

Re-Engineering Engineering Education

BIOMATERIALS FORUM



OFFICIAL NEWSLETTER OF THE SOCIETY FOR BIOMATERIALS

Second Quarter 2011 • Volume 33, Issue 2



Biomaterials Forum, the official news magazine of the Society For Biomaterials, is published quarterly to serve the biomaterials community. Society members receive *Biomaterials Forum* as a benefit of membership. Non-members may subscribe to the magazine at the annual rate of \$48. For subscription information or membership inquiries, contact the Membership Department at the Society office (e-mail: info@biomaterials.org) or visit the Society's web site, www.biomaterials.org.

It is the policy of the Society For Biomaterials that all articles reflect only the views of the authors. Publication of articles or advertisements within *Biomaterials Forum* does not constitute endorsement by the Society or its agents of products, services or views expressed herein. No representation is made to the accuracy hereof, and the publication is printed subject to errors and omissions. Articles that do not have an author byline may originate from press releases. The Society For Biomaterials retains press releases on file for a period of one year from the date of publication.

Editorial contributions to *Biomaterials Forum* are always welcome. Contributions should be sent to the Executive Editor and are subject to the terms and conditions of the Editorial and Publication Release. Authors should refer to the Author Guidelines, which are available on the Society's web site, when writing submissions. The publisher accepts no responsibility for return or safety of artwork, photographs or manuscripts. Submission of editorial content does not guarantee acceptance or publication.

Address corrections should be sent to *Biomaterials Forum*, 15000 Commerce Parkway, Mt. Laurel, NJ 08054.

Requests for advertising information should be directed to Frank Scussa at fscussa@ahint.com or (856) 439-0500, ext. 4427. Information is also available on the Society's web site, www.biomaterials.org.

Unauthorized reproduction of this magazine in whole or in part is prohibited without the permission of the publisher. Requests for permission should be directed to the Managing Editor.

Scientific photos may be submitted for cover consideration in future issues. Submit color photo, no larger than 4" x 6", along with credit information and scientific description, to the Executive Editor.

Copyright© 2011 ISSN 1527-6031
Society For Biomaterials
All rights reserved

BIOMATERIALS FORUM



The official news magazine of the **SOCIETY FOR BIOMATERIALS** • Volume 33, Issue 2

Executive Editor

Karen Burg, Clemson University, Department of Bioengineering
401 Rhodes Engineering Research Center, Clemson, SC 29634
Phone: (864) 656-6462 • Fax: (864) 656-4466
E-mail: kburg@clemson.edu

Managing Editor

Erik Caplan, Society For Biomaterials
15000 Commerce Parkway, Mt. Laurel, NJ 08054
Phone: (856) 793-0901 • Fax: (856) 439-0525
E-mail: ecaplan@ahint.com

Government News Contributing Editor

Joy Dunkers, National Institute of Standards and Technology
E-mail: joy.dunkers@nist.gov

Government News Contributing Co-Editor

Christine A. Kelley, National Institutes of Health
E-mail: kelleyc@mail.nih.gov

Industrial News Contributing Editor

Steve T. Lin, Exactech Inc.
E-mail: steve.lin@exac.com

Society Business & Membership News Contributing Editor

Warren Haggard, University of Memphis
Department of Biomedical Engineering
E-mail: whaggrd1@memphis.edu

Special Interest Group News Contributing Editor

Christopher Siedlecki, Penn State University
Department of Bioengineering
E-mail: csiedlecki@psu.edu

Book Review

Liisa Kuhn, University of Connecticut Health Center
Center for Biomaterials and Regenerative Medicine
E-mail: Lkuhn@uchc.edu

AIMBE News Contributing Editor

Alan S. Litsky, The Ohio State University
Biomedical Engineering Department
Email: litsky.1@osu.edu

Education News Contributing Editor

Jan P. Stegemann, University of Michigan
Department of Biomedical Engineering
Email: jpsteg@umich.edu

Graphic Designer

Jenelle Rittenhouse

Special Interest Group Reporters

Biomaterials Availability & Policy

Carl R. McMillin, carl@syntheticbodyparts.com

Biomaterials-Cell/Organ Therapies

Todd McDevitt, todd.mcdevitt@bme.gatech.edu

Biomaterials Education

Elizabeth A. Friis, lfriis@ku.edu

Cardiovascular Biomaterials

Peter G. Edelman, peter.edelman@bsci.com

Dental/Craniofacial Biomaterials

Hyun Joon Kong, hjkong06@illinois.edu

Drug Delivery

Thomas Dziubla, dziubla@enr.uky.edu

Implant Pathology

Janson Emmanuel, jemmanuel@wlgore.com

Nanomaterials

Thomas Webster, Thomas_Webster@brown.edu

Ophthalmic Biomaterials

Ping-fai "Sidney" Sit, sidney@latech.edu

Orthopaedic Biomaterials

Lakshmi S. Nair, nair@uchc.edu

Protein & Cells at Interfaces

Carl Simon, Jr., carl.simon@nist.gov

Surface Characterization & Modifications

Jeffrey L. Schwartz, jlschwar1999@yahoo.com

Tissue Engineering

Jan P. Stegemann, jpsteg@umich.edu

Departments

The Torch

- 2 From the Editor
- 3 From the President
- 4 Staff Update
- 6 Biomaterials Day at University of Memphis
- 10 2011 Award Winners

Government News

- 5 AIMBE Update

Education News

- 7 Providing Case Studies as a Method to Teach Biomaterials Science

Special Interest Group News

- 8 Human Microvascular Endothelial Cells Uptake Nanoparticles

Industry News

- 11 BioInk

Book Review

- 12 Biomaterials and Devices for the Circulatory System

Student News

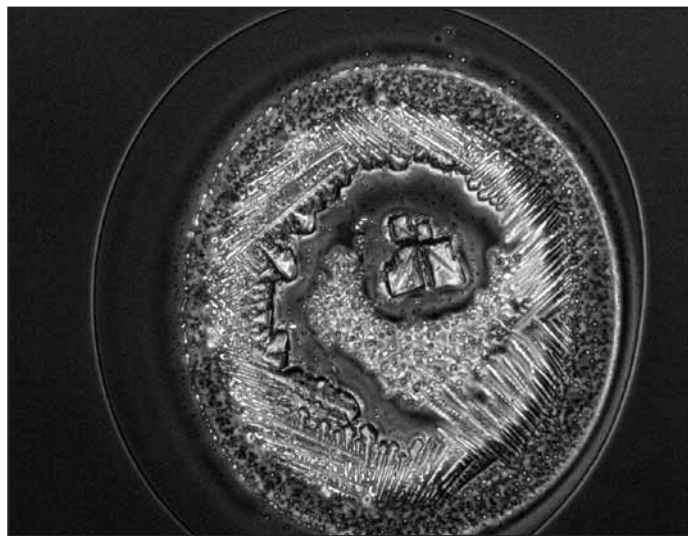
- 12 Events, Announcements and Tips

Chapter News

- 13 Members in the News

Biomaterials Community

- 13 Community Calendar



On the cover: Contribution by L. Roudsari, Clemson University Department of Bioengineering student and recipient of the C. William Hall Award Scholarship.

Collagen printed using biofabricator at the Institute for Biological Interfaces of Engineering at Clemson University to study development of 3D tissue test systems (100x magnification).



