RE-Training Overview and Activities

The objective of this program is to train PhD students through collaborative work with established investigators in academia, clinical medicine, and leading researchers in industry in an environment of state-of-the-art knowledge and technologies in regenerative engineering. This program will enable students to acquire fundamental knowledge in developmental and stem cell biology, regenerative medicine and engineering, and translational medicine; gain the ability to design experimental models to understand human disorders and develop engineering systems for controlling cell and tissue regeneration; attain expertise of translating basic discoveries to clinical applications; and ultimately help develop regenerative engineering-based treatment strategies. We are requesting 6 slots, starting with 3 slots in year 1. The objective will be achieved through the following training strategies.

Required Courses and Electives The pre-doctoral curriculum consists of 12 courses from the areas of mathematics/statistics, engineering, biology, physiology, and independent research based on the Biomedical Engineering Department policy. Students must take 2 mathematics/statistic courses, 2 biology and physiology courses, 1 quantitative sciences and engineering course, and 7 elective courses from science and engineering areas. The 7 elective courses may include up to 2 graduate independent research courses. These are quarter-based courses with each course equivalent to 1 credit. Trainees must complete 4 courses from the following 3 areas – *Developmental and Stem Cell Biology, Regenerative Medicine and Engineering, and Translational Medicine*. These 4 courses are counted toward the 7-elective course requirement. Below are the courses in these 3 areas that will be offered.

1. Developmental and Stem Cell Biology

BIOL SCI 391 Development and Evolution of Body Plans This course is focused on the molecular mechanisms underlying early embryonic development, morphogenesis of organ systems, and relationship between structure and function. Student performance will be assessed based on knowledge acquirement and completion of a research design project report. This is a required course for all trainees.

2. Regenerative Medicine and Engineering

BMD ENG 346 Tissue Engineering This engineering course is focused on the fundamental principles behind tissue engineering, the matrix or scaffold, the cellular components, and the signaling that is required to grow tissues in the laboratory setting or in the body. It is thought via student-directed learning methodology so that they can have an immersive experience into the aspects of the topic that they are most interested in understanding. This course has a significant discussion component that enables cross-fertilization of ideas and learning methods.

BMD ENG 347 Foundations of Regenerative Engineering . This engineering course covers the fundamentals of regenerative engineering, including embryonic development, stem cell biology, cell signaling systems, recombinant biotechnology, gene transfer, gene editing, gene silencing, stem and somatic cell preparation and transplantation, cell function assessment, and tissue scaffold construction, implantation, and functional assessment. Student performance will be evaluated based on knowledge acquirement and a research proposal addressing a regenerative medicine and engineering problem.

BMD_ENG 348 Applications of Regenerative Engineering This engineering course covers the pathogenic mechanisms (impact of environmental factors and gene mutations),

pathology, pathophysiology, conventional interventions, and regenerative engineering strategies for selected human disorders, including traumatic brain injury, spinal cord injury, peripheral nerve injury, hepatitis, cirrhosis, diabetes, atherosclerosis, ischemic heart disease, arterial aneurysms, and skin injury. This course is a continuation of BMD ENG 347. The criteria for BMD ENG 347 will be used for evaluating student performance.

**BMD ENG 495 Experimental Regenerative Engineering Laboratory* The Center for Advanced Regenerative Engineering has established an Experiential Learning Core Facility that will cater to the requirements of a regenerative engineering education. The facility is equipped with various experimental systems, including surgical instruments and equipment for animal model-based research, molecular imaging systems, protein and DNA analytical systems, histology and pathology processing and testing systems, polymer synthesis and characterization, and biomechanical testing. This is a graduate-level laboratory course, covering cell culture techniques, bone marrow stem cell identification and isolation, animal-based disease/tissue injury modeling (liver injury and regeneration, skin wound and regeneration, stroke and neuronal regeneration, and heart attack and myocardial regeneration). Students will complete an independent research project report addressing a topic in regenerative engineering. This report will be used to evaluate student performance. This is a required course for all trainees.

**TBD, the details of this course are currently under discussion*

3. Translational Medicine

MSTP Topics in Molecular and Translational Medicine This course covers the molecular mechanisms of human disease, integrates basic science with clinical medicine, and provides clinical education for research students. In this course, students discuss and assess current research and discoveries, formulate hypotheses for research problems, complete research proposals, and participate in peer review of research proposals. These activities enable students to acquire fundamental knowledge of translational medicine. This course is considered a biology course and required for all trainees.

Immersion Experience in Biology and Engineering Research laboratories In addition to the clinical rotations that are required to be eligible to participate in the RE-Training Program, all students are required to have an immersion experience in life sciences and engineering by rotating in two different research laboratories – a biology and an engineering laboratory with 1 quarter for each laboratory. These immersion experiences can take place within the labs of the Mentor Team or one of the research laboratories of participating preceptors. The immersion experience requirement is fulfilled through the independent research course mechanism (BMD ENG 499). Students can select laboratories from a list of participating faculty preceptors based on students' interests, must design and conduct independently a hypothesis-driven research project in biology, regenerative engineering, or translational medicine, and complete a research project report, which will be evaluated by the Mentor Team and the Executive Committee. These two experiences will qualify as graduate independent research courses.

Immersion Experience in the Clinical Setting for Understanding the Medical Challenge As part of our team science-based research training, all trainees are required to include a clinician as part of their Mentor Team and as part of their training they must demonstrate that they have spent at least 6 cumulative weeks following and working with a clinical mentor in a

topic area of relevance to the trainee's thesis project. Although the clinical rotation does not have to take place over a continuous period, it should be completed within the first year of appointment to the training program. The trainee, with the endorsement of the clinical mentor, must demonstrate to the program leadership, via a written report and an oral presentation, that significant immersion occurred. Through this mechanism the trainee will describe the new knowledge or perspective that was gained as a result of the clinical immersion experience. Trainees may witness surgeries, medical team discussions, communicate with the patient, all according to the standard rules and policies that would apply to a medical school student.

RE-Practice School - Experience for Direct Exposure to Translational Challenges CARE has secured partnerships with Vericel, Inc, Sigilon Therpeutics, Acuitive Technologies, Inc, Medline Industries, Inc., Dimension Inx, Rhaeos, and The United States Army Institute for Surgical Research to provide internships for the duration of the training program. CARE anticipates this list of partners to grow over time as the program continues. The industrial experiences will be carefully tailored to complement or relate to the student's thesis research as much as possible by including the industry and Army liaisons during the trainee selection process. Liaisons are part of the Executive Committee; therefore, we will be able to plan an integrated and relevant experience for the trainees and the Mentor Team. The main goal of the internship is to expose the trainee to the skills that are required for development, scale up, and manufacturing of regenerative engineering products, thereby complementing the academic experience and informing the mentor and trainee teams of potential limitations to the applicability of their approach. The internship is expected to last at least 3 months and will take place within the 2nd year of their appointment to the training program. Trainees will be required to produce a report to their Mentor Team and the Executive Committee upon their return to Northwestern and present an overview of their experience at the program's Student Research Forum.