Fischel Cancer Center, (2) University of Missouri Health Care, (3) University Physicians, (4) School of Medicine, (5) Thompson Family Center for Autism and Neurodevelopmental Disorders, (6) Biostatistics Support Group, (7) Department of Health Management and Informatics, (8) College of Veterinary Medicine, (9) Sinclair School of Nursing, (10) Rusk Rehabilitation Center, (11) Harry S. Truman Memorial Veterans' Hospital, (12) Missouri Telehealth Network, (13) Rural Health Network, and (14) Health Communication Resource Center.

D. Library Resources

An advanced degree program in clinical and translational science will require excellent library resources, but these needed facilities already exist on the MU campus. The Elmer Ellis Library, the main library in the MU system, occupies a central block on campus. Six branch libraries, including Veterinary Medicine and Health Sciences Center Libraries, are located throughout the campus. The MU Libraries comprise the 47th largest research collection in North America with holdings of 2.6 million books and 5 million microforms. The MU Libraries subscribe to over 16,000 periodical titles in various disciplines. Approximately 45 professional librarians, 118 support staff, and many part-time student assistants staff the Libraries. Ellis Library contains the principal resources for research in the humanities, the social sciences, and the basic sciences. The building has several specialized collections, such as Government Documents, Recorded Sound, Rare Books, and an extensive microform collection. Subject librarians provide reference assistance, collection development, database searching and bibliographic instruction in their fields. They work closely with their faculty liaisons in academic departments.

E. Computing Resources

An advanced degree program in clinical and translational science will require excellent computing resources, but these needed facilities already exist on the MU campus. The Research Support Computing (RSC) group within the Information and Technology Services organization is focused on supporting the research community at MU. This support involves soliciting input from researchers throughout the campus to assess needs for specialized, high performance computing and networking resources, ensuring that the campus' computing and networking infrastructure is positioned to support these needs and to provide education, training and consulting to take maximum advantage of the resources available. The UM Bioinformatics Consortium is a four-campus collaboration to provide centralized high-capacity data storage and analytical tools that can be used over our high-speed Internet2 connections. The Research Support Computing (RSC) group in Information and Technology Services supports the research community at MU by soliciting input from researchers across campus to assess needs for specialized, high-performance computing and networking resources, ensuring that the campus computing and networking infrastructure is positioned to support these needs and to provide education, training, and consulting to take maximum advantage of the resources available.

F. Academic (non-clinical) Departments

Given the interdisciplinary nature of a clinical and translational science curriculum, the existence of several non-clinical departments and resources are also important for delivery of the program as follows: (1) Department of Statistics, (2) Division of Biological Sciences, (3) Department of Computer Science, (4) Digital Biology Laboratory, and (5) Department of Psychological Sciences.

APPENDIX A – PROPOSED NEW COURSES FOR THE CLINICAL AND TRANSLATIONAL SCIENCE Ph.D.

In a PBL curriculum, there will be no need for the development of new courses in the traditional sense, although there will be a need for extensive new curriculum development within the framework of the PBL approach. Specifically, Year 1 and Year 2 of the clinical and translational science program will involve eight PBL blocks, and each block will require the development of novel educational material. Specifically, each block will require faculty to conceptualize and prepare a series of research "problems" for students to solve, and these research problems/exercises will need to encompass the core content that students must master in that particular block. In addition, the clinical and translational science curriculum involves summer learning experiences that will need to be developed in an original format. The summer learning experiences will include the following: (a) a Practicum on Innovation and Entrepreneurship, (b) a Health Care Practicum, and (c) a Practicum on Science Writing. During Years 1-2 and the summer learning experiences, the clinical and translational science program will be based on a novel PBL educational model, so existing courses (in the traditional framework) will not meet training objectives. However, during Year 3 of the doctoral program, students will be enrolled in traditional courses, but all of these courses already exist on the MU campus. During Year 4, doctoral students will be involved in dissertation research.

APPENDIX B – CHBE CLARIFYING COMMENTS

1. Alignment with Institutional Mission: The vision of the University of Missouri is to be "recognized as one of the premier world-class public research universities in the country." The mission of the University of Missouri is "to discover, disseminate, preserve, and apply knowledge. The University promotes learning by its students and lifelong learning by Missouri's citizens, fosters innovation to support economic development, and advances to health, cultural, and social interests of the people of Missouri, the nation, and the world."