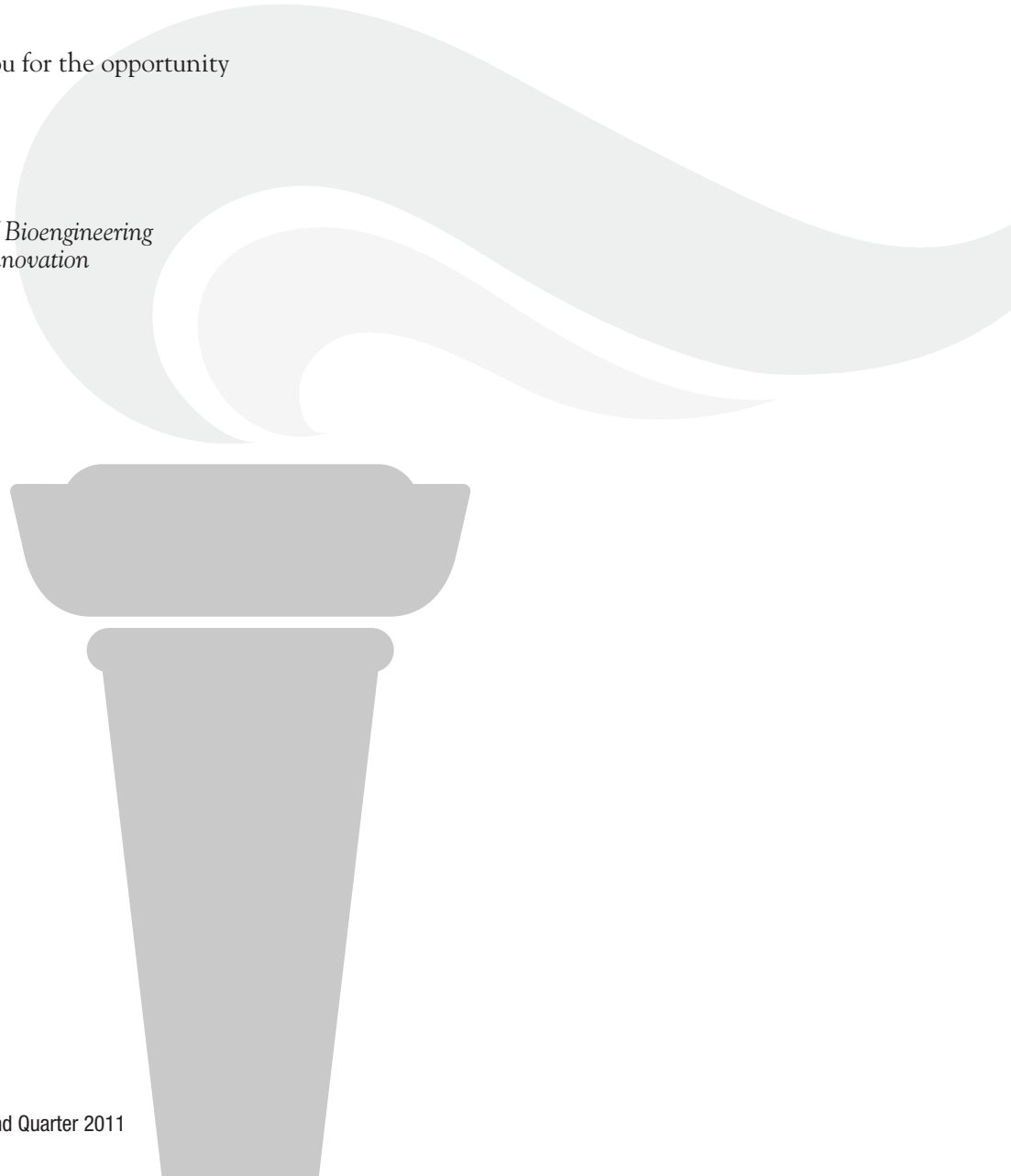
This issue serves as the last of my five-year term as Executive Editor of *Biomaterials Forum*. I have enjoyed interacting with you, philosophizing about our field and pondering opportunities. I look forward to future interactions outside the bounds of the magazine. I am very pleased to introduce our new Executive Editor, Dr. Liisa Kuhn, who is a familiar *Biomaterials Forum* name, as she has contributed book reviews for more than a decade. Liisa is a faculty member in the Center for Biomaterials and Regenerative Medicine at the University of Connecticut Health Center, with particular focus on biomaterials for dental applications. As you already know or may have guessed, she “consumes” biomaterials-related books at an unbelievably rapid and consistent pace, is extremely reflective (and organized) and will provide unique insight to and outstanding oversight of this news magazine. Please join me in welcoming and supporting her in this new position.

Again, my sincere thanks to all of you for the opportunity to serve our Society as news editor.

Best wishes from Clemson,

Karen J.L. Burg
Hunter Endowed Chair & Professor of Bioengineering
Interim Vice Provost for Research & Innovation
Clemson University

This issue serves as the last of my five-year term as Executive Editor of *Biomaterials Forum*. I have enjoyed interacting with you, philosophizing about our field and pondering opportunities.





This year's annual meeting venue, Disney World, provided a creative and "animated" place to explore the latest scientific results in the field of biomaterials. We received 1000 abstracts for the meeting, and, through the dedicated efforts of Nick Ziats and the Program Committee, I believe we put an outstanding program in place. Several elements of the meeting were worthy of

note. We had a preeminent scientist, Anthony Atala, MD, as our keynote speaker. His pioneering work on tissue engineering and regenerative medicine made Dr. Atala an ideal choice. We also had another distinguished member of our Society, Mike Sefton, receiving the Acta Biomaterialia Gold Medal award. This acknowledgement of Mike's outstanding contributions to the field of biomaterials is well deserved. Additionally, we added one set of parallel sessions on Wednesday afternoon prior to the official opening session to provide greater opportunities for oral presentations at the meeting and expand the range of talks presented. The Program Committee worked diligently to develop general sessions, symposia and panels capturing basic, clinical and translational (applied) biomaterials research. With such a diverse and balanced offering of topic areas, I truly believe there was something enlightening and interesting for everyone in our community, whether academic-, industry- or government-based.

Our Society also made headway at the end of 2010 in finalizing our contract with J. Wiley and Sons. We put in place a new contract and updated many of the terms of the prior contracts. I look forward to a strong and continuing relationship with Wiley and strong revenues from journal royalties.

We made commitments to hold the 2013 annual meeting of the Society in Boston. One upside of the economic downturn is that hotel room costs and other venue costs remain very reasonable, and the Society made a good deal for the meeting.

Every week I am grateful for the excellent work of the committee chairs of council—whether selecting Biomaterials Days locations, finding meeting locations, membership, bylaws or handling the finances of the Society, I am filled with the incredible sense of commitment and caring each person on council brings to their job. Our budget at the end of the year is strong, and we are looking at a significant surplus for 2010. This, of course, is necessary to get us past the World Congress year. We are also looking at our October 2012 meeting in New Orleans, to be chaired by Monty Reichert, as an additional means to provide value to our members as a scientific meeting and also as a means to offset any financial losses anticipated from forgoing an annual meeting. I believe we are in a good position to handle these concerns in 2012 and beyond.

I also believe it is high time SFB serve as the host society for a future World Congress, so I am moving ahead with preliminary planning to make this vision a reality. The earliest the U.S. could host a World Congress will be 2020, so we are making every effort possible to bring that date, or the next available one, to fruition.

Our Society is diverse, and it thrives, in my opinion, on a diversity of thinking and approaches to the study and advancement of biomaterials. My goal as President has been to work to support all elements of our Society to advance their research and educational missions and to bring our best efforts in discovery and translation into clinical usage.

