Interdisciplinary Graduate Education Program in Regenerative Medicine
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Introduction

Regenerative medicine (RM) is a new medical approach that seeks to restore both structure and function of tissues lost to injury, disease or congenital defects. This field incorporates use of stem cells, proteins that stimulate healing, and engineered biomaterials to help cure diseases from diabetes to osteoarthritis. Regenerative strategies are modeled on mechanisms drawn from embryonic development and naturally-occurring examples of regeneration. This field represents a paradigm shift in biology, medicine and biomedical engineering. Ethical and societal impacts need to be considered as this rapidly expanding technology is developed. Furthermore, the swift translation of these technologies to the clinical realm provokes a need for both public policy considerations and practical feasibility from a business perspective. Leaders in RM must have training, understanding and interactions across diverse disciplines. An IGEP in RM will position Virginia Tech at the forefront of one of the most promising fields in medicine.

While promising and compelling in concept, the regeneration of complex tissues and organs to cure disease presents a myriad of biological, engineering and medical challenges. As an emerging medical paradigm, RM urgently requires development of new commercial and regulatory frameworks [2]. Existing infrastructures may be adequate for conventional surgical, drug and device-based treatments but are inadequate for commercially produced cells, tissues and organs. Moreover, the social implications of RM are complex and raise critical public policy issues including education of the general public, and patient access and empowerment. As the field grows, graduates with specialized training in each of these areas will be required [4]. Accordingly, our graduate training program will provide students the opportunity to conduct specialized research in stem cell biology, biomaterials, modeling and experimental design, business and public policy or science studies as related to RM.

Educational Goals: We aim to produce leaders in RM by training students in the broad complexities inherent to the field, beyond expertise gained in their specific disciplines. To accomplish this goal we will:

- Attract students with interests in disciplines represented by participating academic units.
- Offer a broad-based training experience incorporating scientific, engineering, societal, and business aspects.
- Engender heightened cross disciplinary understanding.
- Foster the placement of our graduates in leadership roles in RM.

Our IGEP will be among the first programs of its kind to equip students with a broad-based, graduate-level education in the field of RM.
Program Description

Virginia Tech is committed to an active and expanding role in RM. Our IGEP will build upon existing strengths in extramurally funded research, ongoing instructional efforts, and graduate student advising shared between CVM and COE. The newly established Center for Veterinary Regenerative Medicine (CVRM) is a formal collaboration between the CVM and the Wake Forest Institute for Regenerative Medicine including CVM faculty involved in this IGEP. CVM, COE, and VTCRI have existing and developing research projects that can form the basis for initial and future IGEP projects. Development of the IGEP provides an impetus for scientists and engineers to collaborate with science studies and business faculty to broaden our RM program, and leverage our research strengths to train students for careers in RM.

We have assembled faculty from each focus area to serve as mentors for graduate research and to develop and teach a comprehensive core course in RM (GRAD 5134). Each faculty member has research and teaching expertise in their respective fields that is directly applicable to the array of needs and challenges facing RM. Through a combination of specialized courses and the GRAD 5134 course in RM and expert mentoring in dissertation research, students will receive a unique, broad-based training experience to equip them for a variety of careers in RM.

Research and Educational Focus: Students enrolled in the RM IGEP will enter the program by way of their individual research interests and supplement their program of study with courses from five thematic areas.

- **Stem Cell Biology**: Stem cells are a key element in many RM strategies and are therefore a critical area of research advancement. A strong background in stem cell biology will be pivotal for students hoping to make a career in the field of RM. Students in this core area will gain a functional knowledge of embryonic and adult stem cell biology, preparing them to make an impact in this scientific field.

- **Biomaterials**: Inherently interdisciplinary on its own, the topic of biomaterials derives from engineering and chemistry backgrounds. In this RM IGEP one focus will be on materials used to achieve tissue regeneration through drug delivery, scaffolding, cellular delivery, or a combination of the three. Students in this core area will have the opportunity to explore synthesis, design, fabrication, and characterization of different biomaterials.

- **Social and Ethical Issues**: By studying social and ethical implications of RM, students will develop the skills for real-time technology assessment, larger meaning, context, and societal impacts in the growing area of RM. Students in this core area will be provided a unique opportunity for students in the humanities and business to explore more thoroughly a specific area of technology from a deeper perspective, as well as providing training typically overlooked in the engineering and sciences.