The proposed new advanced degree program in clinical and translational science is highly consistent with both the vision and the mission statements of the University of Missouri. Specifically, premier world-class universities are increasingly recognizing that a key research frontier pertains to the translation of basic life sciences discoveries into improved health-related outcomes for citizens; this theme is strongly underscored by the NIH Roadmap initiative, which will vastly increase future funding opportunities in the area of clinical and translational science. In addition, as a land-grant university, a key strategy for the University of Missouri is to foster economic development and to facilitate improved health care for citizens. The advanced degree in clinical and translational science will serve as a key venue for harnessing the innovative, basic life sciences research conducted by the faculty of the University of Missouri and translating this creative work into highly valued products and services for various constituencies.

2. Market Demand and Importance to Missouri's Economic and Educational Needs: Given the health care crisis facing the United States, both the NIH and major universities are recognizing the need to more effectively translate basic science discoveries into clinical applications and health care system improvements. Indeed, future NIH funding opportunities are expected to be closely tied to the ability of universities to assure clinical and translational environments for new research awards. Accordingly, most major universities are moving forward to establish advanced degree programs in clinical and translational science, and they are re-organizing their academic environments to more effectively foster clinical and translational scientific activities. Accordingly, there is expected to be a strong demand for graduates of clinical and translational science programs; they will emerge as future leaders in the advancement of innovation within health care systems. With innovation, opportunities for entrepreneurship and economic development also materialize.

3. Efficient Use of Resources: The advanced degree programs (Master's and doctoral) in clinical and translational science will provide opportunities for students in many other programs to augment their training with a new degree program. Specifically, physicians, nurses, health professionals, engineers, and basic scientists, among others, will be able to augment their primary professional training through the acquisition of clinical and translational research expertise. The existence of advanced degree opportunities in clinical and translational science is expected to be a major recruitment tool for both top-level graduate students and faculty. In addition, the MU-ICTS is conceptualized as a campus resource that brings existing faculty together in a manner that can optimize teaching, research, and service as related to clinical and translational science. Specifically, the MU-ICTS has been strongly supported by the deans of the schools and colleges on the MU campus, and 20 core faculty have been identified for major roles within the clinical and translational science program. For most all MU schools and colleges, clinical and translational science is already a high priority, so the MU-ICTS is an efficient mechanism for re-organizing resources and bringing a critical mass of talent together to help the campus meet goals and increase funding competitiveness.

4. Benefits of Collaborations and Lack of Duplication: The proposed advance degree program in clinical and translational science does not duplicate any existing educational programs in Missouri. Both MU and UMKC have schools of medicine, and both have basic life sciences research programs. Therefore, even though the new advanced degrees in clinical and translational science will be based at MU, all opportunities for collaboration between MU and UMKC in the clinical and translational science arena will be actively pursued (in a framework similar to nursing and/or pharmacy training collaborations between the MU and UMKC campuses). Indeed, the Schools of Medicine and the other health professions programs at MU risk a notable loss of national stature if re-invention of educational and research programs in clinical and translational sciences does not occur.

APPENDIX C – LETTERS OF SUPPORT (available on request)

1. Robert J. Churchill, MD, Interim Dean, School of Medicine

2. R. Lawrence Dessem, JD, Dean and Professor of Law, School of Law

3. Stephen R. Jorgensen, PhD, Dean and Professor, College of Human Environmental Sciences

4. Judith F. Miller, PhD, RN, FAAN, Dean and Professor, MU Sinclair School of Nursing

5. Dean Mills, PhD, Dean, School of Journalism

6. Michael J. O'Brien, PhD, Dean, College of Arts and Science

7. Richard E. Oliver, PhD, FASAHP, Dean, School of Health Professions

8. Neil Olson, DVM, PhD, Dean, College of Veterinary Medicine

9. Thomas L. Payne, PhD, Vice Chancellor and Dean, College of Agriculture, Food and Natural resources

10. Rosemary T. Porter, RN, PhD, Interim Dean, College of Education

11. James H. Ross, Chief Executive Officer, University of Missouri Health Care

12. James E. Thompson, PhD, PE, Dean and Ketcham Professor, College of Engineering

13. Bruce J. Walker, PhD, Dean, Raymond W. Lansford Distinguished Professor of Leadership, and Allen C. Bluedorn, PhD, Associate Dean for Graduate Studies and Research, and Emma S. Hibbs Distinguished Professor, Trulaske College of Business

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