I look forward to the remaining time of my presidency and the transition to our next president, Karen Burg. I know she will be outstanding, committed and insightful in advancing our Society's mission and vision.

Jeremy Gilbert

Headquarters staff has been active in supporting the Society's committees with the following activities:

Awards, Ceremonies and Nominations Committee:

Art Coury (Chair); The Awards, Ceremonies and Nominations Committee is pleased to announce the recipients of the 2011 Founders Award, the C. William Hall Award, three Clemson Awards, two Young Investigator Awards, the Technology Innovation and Development Award and four Outstanding Research Awards on Page 10. In addition to the Society For Biomaterials Awards, Michael Sefton of the University of Toronto, SFB Past President, was selected to receive the 2011 Acta Biomaterialia Gold Medal, and he elected to receive this prestigious award at the SFB 2011 Annual Meeting. Congratulations to all of the 2011 Award recipients!

Bylaws Committee:

Joel Bumgardner (Chair); The committee undertook a thorough review of the Society's bylaws and proposed a number of revisions at the annual meeting. These include the addition of an Audit Committee, correction of a few inconsistencies arising, in part, due to previous bylaw changes and an update of the bylaws to be current with Texas Nonprofit Corporation Law. The Audit Committee will be responsible for reviewing the prior year's financial reconciliation documents prepared by the SFB auditor and will periodically review the policies and procedures for the handling of funds. The addition of this committee is to be consistent with current non-profit management protocols. The Society is incorporated in the State of Texas, which implemented new non-profit legislation effective January 1, 2010. To be in compliance with the new law, amendments were proposed to specifically allow electronic balloting, update the percentage of members needed to call a special meeting of the membership and specify how to designate locations for annual or special meetings. The detailed amendments were distributed to the Society membership by mail for review prior to the annual meeting as specified by Article XVI of the bylaws.

Education and Professional Development Committee:

Julie Hasenwinkel (Chair); The committee evaluated applications for the 2011 Biomaterials Day program and awarded six \$5,000 grants to the University of Michigan, Duke University, Purdue University (with Case Western Reserve University and University of Kentucky), Texas A&M University, Clemson University and Syracuse University/University of Rochester. Each of these institutions will host regional conferences during the 2011 calendar year. The committee was also pleased to announce Laila Roudsari of Clemson University was awarded the 2011 C. William Hall Scholarship. Committee members continue to evaluate endorsement requests from other organizations and develop a mentoring program for SFB members.

Finance Committee:

Laura Suggs (Chair); With fiscal year 2010 now concluded, the Finance Committee is pleased to report it had a very successful year. Better-than-expected meeting attendance, membership applications and renewals and journal royalties combined to return

more than \$200,000 in net income to the Society. This will make weathering the 2012 World Congress much easier financially and will also ease pressure to increase dues in future years.

Meetings Committee:

Jeremy Gilbert (Chair); In addition to finalizing contracts for the 2012 Fall Symposium (New Orleans Marriott, October 3-6, 2012) and the 2013 Annual Meeting (Sheraton Boston/Hynes Convention Center, April 9-13, 2013), a task force of the Meetings Committee has begun work on developing a pitch to host the 2020 World Congress in the United States. The pitch will be made to the International Union of Societies for Biomaterials Science and Engineering (IUSBSE) at the World Congress in Chengdu, China in June, 2012.

Program Committee:

Nicholas Ziats (Chair); The Society For Biomaterials' 2011 Annual Meeting, "Animating Materials," was held April 13-16, 2011 in Orlando, Fla. We are pleased to report the Society received 1000 completed abstracts for consideration. The Program Committee finalized the program, and abstract submitters received their notifications at the end of January. Dr. Anthony Atala, Director of the Wake Forest Institute for Regenerative Medicine, delivered the keynote address at the 2011 Annual Meeting entitled "Regenerative Medicine: Approaches to Translation." It should also be noted that the program this year was extended with an added concurrent session of abstract presentations Wednesday afternoon (April 13, 2011, 4-6 p.m.) prior to the Opening Ceremony/Reception, which began at 6:30 p.m.

Special Interest Groups:

(Chris Siedlecki, SIG Chair Representative); SIGs have been active this year with submissions of articles to the *Forum*, contributions to the annual meeting program and nominations for the Student Travel Achievement Recognition (STAR) program. New SIG officer elections were conducted in early April, and new SIG officers were announced at the Annual Meeting.

If you are interested in knowing more about a particular issue, policy or committee activity, or if you have any suggestions for improved membership services, please contact me directly at the SFB headquarters office.

Sincerely,



Dan Lemyre, CAE, IOM
Executive Director
Society For Biomaterials
15000 Commerce Parkway, Suite C
Mount Laurel, NJ 08054
Phone: 856-642-4201
Fax: 856-439-0525

American Institute for Medical and Biological Engineering (AIMBE) News

AIMBE Update

Alan Litsky, AIMBE News

Contributing Editor

From Press Release



AMERICAN INSTITUTE FOR MEDICAL
AND BIOLOGICAL ENGINEERING

AIMBE, the American Institute for Medical and Biological Engineering, was founded in 1991 “to establish a clear and comprehensive identity for the field of medical and biological engineering” and “to serve and coordinate a broad constituency of medical and biological scientists and practitioners, scientific and engineering societies, academic departments and industries.” The Society For Biomaterials is a member society of AIMBE; two SFB members serve on the AIMBE Council of Societies. More about the organization can be found at: www.aimbe.org.

Food and Drug Administration (FDA) Impact on Innovation Study Released

A study on the FDA approval process for medical technologies was released by Dr. Josh Makower, consulting professor at Stanford University and CEO of ExploraMed. After surveying more than 200 CEOs at medical technology companies in the United States, the survey found that due to inefficiencies at the FDA, innovative new medical devices are available to U.S. citizens on average two full years later than patients in other countries. The study cites specific challenges faced by small innovative medical device companies seeking FDA approval for their technologies. The study can be found at: www.advamed.org/NR/rdonlyres/040E6C33-380B-4F6B-AB58-9AB1C0A7A3CF/0/makowerreportfinal.pdf

COMPETES Act Signed into Law

Before adjourning, the 111th Congress passed the America COMPETES Reauthorization Act of 2010. The legislation, which President Obama signed into law January 4, 2011, authorizes federal investment in science, engineering, innovation, technology and competitiveness, and it is designed to help the United States maintain its world leadership in high-technology and create jobs.

“COMPETES,” short for “Creating Opportunities to Meaningfully Promote Excellence in Technology, Education and Science,” is based on recommendations outlined in the 2005 National Academy’s report, *Rising Above the Gathering Storm*.

FDA Seeks Comments on Actions to Improve Transparency

The FDA is seeking comments on “19 action items and five draft proposals to improve transparency to regulated industry.” Among other groups, regulated industry consists of providers of food, drugs and medical devices. The proposals include providing a timeline for the creation of guidance, the posting of FDA employee presentations to external audiences to the FDA website, providing submitters an expected decision date on appeals, a review of existing procedures to evaluate importers that electronically file product information and the initiation of “a planning process to develop a web-based system that provides information about importing requirements.” The proposals can be found in the released report titled “FDA Transparency Initiative: Improving Transparency to Regulated Industry.”