- **Experimental Design**: Rigorous disease modeling and experimental design are needed to investigate both the biological basis and clinical efficacy of RM-based therapies. Using stem cells introduces an increased need for long-term safety testing when evaluating RM technology. In this core area we will train graduate students in available in vitro and in vivo studies and the fundamentals of experimental design.

- **Business and Public Policy**: RM promises to foster innovation and growth of business enterprises that face entrepreneurial challenges as a result of the combination of cutting-edge science, complex technology transfer, and economic risk. These factors have important implications not only for businesses to be competitive, but also for effective public policy.
Existing courses and courses needed:

Courses in Development

- **GRAD 5134 Regenerative Medicine: Science and Society:** General introduction to how the entire RM field works together from stem cell biology, biomaterials/bioengineering, social and ethical issues, experimental design, and business and public policy.
- **MSE 5974 (CHE 5974) In vitro and In vivo Design of Experiment:** Case studies and peer-reviewed articles will be used to guide discussion on aspects of study design.

Existing Courses

- **BMES 5984 Special Studies (Regenerative Medicine)**
- **STS 5424 Topics in Science and Technology Studies**
- **STS 5444 Issues in Bioethics**
- **STS 5614 Introduction to Science and Technology Policy**
- **STS 6624 Advanced Topics in Life Sciences and Medicine**
- **MSE 4574 (ESM 4574) Biomaterials**
- **GRAD 5134 Polymers in Medicine and Biology**
- **CHE 5214 (BMES 5434) Polymeric Biomaterials**
- **BMVS 5214 Pharmacology and Toxicology Testing**
- **BMVS 5224 (BMES 5024) Biomedical Engineering and Human Disease**
- **BMVS 5284 Cellular Pathology**
- **BMVS 5564 (VM 8534) Introduction to Clinical Research**
- **MGT 5594 Technology and Innovation Management**
- **MGT 5834 Essentials of Management of Technology**
- **MKTG 5254 Product Strategy**
- **MKTG 5444 Marketing, Management and the Public Purpose**
- **MKTG 5564 Marketing of High Technology**

Student recruitment: Our primary goal will be to attract the best and brightest students with a genuine enthusiasm for the multidisciplinary nature of our program. Initially, students for the IGEP in RM will be recruited from pools of candidates applying through existing Biomedical Veterinary Sciences (BMVS), COE, Science and Technology Studies (STS), and PCoB graduate programs. Aided by an IGEP-specific website linked to these programs, we will work closely with graduate coordinators to bring the RM IGEP opportunity to the attention of applicants. The website will contain details of the interdisciplinary program and the enrichment it provides to the associated programs, information on the core faculty and their areas of research interest, as well as links for contact information and to the graduate school.

To attract subsequent student cohorts, we will distribute RM IGEP posters and brochures to selected undergraduate programs with a reputation for producing excellent students in our diverse subject areas. We will utilize social media outlets such as Facebook, LinkedIn, and Twitter to post information about upcoming activities, deadlines, and research milestones. Additionally, we will recruit at conferences with significant undergraduate attendance.

A Steering Committee representing all participating units will review applications of candidates seeking support under the RM IGEP. Applicants meeting prevailing requirements of individual programs and for whom provisional advisors can be identified will be recommended for admission by the graduate committees of host departments under the aegis of the RM IGEP. Every effort will be made to allocate assistantships equitably among the participating programs.
**Student retention:** We regard the recruitment of motivated students and their judicious matching to fully-engaged advisors as the first step in successful retention. Thereafter, the Steering Committee will review annually each supported student’s progress toward a PhD, with reliance on input from the trainee’s graduate committee and assessments of instructors in courses of special relevance to the RM IGEP. In order to foster a sense of community, programmatic activities will include journal clubs focused on relevant scholarly developments, and social gatherings including periodic poster sessions working towards an internal research symposium. We will aim to develop an RM seminar series featuring leaders in the field.

**Reaching a steady state of graduate students:** We believe that recruitment of strong students early in the program’s life will be crucial to its subsequent success. Once our first cadre of students is in place, we will partner with them in hosting well-qualified candidates during campus visits, an approach that can heighten both eagerness among applicants and engagement among existing students. Programmatically, we will consider guiding RM IGEP students to the recently-approved Certificate in Translational Research, the requirements of which partially overlap the aims of our proposal, or explore the possibility of creating a new Certificate program tailored to the unique mission of the RM IGEP. Development of a well-justified Certificate program should be achievable in a 1-2 year time frame and would provide a desirable form of program identity, a beacon for student recruitment, and a feather in the caps of our RM IGEP graduates.

