Biology and Engineering of the Extracellular Matrix: An Interdisciplinary Course for Tissue Engineers

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Introduction: Control of cell function is a main component of tissue engineering. Rensselaer has developed an interdisciplinary course titled "Biology and Engineering of the Extracellular Matrix" that focuses on how cell function is controlled and maintained by the extracellular matrix (ECM) in a variety of tissues. A major goal of this course is to emphasize the application of biology, and the use of an engineering approach to solving problems in biology and medicine. It is co-taught by faculty members from the Biology Department and the Department of Biomedical Engineering. It is based on the latest concepts in ECM biology and is designed to be highly interactive. Students are taught to critically analyze the current literature, and must lead class discussions on selected current topics. This class has proven very successful in broadening the experience of bioengineering students at Rensselaer. Although not explicitly a tissue engineering course, it provides a solid background in control of cell function by extracellular signals, and therefore augments the education of tissue engineers.

Methods: The current format of this class combines lectures with case studies from the recent literature. The semester begins with background in cell structure and function, with an emphasis on functions mediated by the ECM. A review of basic molecular biology, in particular as related to protein structure and cell signaling, is also included. Covering basic cell and molecular biology early in the semester ensures that all students have the requisite knowledge to participate in the class, though it is a review for some students.

The remainder of the semester progresses rapidly into more advanced topics and is divided into 7 modules: collagens, other ECM proteins, ECM signaling, mechanics of the ECM, ECM pathology, tissue engineering, and recent advances in ECM research. Each module consists of a lecture component, as well as a "literature-based learning" session in which a pre-selected team of students leads a class discussion on a recent paper from the primary literature. Although only one module of seven is devoted specifically to the field of tissue engineering, this course provides an important basis for the application of advanced biology and engineering techniques to the development of engineered tissues.

The interdisciplinary nature of instruction in this course is important. Both instructors attend all classes, though lectures are divided among them. Both instructors also attend all literature discussion sessions, and this brings different viewpoints to the class interactions.

Results/Discussion: This class has been run four times and the results have been very positive. For the first run, the course was open to junior and senior level students from all departments. Students from biology, math, biomedical engineering, chemical engineering enrolled. The diversity of the student's background was helpful in generating active discussions, but created difficulty in keeping the entire class moving at the same pace. Subsequently, registration was restricted to upper level biomedical engineering majors, with the result that the class background was much more homogeneous. These students had a good background in human physiology, and some exposure to biology. However, the BEECM class was for many the first opportunity to learn more advanced cell and molecular biology, and to combine this knowledge with their engineering skills. The more uniform class composition simplified teaching the class, but reduced the diversity of input into class discussions.

Based on formal surveys (IDEA) and other student feedback, this course has been well received and has added a valuable component to the bioengineering curriculum at Rensselaer. Although the current format has been a success, the course is still evolving. A next step will be to incorporate a hands-on laboratory module in which students can perform experiments to examine the effect of ECM components on cell function. In addition, the instructors are considering the introduction of "concept mapping" [DiCarlo 2006] to this class. This technique uses software to help students link facts together into concepts, and emphasizes the understanding of these concepts over simply knowing the facts. The structure of this course and the way in which students progress in taking on successively more complex topics makes this a good environment to implement concept mapping.

Conclusions: This class has augmented the education of bioengineering students at Rensselaer in the areas of ECM control of cell function, and the application of this knowledge in biology, medicine and tissue engineering. The class has proven to be dynamic and well received, and has been an excellent learning experience for both the students and the instructors.

References:

DiCarlo SE, "Cell Biology Should be Taught as Science is Practiced", Nature Rev Mol Cell Biol, 7:290-296, 2006.