Biomaterials Day 2011 at the University of Memphis

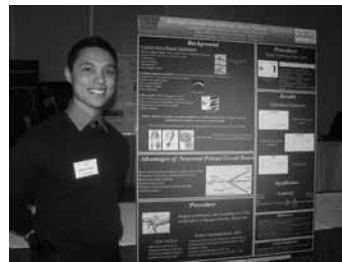
By Marvin Mecwan, University of Memphis

The Society For Biomaterials student chapter at the University of Memphis hosted its most recent Biomaterials Day January 28, 2011, at the Holiday Inn at the University of Memphis. A major goal for Biomaterials Day is to provide a forum for biomaterials for local and regional undergraduate and graduate students, university faculty and biomedical company professionals. Another goal is to educate students and professionals about the potential of biomaterials in the medical field. The event was planned to increase collaborations between universities and companies interested in the field of biomaterials and biomaterials research by fostering networking and professional development. With three months of intense planning, the Planning Committee organized three oral sessions, a networking luncheon and a poster presentation session.

Biomaterials Day 2011 had an overwhelming attendance of more than 180 attendees. Of these, approximately 140 were students and faculty members from the University of Memphis, University of Tennessee Health Science Center, Vanderbilt University, Christian Brothers University, Rhodes College, The University of Alabama at Tuscaloosa, The University of Alabama at Birmingham, Mississippi State University, University of Louisville and the University of Michigan. Additionally, more than 40 biomedical industry representatives from Medtronic Inc., Wright Medical Technology, Smith & Nephew, MB Venture Partners, Active Implants, Surmodics Pharmaceutical Inc., Sandvik and Extremity Innovations were present at the day-long event.

The keynote address was given by Dr. Steven Peckham, the Director of Product Development at Medtronic and a graduate of the joint biomedical engineering program at the University of Memphis and the University of Tennessee Health Science Center. Dr. Peckham's address highlighted his career in a biomedical company and his many interesting biomaterials-related projects during his past 12 years at Medtronic. The keynote address segued into the first oral session, highlighting roadmaps for a successful career in the biomaterials industry. During this session, students had the opportunity to ask questions to industry representatives about their successful careers in departments ranging from product development to regulatory affairs. Furthermore, they were able to hear helpful tips on professional development and resume writing.

The process of evolving an idea into a commercial reality was the subject of the second oral session. This session provided attendees with an overview of the patenting process, launching of a start-up company, working in a start-up company and the evolution of a successful start-up company into a mature company. This session was followed by a networking luncheon, which provided an opportunity for students and company representatives to network for potential current and future job prospects. This luncheon topic catered to attending students and gave them the opportunity to discover the important skills and characteristics needed for obtaining jobs and navigating biomaterials-related careers.



The final oral session for the day was conducted by a panel of clinicians who talked about the grand challenges being faced in the field of biomaterials today from a dental and orthopedic surgeon's perspective. The session discussed optimal

biomaterials and biomaterial devices presently needed to restore function in many challenging clinical problems doctors and their patients are facing today.

The day came to a conclusion with a poster presentation session and closing reception. More than 35 research posters were presented. Thirty of these came from undergraduate and graduate students. All posters were judged by faculty and industry professionals, and three outstanding posters were selected for the student poster awards. The student poster award winner from the undergraduate category was George-Rudolf Tamula from the University of Memphis. Amanda Glover and Charleson Bell from the University of Alabama and Vanderbilt University, respectively, were the recipients of the graduate student poster award.

With the help of the grant from the Society For Biomaterials and the generous support of the Herff College of Engineering at the University of Memphis, Society For Biomaterials Student Chapter at the University of Memphis and the Biomedical Engineering Department at the University of Memphis, the Planning Committee was able to put together a line-up of events for Biomaterials Day 2011 at the University of Memphis in order to make it a grand success. "The real success, however, came as a result of the overwhelming participation of students and industry professionals with an interest in the field of biomaterials," commented Dr. Joel Bumgardner, Professor of Biomedical Engineering at the University of Memphis and faculty advisor for the Biomaterials Day 2011 Planning Committee.

Case Studies as a Method to Teach Biomaterials Science

Many educators strive to bring real world issues and “hands on” experiences to their students. In some areas of science and engineering, these efforts are relatively advanced, and many programs include internships and capstone design experiences to provide such experiences. Biomaterials science is certainly a field that can be taught this way. However, since most biomaterials classes (particularly introductory classes) use a lecture format, it can be challenging to include such content. Case studies provide an opportunity for educators to enhance their curriculum by adding current, interactive and relevant material to their course.

Most people are aware of some form of the case study approach in education. Perhaps the most widely known technique is the Harvard case method, which is used extensively in its professional schools, though a number of other academic institutions have similar approaches. This method is now highly developed, and there are a variety of teaching resources available to help instructors implement the case method in their courses. The National Science Foundation has recently recognized the value of case teaching in science and has started the National Center for Case Study Teaching in Science, which contains a variety of resources for instructors.

Of course, one does not need to have the same goals as the Harvard method in order for case studies to be effective educational tools. In my experience, one can include some elements of the case study method in undergraduate classes, even when students are not familiar with formal case analysis. Many of us have used variations of this method to help our students understand topics in biomaterials science. However, often these attempts revolve around a current scientific paper, analysis of the findings in the paper or posing a biomaterials-related problem and asking students to propose solutions. While these approaches can certainly be helpful in teaching students about biomaterials science, they often do not have the same focus or outcome as a more structured case study.

A key element of most cases is that students are presented with a situation and are often asked to place themselves in the role of one of the stakeholders. With this role comes the responsibility to analyze the situation from the stakeholder’s perspective and identify the core problem. In this way, the study of specific cases can resemble Problem-Based Learning (PBL), but case studies do not depend on solving problems. Rather, they inform students by making them think about the sequence of events

leading to a problem from a variety of perspectives. The “best” solution to the problem need not necessarily be a focus of the case—often it is more instructive to focus on the cause of the problem and a range of possible solutions.

Unfortunately, there are currently very few prepared cases designed specifically to teach biomaterials science (in contrast to the large number of professionally prepared and topic-specific cases available in business, law and medicine). However, it is possible to quite easily create learning materials to serve as the basis for a case discussion. For example, I assembled a case a few years ago dealing with a recent (at the time) biomaterials-related recall of a medical device. To prepare the case, I simply used the internet to find documents related to the recall from three different perspectives—*The New York Times* reports on the recall, the FDA’s official correspondence regarding the recall and the device manufacturer’s correspondence regarding the recall. It was surprisingly easy to find information from each of these sources, and these documents served as a foundation to discuss the case in class.

There are a number of very valuable aspects to teaching using the case method. Like PBL, it is very student-centered, and the instructor usually plays the role of facilitator rather than explicitly teaching course material. Though typically some pre-class preparation is required of the students, most of the learning comes as students discuss the case with each other as a group with the help of the instructor to guide and summarize the discussions. Such a format necessarily leads to a very interactive classroom environment and can help develop critical thinking and decision-making skills. It is also a very flexible format, and a course can include just one or two cases or be entirely based on a series of cases. Finally, it is an excellent way to engage students while having them analyze current and practically relevant issues in biomaterials science.