**Plan for securing funds for assistantships:** IGEP funds received from VT will be used as seed funding to develop this dynamic program, recruit the first cadre of students, strengthen existing collaborations, and aid in the development of new ones, especially those with STS and PCoB. The developing strength of the program after the first three years will position us to compete for extramural funding designed specifically to support future graduate student assistantships. Such programs include NIH T32, NSF IGERT (e.g. Biomedical Engineering and Science, Technology, and Society), DoEd GAANN programs, and the newly announced NSF CREATIV (Creative Research Awards for Transformative Interdisciplinary Ventures). The NSF Ethics Education in Science and Engineering program would be appropriate for this integration of emerging technology research and social and ethical issues within the context of RM. The novelty of these combined disciplines and their individual histories in procuring funding are expected to provide a competitive platform from which to launch this campaign to secure ongoing extramural funding to sustain the proposed program.

**Program assessment and outcomes:** Assessment will include development of an advisory board consisting of faculty from all four colleges to quantify the success of the program. Exit interviews conducted with graduating students will be used to develop a tracking matrix to assess how training has influenced former students’ careers. To demonstrate full integration within the proposed IGEP, each student will be required to address in their dissertation broader aspects of RM outside of their scholarly focus. Additionally, we plan a minimum of two joint grant submissions by year 2 of the program and will create a matrix for number of publications and presentations per year to demonstrate the success of our research and education program.
9 November 2011

Dr. Karen P. DePauw
Vice President and Dean for Graduate Education
Virginia Tech
Graduate Life Center 235

Dear Dr. DePauw,

The Virginia-Maryland Regional College of Veterinary Medicine enthusiastically supports the proposed Interdisciplinary Graduate Education Program in Regenerative Medicine. We believe this program will enhance existing collaborations in the area of regenerative medicine as well as provide a unique training opportunity for our graduate students. The proposed program has grown out of both existing and new collaborations and has been developed by faculty in our College, College of Engineering, the College of Liberal Arts and Human Sciences, and Pamplin College of Business. This extraordinary approach of combining the clinical need and current treatments, stem cell biology, biomaterials, social/public policy issues, modeling and experimental design, and commercial development would provide students with the broad-based training and education to become leaders in the rapidly growing field of regenerative medicine.

Sincerely,

Gerhardt G. Schurig, Dean WMRGVM

S. Ansar Ahmed, Department Head Biomedical Sciences and Pathobiology

Roger J. Avery, Senior Associate Dean, Research and Graduate Studies

Gregory B. Daniel, Department Head Small Animal Clinical Sciences

David R. Hodgson, Department Head Large Animal Clinical Sciences

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9 November 2011

Dr. Karen P. DePauw
Vice President and Dean for Graduate Education
Virginia Tech
Graduate Life Center 235

Dear Dr. DePauw,

The College of Engineering enthusiastically supports the proposed Interdisciplinary Graduate Education Program in Regenerative Medicine. We believe this program will enhance existing collaborations in the area of regenerative medicine as well as provide a unique training opportunity for our graduate students. The proposed program has grown out of existing collaborations and has been developed by faculty in the Virginia-Maryland Regional College of Veterinary Medicine, College of Engineering, and the College of Liberal Arts and Human Sciences. This extraordinary approach of combining the clinical need and current treatments, stem cell biology, biomaterials, social/public policy issues, modeling and experimental design, and commercial development would provide students with the training and education to become leaders in the rapidly growing field of regenerative medicine.

Sincerely,

Richard Benson, Dean College of Engineering

John Y. Walz, Depart Head Chemical Engineering

Ishwar K. Puri, Dept Head Engineering Science and Mechanics

David Clark, Dept Head Materials Science and Engineering

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November 11, 2011

Dr. Karen P. DePauw
Vice President and Dean for Graduate Education
Virginia Tech
Graduate Life Center 235

Dear Dr. DePauw,

We support the proposed Interdisciplinary Graduate Education Program in Regenerative Medicine. We believe this program will enhance existing collaborations in the area of regenerative medicine as well as provide a unique training opportunity for our graduate students. This creative approach of combining the clinical need and current treatments, stem cell biology, biomaterials, social/public policy issues, modeling and experimental design, and commercial development would provide students with the broad-based training and education to become leaders in the rapidly growing field of regenerative medicine.

