Critical Reviews™ in Biomedical Engineering, 42(3–4):vii–ix (2014)

Special Issue on Research in Biomedical Engineering at Clemson University: A Clinical-Engineering Partnership

Clemson University's Department of Bioengineering has been widely recognized as a pioneer in the field of biomaterials science and engineering and is renowned for its leadership in biomaterials research and education. One of the oldest in the world, Clemson's bioengineering program began in 1963 with the inception of a doctor of philosophy in bioengineering degree. A master of science degree was added in 1966, followed by a bachelor of science degree in 2006 and a master of engineering in biomedical engineering degree in 2014. In recent years the Department of Bioengineering has experienced unprecedented growth in faculty, personnel, facilities, and programs. Clemson University has strengthened its commitment to provide a unique learning environment to students and scientists-in-training by integrating state-of-the-art translational research with education in biomedical engineering.

As guest editors, we are pleased to provide 7 in-depth and scholarly review articles representing some of the key areas pursued by our faculty and students in the Department of Bioengineering at Clemson University. Here we provide descriptions highlighting the significance of each review article.

Percutaneous transluminal angioplasty with metal stents revolutionized coronary and peripheral revascularization. However, it is always accompanied with major drawbacks such as in-stent restenosis, late stent thrombosis, and delayed endothelialization. Non-stent-based methods of delivery, such as drug-coated balloons (DCBs), which can deliver drugs to inhibit in-stent restenosis or to de novo lesions, are currently emerging at a rapid pace. DCBs carry an active drug and a nonpolymeric carrier molecule or excipient that enhances the bioavailability of the drug to the vessel wall. The article by Betala *et al.*[1] addresses the history, principles, and current advancement of the DCB technology as it relates to clinical applications.

Cardiac regenerative medicine presents many unique challenges. Not only does the heart have limited potential for self-repair, but to be effective grafts of donor cells must be functionally integrated into the damaged region of the heart. Combining progenitor cells with engineered biomaterials can greatly enhance their regenerative capacity in cardiac tissues. The review by Dai and Foley[2] examines potential sources of cardiomyocytes and cardiac progenitors, the differentiation of myocardial cells in embryos and embryonic stem cells, and biomaterial-based technologies for engineering cardiovascular tissues.

Corneal collagen cross-linking with riboflavin and ultraviolet A light has become a viable treatment for keratoconus. Changes to the original protocol have been tested; these include leaving the epithelium intact and increasing the ultraviolet A intensity while decreasing the duration of exposure. The variation in results and protocols underscores the need for a greater understanding of the procedure and its effects. The article by Hepfer *et al.*[3] provides a description of all the procedures and reviews various methods for testing the change in material properties that occurs as a result of cross-linking. Further, the authors return to the current models for correlating the procedure and material property changes to the clinical outcome.

There has been an increased attention given to investigating the stem cell populations that reside within fetal amnion and chorion membranes. Stem cells found in these perinatal tissues possess many attractive characteristics for tissue engineering and regenerative medicine applications, such as the vast quantity of "young" stem cells, which are present in numbers that are orders of magnitude greater than can be initially obtained from all other adult tissues. The review by Keeley *et al.*[4] describes the development, structure, and function of fetal membranes and the characteristics of the stem cells derived from those membranes, summarizes the applications of human fetal membrane–derived stem cells in ortho-

1040-8401/14/$35.00

pedic tissue regeneration, and discusses regulatory issues. The authors also identify key future directives in this research.

The number of topical adhesives, surgical sealants, and hemostats approved for use in the surgical setting is ever expanding, although no single device fills all medical and surgical needs to replace sutures. As more surgical procedures are performed through laparoscopic and robotic approaches, these devices are becoming more important, and current research is focused on solving limitations of conventional wound treatments. The article by Sanders and Nagatomi[5] reviews the clinical applications of various biologically derived and synthetic products that are currently available to surgeons and those that are in development.

Laparoscopic surgery is a minimally invasive surgical technique with significant potential benefits for patients. There is a growing need to teach surgical trainees this emerging surgical technique. Simulators, ranging from simple "box" trainers to complex virtual reality trainers, have emerged as the most promising method for teaching basic laparoscopic surgical skills. In general, however, current virtual reality trainers have limited credibility because of the lack of haptic feedback, which refers to the range of touch sensations encountered during surgery. The article by Sigapogu *et al.*[6] presents a perspective on the role and utility of haptic feedback during laparoscopic surgery and laparoscopic skills training. The article also highlights key research directions in this field.

Tissue engineering has been touted as the solution to regenerating tissue in patients. Yet current strategies for orthopedic applications are limited because of the inability to successfully manage critical-sized defects without a working vascular system. Bone grafts are commonly used in critical-sized defects to fill the gap in missing bone tissue. Proper vasculature is vital to the success of these grafts to promote bone growth. The review by Tabbaa *et al.*[7] describes the contribution of tissues surrounding critical-sized defects to progenitor cell influx and neovascularization. This leads to an evaluation of current clinical techniques to increase blood flow to the critical defect to promote proper bone formation. Further, the article indicates that opportunity and need both lie in the development of tissue-engineered bone grafts that can use and enhance available vascular supplies.

The articles included in this special issue represent some of the core research expertise available in the Clemson bioengineering department, which encompasses cardiovascular devices and implantology, orthopedic materials, tissue engineering, hybrid systems, biophotonics, nanoscale biointerfaces, biomolecular simulations, dental biomaterials, mechanobiology, and many other emerging technologies. We sincerely thank the editor and editorial board members of *Critical Reviews™ in Biomedical Engineering* for the opportunity to present to the bioengineering community cutting-edge research that exemplifies translation and innovation.

Hai Yao
Associate Professor and Associate Chair of CU-MUSC Bioengineering Program
Department of Bioengineering
Clemson University
Medical University of South Carolina

Martine LaBerge
Professor and Chair
Department of Bioengineering
Executive Director, Clemson University Biomedical Engineering Innovation Campus
Clemson University

REFERENCES

1. Betala JV, Langan, EM III, LaBerge M. Drug-coated percutaneous balloon catheters. Crit Rev Biomed Eng. 2014;42(3–4):193–211.
2. Dai Y, Foley AC. Tissue Engineering Approaches to Heart Repair. Crit Rev Biomed Eng. 2014;42(3–4):213–27.
3. Hepfer RG, Shi C, Wu Y, Waring, GO IV, Yao H. Corneal Cross-Linking: Engineering a Predictable Model. Crit Rev Biomed Eng. 2014;42(3–4):229–48.
4. Keeley R, Topoluk N, Mercuri J. Tissues Reborn: Fetal Membrane-Derived Matrices and Stem Cells in Orthopedic Regenerative

Medicine. Crit Rev Biomed Eng. 2014;42(3–4):249–69.

5. Sanders L, Nagatomi J. Clinical Applications of Surgical Adhesives and Sealants. Crit Rev Biomed Eng. 2014;42(3–4):271–92.
6. Singapogu RB, Burg TC, Burg KJL, Smith DE, Eckenrode AH. A Perspective on the Role and Utility of Haptic Feedback in Laparoscopic Skills Training. Crit Rev Biomed Eng. 2014;42(3–4):293–318.
7. Tabbaa SM, Horton CO, Jeray KJ, Burg KJL. Role of Vascularity in Successful Bone Formation and Repair. Crit Rev Biomed Eng. 2014;42(3–4):319–47.