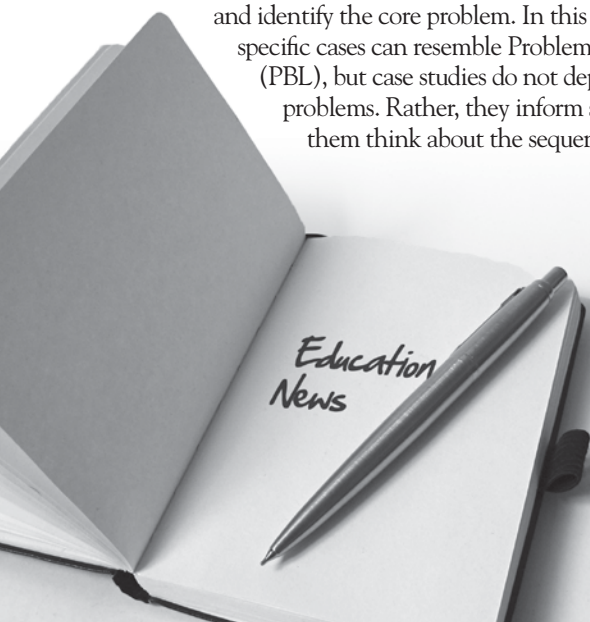
There is no doubt in my mind that some of the most effective teaching (and learning) experiences I have had were in the context of analyzing a current and relevant case with students. Undergraduate students who are interested in bioengineering and biomaterials science are often eager to learn more about the current state of the field and industry. My experience comes mainly from teaching engineering students, however, I expect that students in other programs have similar interests in real world issues. Obviously, I am a strong proponent of incorporating case studies into biomaterials science education. I am aware many instructors

Continued on page 9

Education Quote of the Quarter:

“I cannot teach anybody anything, I can only make them think.”

— Socrates



Human Microvascular Endothelial Cells Uptake Nanoparticles

Special Interest Group News

Christopher Siedlecki, *Special Interest Group News*
Contributing Editor
Carl Simon, Jr., *Protein & Cells at Interfaces*
Special Interest Reporter

Qinghe Zhao¹, Patrick L. Apopa², Diane Schwegler-Berry², Yong Qian^{2,*}, Bingyun Li^{1,3*}

¹Department of Orthopaedics, School of Medicine, West Virginia University, Morgantown, W. Va., USA

²The Pathology and Physiology Research Branch, Health Effects Laboratory Division, National Institute for Occupational Safety and Health, Morgantown, W. Va., USA

³WVNano Initiative, Morgantown, W. Va., USA

Introduction

Nanotechnology is a technique that manipulates materials in the range of 1-100 nanometers and uses the quantum effect of materials in the nano scale distinct from their bulk materials. Advances in nanotechnology provide opportunities in biotechnology and nanomedicine; for instance, nanoparticles were used to diagnose and image diseases and to treat tumors by targeted delivery of drugs to the tumor sites [1].

Nanoparticles can be taken up by living cells and tissues and are very promising as intracellular drug delivery systems. There are a few studies on the efficiency and mechanism of nanoparticle uptake into human cells [2-4]. In general, the cellular uptake of nanoparticles is believed to depend on nanoparticle size, surface chemistry and type of cells and nanoparticles [2, 3]. Studies by des Rieux and coworkers reported the influence of physical-chemical properties of nanoparticles on the translocation of nanoparticles across the intestinal epithelial cell monolayer and found nanoparticles with positive charges had a higher penetration rate than nanoparticles with negative charges [4]. However, Geiser and coworkers found nanoparticle uptake by pulmonary macrophages and red blood cells was not affected by nanoparticle surface charges and surface chemistry [2]. Therefore, nanoparticle uptake may be cell specific.

We studied the uptake of polystyrene (PS) nanoparticles by human microvascular endothelial cells (HMVECs), which may play a key role in cellular uptake of nanoparticles as intracellular drug delivery systems or nanoparticles from the environment. PS nanoparticles are used due to their narrow size distribution and well characterized properties [5].

Materials and Methods

Materials

Fluorescein isothiocyanate (FITC) labeled PS nanoparticles (20 nm) with carboxylate end groups and penicillin and streptomycin antibiotics were obtained from Invitrogen (Eugene, Ore., USA). Endothelial basal medium-2 (EBM-2) was purchased from Lonza (Boston, Mass., USA). Fetal bovine serum was obtained from Atlanta Biologicals (Lawrenceville, Ga., USA). Epidermal growth factor (EGF) and hydrocortisone were from Sigma (St. Louis, Mo., USA). All antibodies used in this study were purchased from Invitrogen (Eugene, Ore., USA).

Cell culture

HMVECs were obtained from a previous study [6], and were cultured according to the reported protocol [6, 7]. Briefly, HMVECs

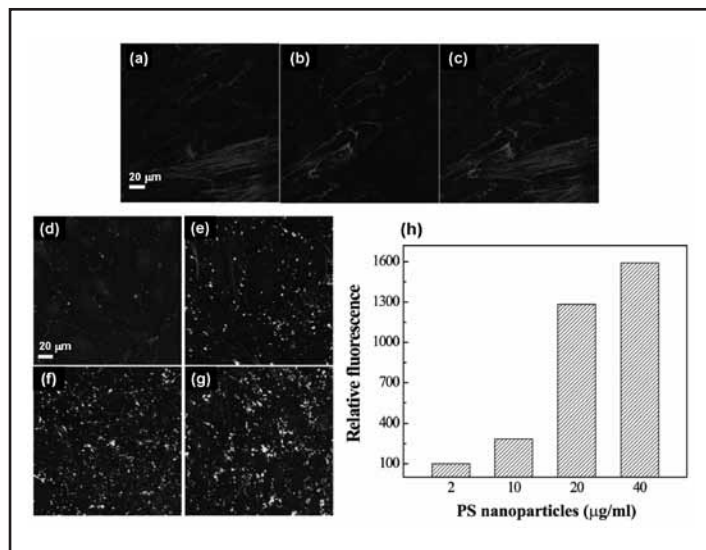


Figure 1: (a-c) Control-HMVECs. (a) Blue fluorescence: actin cytoskeleton. (b) Red fluorescence: cell membrane. (c) Combination of (a) and (b). The scale bar is 20 μm. (d-g) PS nanoparticles uptaken by HMVECs at dose of (d) 2 μg/ml, (e) 10 μg/ml, (f) 20 μg/ml, and (g) 40 μg/ml (blue = actin cytoskeleton, red = cell membrane, green = PS nanoparticles). (h) Relative fluorescence intensity of PS nanoparticles inside HMVECs vs. PS nanoparticle dose.

were seeded in 24-well tissue culture plates and incubated in EBM-2 supplemented with 10% (v/v) fetal bovine serum, 100 U/ml penicillin, 10 μg/ml streptomycin, 1 μg/ml of EGF and 50 μg/ml hydrocortisone. The cells were cultured at 37°C with 5% CO₂ to a confluent monolayer before adding PS nanoparticles. To determine the effect of concentration on nanoparticle uptake, PS nanoparticles of 2 μg, 10 μg, 20 μg or 40 μg were added to HMVECs in 1 ml medium and incubated for 30 min. The cell plates were then quickly put on ice for 10 min and the cells were washed three times with ice-cold 0.1 M phosphate buffered saline (PBS, pH7.4). Subsequently, the cells were fixed with 4% formaldehyde for 15 min at room temperature and washed three times with PBS. To determine the effect of incubation time on nanoparticle uptake, 2 μg PS nanoparticles were incubated with HMVECs for 10, 20, 30, 60, 180, 300 and 720 min. The fluorescence of the cells was recorded with a Cytofluor Series 4000 plate reader (PerSeptive Biosystems Inc., Framingham, MA, USA) at a wavelength of 505 nm for excitation and 515 nm for emission. Fluorescent images were acquired with a ZEISS LSM 510 confocal microscope (Thornwood, N.Y., USA) at an excitation wavelength of 488 nm, 543 nm and 633 nm. All pictures were taken under the same instrumental parameters. For confocal microscope imaging,

Special Interest Group News

Christopher Siedlecki, *Special Interest Group News*

Contributing Editor

Carl Simon, Jr., *Protein & Cells at Interfaces*

Special Interest Reporter

times of that of nanoparticles uptaken at 10 min (Fig. 2i). The increase in nanoparticle uptake is probably because the efficiency of nanoparticle uptake depends mainly on cell trafficking rate and amount of delivery vehicles [5].