The involvement of Assistant Professor Ashley Shew and Professor Doris Zallen of the Department of Science and Technology in Society on the steering committee for this new interdisciplinary approach to regenerative medicine ensures that the perspectives of the social and human sciences will be incorporated into the program. As the IGEP develops, we hope it will draw upon additional faculty and departments to offer graduate courses, advise students, and develop thesis topics. The involvement of CLAHS faculty, along with faculty from the Colleges of Veterinary Medicine, Engineering, and Business, indicates the great potential for this IGEP to create new research opportunities for graduate students and faculty.

We look forward to working with the departments and faculty involved in this proposal, which brings a broad range of interdisciplinary perspectives to an important field.

Sincerely,

Sue Ott Rowlands
Dean, CLAHS

Ellsworth (Skip) Fuhrman
Professor and Chair, Department of Science and Technology in Society,
Director, Science and Technology Studies Graduate Program
November 10, 2011

Dr. Karen P. DePauw
Vice President and Dean for Graduate Education
Virginia Tech
Graduate Life Center 235

Dear Dr. DePauw:

With the initial participation of the Department of Management and Department of Marketing, the Pamplin College of Business enthusiastically supports the proposed Interdisciplinary Graduate Education Program in Regenerative Medicine. We believe this program will enhance existing collaborations in the area of regenerative medicine as well as provide a unique training opportunity for our graduate students.

The proposed program has grown out of existing collaborations and has been developed by faculty in the Virginia-Maryland Regional College of Veterinary Medicine, College of Engineering, Pamplin College of Business, and the College of Liberal Arts and Human Sciences. This extraordinary approach of combining the clinical need and current treatments, stem cell biology, biomaterials, social/public policy issues, modeling and experimental design, and commercial development would provide students with the training and education to become leaders in the rapidly growing field of regenerative medicine.

Sincerely,

Richard E. Sorensen
Dean
RES/dj

cc: Kay Hunnings, Associate Dean for Administration
    Ken Nakamoto, Associate Dean for Research and Head of Marketing
    Anju Seth, Head of Management

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Karen DePauw, Ph.D.
Dean of the Graduate School, VT

Dear Karen,

I am writing to enthusiastically support the proposed IGEP in regenerative medicine proposed by Willard Eyestone. As you know, the VTCRI is building biomedical research programs in a variety of areas. One area that undergirds many of our programs is regenerative medicine. That is, cell and tissue repair and recapitulation relaying on the biology and engineering approaches is central to our research programs in neuroscience, cardiovascular science and cancer biology. In fact, we are currently in the process of negotiating with a senior faculty member at another institution who works in the area of tissue repair and regeneration in the skin and in the heart. He would bring a substantial NIH funded research program here with several students and staff. His work spans cell and molecular biology, bioengineering and computation. In addition, we have made another faculty offer to a person who works in the area of nervous system aging and regeneration and we also have investigators at the VTCRI working in areas of cancer biology stem cells as well as in neurorehabilitation including brain machine interfaces. These are all areas where we will be continuing to build our own strengths as well as to partner with other programs and institutions such as Wake Forest University. As you may know, our programs in neuroscience research also make forays into the social science aspects of the biomedical research ongoing at the VTCRI such a policy, ethical impact of the scientific discoveries an decision-making. In fact, at the VTCRI, we have considerable expertise and funding in these areas as well. Thus, we are eager to interface some of these approaches with the regenerative medicine research. In addition, we have a strong and growing collaborative relationship with several clinical groups at Carilion such as Emergency Medicine where we are developing collaborative research ties.

It is in this context that I want to offer my very strong support to the proposal for the Regenerative Medicine IGEP. It would provide a key component to enable the recruitment of graduate students to work in the funded labs of some of the investigators who we are recruiting, provide a critical tie through graduate training between VTCRI and other programs at VT, and would help to strengthen the universities extramural funding portfolio in this important area of health related research. I know personally from meetings I have been part of over the last several months with NIH and AAMC leaders that this area of science and health research will continue to be very strongly supported even in a climate of very tough economics for all research and thus, a program such as the proposed IGEP would definitely be a valuable component of a larger portfolio for VT in this area.

Sincerely,

Michael J. Friedlander, Ph.D.
Executive Director, VTCRI
Professor of Biological Sciences, Core Faculty, SBES
Senior Dean for Research, VTCSOM