In conclusion, we found PS nanoparticles can be uptaken by HMVECs within minutes, and the uptake process is feeding-, dose- and incubation time-dependent. Further studies to determine the trafficking mechanisms of nanoparticles into HMVECs and the distribution of nanoparticles in their organelles are under investigation and may provide new insights into early disease diagnosis and intracellular drug delivery.

Acknowledgements

The authors appreciate the use of confocal laser scanning microscope at the Microscopic Imaging Facilities at NIOSH, Morgantown, W.Va. The authors also thank Suzanne Smith at WVU for proof reading. The findings and conclusions in this report are those of the author(s) and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

References

- 1 Allen TM. Ligand-targeted therapeutics in anticancer therapy. *Nat Rev Cancer* 2002; 2:750-65.
- 2 Geiser M, Rothen-Rutishauser B, Kapp N, Schürch S, Kreyling W, Schulz H, Semmler M, Hof VI, Heyder J, Gehr P. Ultrafine particles cross cellular membranes by nonphagocytic mechanisms in lungs and in cultured cells. *Environ Health Perspect* 2005; 113:1555-60.
- 3 Caliot E, Libon C, Kerneis S, Pringault E. Translocation of ribosomal immunostimulant through an in vitro-reconstituted digestive barrier containing M-like cells. *Scand J Immunol* 2000; 52:588-94.
- 4 des Rieux A, Ragnarsson EG, Gullberg E, Preat V, Schneider YJ, Artursson P. Transport of nanoparticles across an in vitro model of the human intestinal follicle associated epithelium. *Eur J Pharm Sci* 2005; 25:455-65.
- 5 Yacobi NR, DeMaio L, Xie JS, Hamm-Alvarez SF, Borok Z, Kim KJ, Crandall ED. Polystyrene nanoparticle trafficking across alveolar epithelium. *Nanomedicine: NMB* 2008; 4:139-45.
- 6 Apopa PL, Qian Y, Shao R, Guo NL, Berry DS, Pacurari M, Porter D, Shi XL, Vallyathan V, Castranova V, Flynn DC. Iron oxide nanoparticles induce human microvascular endothelial cell permeability through reactive oxygen species production and microtubule remodeling. *Particle Fibre Toxicology* 2009; 6:1-14.
- 7 Shao R, Guo X. Human microvascular endothelial cells immortalized with human telomerase catalytic protein: a model for the study of in vitro angiogenesis. *Biochem Biophys Res Commun* 2004; 321:788-94.

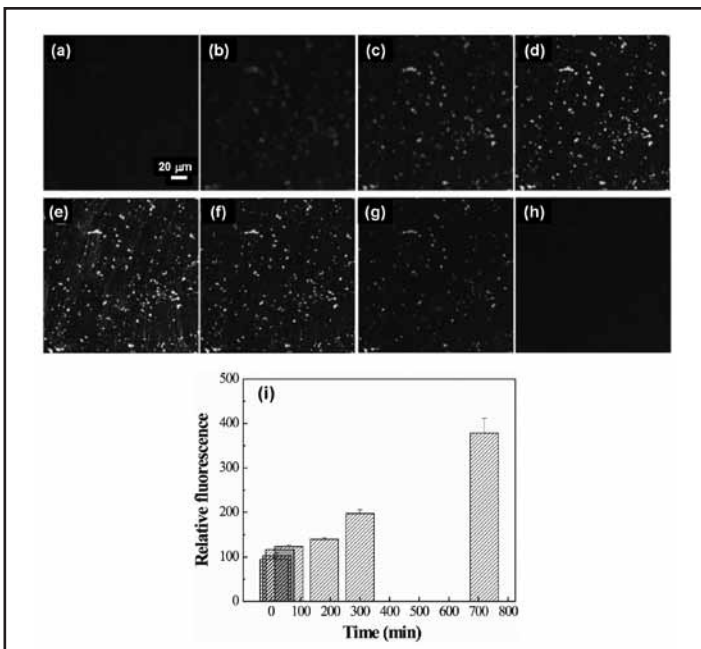


Figure 2: (a-h) Confocal images of HMVECs after uptake of 10 µg/ml PS nanoparticles for 30 min. Cross-sectional view from the apical aspect (a) to the basolateral aspect (h), with a vertical interval of 2 µm. Cell membrane is red, PS nanoparticles are yellow and green, and actin cytoskeleton is blue. (i) Time dependent uptake of PS nanoparticles (2 µg/ml) by HMVECs. Time points studied were 10, 20, 30, 60, 180, 300, and 720 min.

the cell membrane was labeled by incubating permeabilized cells with antibody to VE-Cadherin followed by FITC-labeled secondary antibody. The actin cytoskeleton was labeled using TRITC-phalloidin. The relative fluorescence of PS nanoparticles within cells was analyzed using software Image J 1.42q (NIH, USA).

Results and Discussion

The results showed PS nanoparticles were uptaken into HMVECs within a short time (e.g. 10 min). Figure 1a-c shows the three channel confocal images of control HMVECs. The cell membrane and actin cytoskeleton were clearly observed. No nanoparticles were seen in the control HMVECs (Fig. 1a-c). In comparison, PS nanoparticles (i.e. green fluorescence labeled particles) were found in HMVECs (Fig. 1d-g); this was confirmed in 3D confocal images. The amount of nanoparticle uptake increased with an increasing amount or feeding dose of PS nanoparticles, as demonstrated by an increase of fluorescence intensity inside the cells (Fig. 1d-h). Similar to other reports [5], the nanoparticles aggregated to some degree within HMVECs. Cross-section of HMVECs (Fig. 2a-h) further confirmed that PS nanoparticles were located within HMVECs. Moreover, it was found that the uptake of PS nanoparticles by HMVECs was time dependent (Fig. 2i). The uptake of PS nanoparticles occurred within a short time period, e.g. 10 min and gradually increased up to 720 min. Fluorescence of PS nanoparticles uptaken at 720 min was approximately four

Education News

Continued from page 7

have already used such a format, implemented in a wide variety of ways, to enhance classes and curricula. I would be very interested in hearing from those of you with experiences in this area, and we should consider developing a forum to discuss best

practices specifically for biomaterials science. In addition, our field would benefit from a better set of prepared cases with a focus on biomaterials science. The SFB and its members could take the lead in developing and disseminating such materials.



Founder's Award

Antonios Mikos, PhD - Rice University
Awardee Address: Bones to Biomaterials and Back Again – 20 Years of Taking Cues from Nature to Engineer Synthetic Polymer Scaffolds
Thursday, April 14, 2011
Plenary Session I • Disney's Contemporary Hotel • Fantasia A-G • 8:10 am – 8:30 am



Clemson Award for Applied Research

William Wagner, PhD – University of Pittsburgh

Awardee Address: Designing Temporary Mechanical Supports to Alter Adverse Remodeling in Ischemic Cardiomyopathy: A Biomaterial-based Approach to Cardiac Failure
Saturday, April 16, 2011
Plenary Session III • Disney's Contemporary Hotel • Fantasia A-G • 9:00 am – 9:20 am



C. William Hall Award

Shalaby Shalaby, PhD, PhD – Poly-Med Inc.
Posthumous tribute given by:
Waleed Shalaby, MD, PhD
Awardee Address: Novel Tailoring of Biomaterials from Biocompatible to Bioactive
Thursday, April 14, 2011
Plenary Session I • Disney's Contemporary Hotel • Fantasia A-G • 8:35 am – 8:55 am



Clemson Award for Contributions to the Literature

Ashutosh Chilkoti, PhD - Duke University
Awardee Address: Recombinant Polypeptide Nanoparticles and Synthetic Polymer Brushes for Biomaterial Applications
Saturday, April 16, 2011
Plenary Session III • Disney's Contemporary Hotel • Fantasia A-G • 8:10 am – 8:30 am



Technology Innovation & Development Award

James Burns, PhD – Genzyme Corporation
Awardee Address: Discovery and Development of Sefrafilm; a Unique Surgical Adjunct
Thursday, April 14, 2011
Plenary Session I • Disney's Contemporary Hotel • Fantasia A-G • 9:00 am – 9:20 am



Outstanding Research by a Clinical Fellow Award

Keiko Tarquinio, MD, FAAP – Rhode Island Hospital/ Hasbro Children's Hospital
Awardee Address: Comparison of Quantification Methods Illustrates Reduced Pseudomonas Aeruginosa Activity on Nanorough Polyvinyl Chloride
Saturday, April 16, 2011
International Biomaterials Symposium Part 2 • Disney's Contemporary Hotel • Ballroom of the Americas B • 3:00 pm – 3:20 pm



Acta Biomaterialia Gold Medal

Michael V. Sefton, ScD - University of Toronto
Awardee Address: Poetry, Common Sense and Reality
Friday, April 15, 2011
Plenary Session 2 • Disney's Contemporary Hotel • Fantasia A-G • 9:40 am – 10:00 am



Young Investigator Award

Jeff Karp, PhD – Massachusetts Institute of Technology
Awardee Address: On-demand Drug Delivery from Self-assembled Nanofibrous Gels: A New Approach for Treatment of Proteolytic Disease
Friday, April 15, 2011
Plenary Session II • Disney's Contemporary Hotel • Fantasia A-G • 8:25 am – 8:45 am



Clemson Award for Basic Research

Kevin Healy, PhD – University of California, Berkeley

Awardee Address: Designing Materials to Direct Stem Cell Fate
Saturday, April 16, 2011
Plenary Session III • Disney's Contemporary Hotel • Fantasia A-G • 8:35 am – 8:55 am



Young Investigator Award

Ali Khademhosseini, PhD – Harvard University

Awardee Address: Directed Assembly of Cell-laden Microgels for Building Porous Three-dimensional Tissue Constructs

Friday, April 15, 2011

Plenary Session II • Disney's Contemporary Hotel • Fantasia A-G • 8:05 am – 8:25 am



Student Award for Outstanding Research –PhD Candidate

Joe Baio – University of Washington

Awardee Address: Measuring the Orientation of Electrostatically Immobilized Horse Heart Cytochrome C by Time-of-Flight Secondary Ion Mass Spectroscopy and Sum Frequency Generation

Saturday, April 16, 2011

Concurrent Session VII - Surface Modification for Sensors and Diagnostics

Disney's Contemporary Hotel • Ballroom of the America A • 10:30 am – 10:45 am



Student Award for Outstanding Research –Masters Degree Candidate

Lei Yang - Brown University

Awardee Address: Understanding Osteoblast Responses on Stiff Nanotopographies Through Experiments and Computational Simulations
Poster # 413

Poster Session • Disney's Contemporary Hotel
• Fantasia H-Q



Student Award for Outstanding Research –Undergraduate

Laura Marquardt - Saint Louis University

Awardee Address: Neurite Growth in PEG Gels: Effect of Mechanical Stiffness and Laminin Concentration

Poster # 360

Poster Session • Disney's Contemporary Hotel
• Fantasia H-Q



C. William Hall Scholarship - Undergraduate

Laila Roudsari - Clemson University

Johnson & Johnson (New Brunswick, New Jersey) will pay \$480 million for medical device maker Micrus Endovascular, adding a range of treatments for stroke and brain aneurysms.

The announcement comes as drug and medical device maker Covidien announces the acquisition of the endovascular device maker ev3.

Stryker Corp. (Kalamazoo, Michigan) agreed to buy Boston Scientific Corp.'s stroke-treating neurovascular businesses for \$1.5 billion. In recent months, Johnson & Johnson bought Micrus Endovascular Corp. for \$480 million, while Covidien PLC bought ev3 Corp. for \$2.6 billion. The market's growth rate stands out in a time where bigger device markets for cardiology and orthopedic implants are struggling to grow amid pressure from the economic downturn.

Medtronic Inc. (Memphis, Tennessee) has completed the acquisition of Osteotech, a leader in the growing field of biologic products for regenerative healing, to provide surgeons an expansive range of bone-generating therapies and biologic therapies. Osteotech pioneered several innovative technology platforms including Grafton® demineralized bone matrix, MagniFuse™ Bone grafts and Plexur® Biocomposites, which are used in a broad range of musculoskeletal surgical procedures. It also is seeking U.S. Food and Drug Administration clearance for the first product based upon its Human Collagen Technology platform, an engineered human collagen biomaterial.

Other News:

Illinois kept its lead among nine states and one region in pursuit of venture capital dollars for Midwest healthcare startups so far this year. In the first three quarters of this year, eight Illinois healthcare companies attracted \$147.7 million in venture capital investments. Ohio was second with 38 companies, attracting \$89.2 million, and Western Pennsylvania was third, with \$79.7 million for 19 companies. Midwestern states won a total of \$572 million for their healthcare companies since the beginning of 2010; however, the number of companies financed—111—has been relatively stable.

The U.S. Food and Drug Administration unveiled a plan containing 25 actions it intends to implement during 2011 to improve the most common path to market for medical devices.

Key actions include:

- Streamlining the “*de novo*” review process for certain innovative, lower-risk medical devices.
- Clarifying when clinical data should be submitted in a premarket submission, guidance that will increase the efficiency and transparency of the review process.
- Establishing a new Center Science Council of senior FDA experts to assure timely and consistent science-based decision making.

Continued on page 13

Biomaterials and Devices for the Circulatory System

Edited by Terence Gourelay and Richard A. Black
Edited by Raz Jelinek, 380 pages, new and used from \$230
Copyright 2010 by Woodhead Publishing Limited ISBN: 978-1-84569-464-7

Description and Review

Cardiovascular disease remains one of the leading causes of premature death in virtually all countries of the world. This book describes how bioengineering has played a key role in the development of biomaterials and devices that manage and correct the effects of cardiovascular disease. The historical development and latest advances in valves and stents, as well as cell-based approaches including cardiovascular patches and vascular tissue engineering, are covered in great detail in this book. The authors make no mention of the promising re-cellularized heart work of Dr. Doris Taylor, however, overall the book is highly recommended since it is well-written, the chapters flow together well and it goes into great depths about cardiovascular biomaterials.

What is notable about the book is the focus on the chemistry and biocompatibility of biomaterials for cardiovascular applications. This provides a springboard for understanding the successful innovations in the field, as well as the problems and the work that lies ahead to further decrease the morbidity of cardiovascular disease. The first part of the book is about the fundamental physiological responses to biomaterials in the cardiovascular setting, and the second part moves into the clinical application of biomaterials as it pertains to cardiovascular disease. As a biomaterial scientist, you may, at some point, be asked by family members for advice about cardiovascular devices, or perhaps as a faculty member you will need

to prepare a lecture for students about biomaterials for cardiovascular devices. This book will provide the historical and technical information needed. Industrial colleagues may particularly enjoy Part III on future developments to see where the field is heading. This book provides a thorough and updated overview of the field, and it is educational and informative, particularly for biomaterial scientists.

From the Contents:

- Tissue responses to implanted biomaterials
- Blood interface biomaterials
- Developments in cardiovascular valve technology
- Percutaneous cardiovascular valve replacements
- Cardiopulmonary bypass technologies
- Cardiovascular stents
- Nanotechnology and nanomedicine in cardiovascular therapy
- Biosensor technology in the treatment of cardiovascular disease
- Vascular tissue engineering

Related Titles From the Same Publisher:

Tissue Engineering Using Ceramics and Polymers (ISBN 978-1-84569-176-9) and *Cellular Response to Biomaterials* (ISBN 978-1-84569-358-9). While I have not read these two books, the short descriptions included in the front of the book just reviewed make them seem quite appealing and worthy of a library purchase as well.

Last fall we had our first SFB student chapter conference call with eight of our student chapters represented: University of Florida, Purdue University, University of Washington, University of Memphis, University of Texas, Columbia University, Wake Forest University and Clemson University. Here is a summary of what we discussed.

Annual SFB Meeting: We discussed hosting the SFB Student Networking Lunch for the second time as well as Travel Awards for chapter students going to SFB. An informal student chapter meet-up at the annual meeting was also discussed. Ideas for this were a social event, a lunch or dinner and the annual student chapter business meeting.

Biomaterials Days: This is a great way for your student chapter to host a biomaterials-related event at your school and get more people interested in biomaterials. All you have to do is come up with a plan (ask professors or other schools for their accepted plan for ideas), complete the application (start early) and think about collaborating with other Universities in your area. Submit the application by the deadline (early next fall) and wait for the official decision. Other student chapters have done it—so can you!

Grants: Two grant award opportunities for SFB student chapters were discussed—The Travel Awards and the Student Chapter Awards. The travel awards were given out prior to the annual meeting and the student chapter awards will be available this coming fall.

Networking Among SFB Student

Groups: SFB chapters will have one or two conference calls a year to share information and ideas. We will also send out a student-focused e-mail newsletter. If your chapter has contributions for this, please send it to Heather at hdoty@memphis.edu.

Social Networking: Did you know SFB has an active LinkedIn group and an official page on Facebook? Tell your friends and join today!

Semester Chapter Activities: We discussed previously successful chapter activities. Look for more information about what chapters are doing in the student-focused newsletter coming out later this spring.

Congratulations to:

Dr. Stuart Cooper, past president of SFB and current chair of the Department of Chemical and Biomolecular Engineering at Ohio State University, was recently elected to membership in the National Academy of Engineering. Cooper was elected "...for contributions to polymer chemistry, biomedical polyurethanes, blood compatibility and academic administration."

Election to the National Academy of Engineering is among the highest professional distinctions accorded to an engineer. Academy membership honors those who have made outstanding contributions to "... engineering research, practice or education, including, where appropriate, significant contributions to the engineering literature," and to the "pioneering of new and developing fields of technology, making major advancements in traditional fields of engineering or developing/implementing innovative approaches to engineering education."

Dr. Cato T. Laurencin, Vice President for Health Affairs at the University of Connecticut Health Center and Dean of the University of Connecticut School of Medicine, was elected to the National Academy of Engineering. Dr. Laurencin was elected to the Institute of Medicine of the National Academy of Sciences in 2004; he is among approximately seven percent

of the National Academy of Engineering's total members elected to two National Academies. Dr. Laurencin was honored for his work in biomaterials science, drug delivery and tissue engineering involving musculoskeletal systems and for his academic leadership.

Dr. Joseph C. Salamone, Chief Scientific Officer at Rochal Industries LLP and Professor Emeritus of Chemistry and Polymer Science at the University of Massachusetts in Lowell, Mass., was elected to the National Academy of Engineering (NAE). Dr. Salamone was honored for his significant contributions in biomaterials, specifically in ophthalmology and wound healing.

The following SFB members were elected American Association for the Advancement of Science Fellows:

Dr. James M. Anderson, Case Western Reserve University

Dr. Rena Bizios, University of Texas at San Antonio

Dr. J. Paul Santerre, University of Toronto

Dr. Molly S. Shoichet, University of Toronto

Editor's note: *Would you like to share some good news about an honor you or a colleague received? We would love to hear from you; please e-mail news items to lkuhn@uohc.edu.*

Biolnk

Continued from page 11

The United States continues to lead the world in its capacity to produce the latest in medical technology innovation, but emerging markets led by China, India and Brazil are catching up, and their market power is shifting innovation resources and activity overseas, according to a new PwC report, *Medical Technology Innovation Scorecard: The Race for Global Leadership*. While the United States is expected to maintain its leadership for the foreseeable future, even a narrowing of the gap has implications for U.S. jobs, exports and Americans' access to advances in medical technology. PwC analyzed the specific factors contributing to medical technology innovation and quantified them, using 86 different metrics to evaluate how well each nation promotes the factors that advance innovation. The nine nations evaluated are Brazil, China, France, Germany, India, Israel, Japan, the United Kingdom and the U.S. For the PwC report, see www.thegraysheet.com/nr/FDC/SupportingDocs/gray/2011/012411_pwc_Innovation%20Scorecard.pdf

Community Calendar

Upper Midwest Biomaterials Day

Ann Arbor, Mich.
May 12-13, 2011
www.bme.umich.edu/umbd/

Ceramics, Cells and Tissues 13th Seminar and Meeting

Faenza, Italy
May 17-20, 2011
<http://cct.agenziapoloceramico.it>

2011 Gordon Research Conference in Biomaterials and Tissue Engineering

Plymouth, N.H.
July 31-August 5, 2011
www.grc.org

EUROMAT

Montpellier, France,
September 12-15, 2011
<http://euromat2011.fems.eu/>

The 37th Annual NSH Symposium/Convention

Cincinnati, Ohio
September 16-21, 2011
www.nsh.org

Summer School on Biomaterials and Regenerative Medicine

Trento, Italy
September 19-23, 2011
www.unitn.it/dimti/evento/15205/summer-school-biomaterials-and-regenerative-medicine



Developing next generation technologies is a complicated task....

Collaborate with Zeus.
We'll Bring Your Ideas to Life!

Electrospun Materials

- Nano-fibrous textiles and coverings
- High potential in medical markets
- Multiple polymers available

Aeos® ePTFE

- Biomechanical conformity
- Enables anti-proliferative therapy
- Sheet membrane, monofilament, tubing, and more

Absorv™ Bioabsorbables

- Modulated degradation rates
- Varying strengths and hardness
- Multiple extrusion forms

Are you sure you want to go at it alone?

We continue to lead the medical device industry with new polymer solutions to complex problems. Collaboration is the foundation to innovation and new product development. Our partnerships have resulted in some amazing products that have revolutionized the market. We push the limits of material science beyond measure to help you quickly confront and overcome your challenges.

Who do you want on your innovation team?



ZEUS

VISIONARIES OF POLYMER SCIENCE