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BIOMATERIALS FORUM

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BIOMATERIALS FORUM

The official news magazine of the **SOCIETY FOR BIOMATERIALS** • Volume 34, Issue 2

Special Interest Group Reporters

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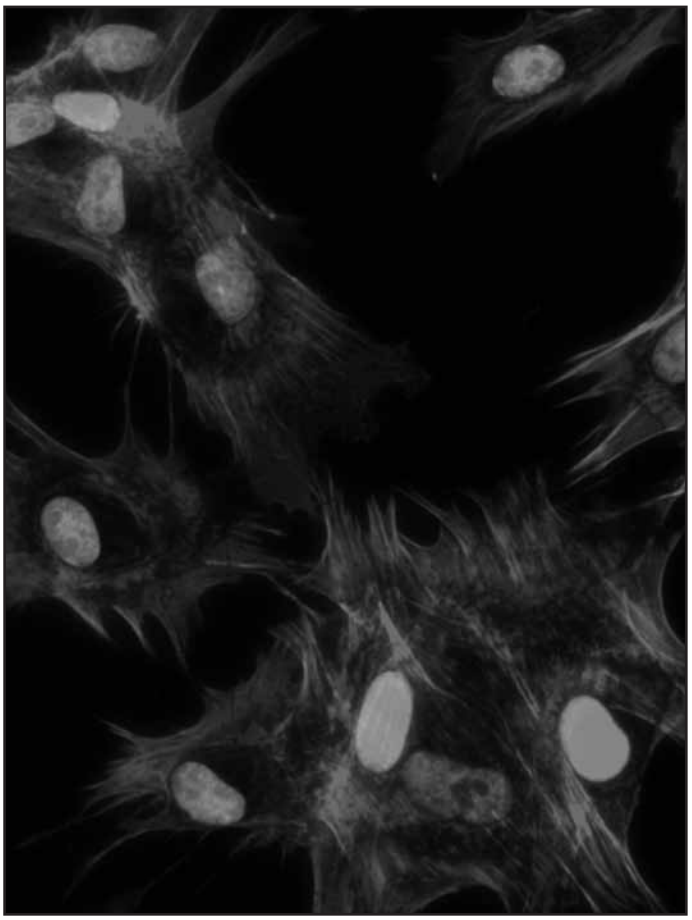
Departments



On the cover: Shape-memory-actuated change in substrate shape results in orientation and morphological change of human adipose derived stem cells. Cells were initially seeded on a flat, shape-memory polymer substrate at 30 °C (shown in the image above). Upon heating to 37 °C, the shape-memory effect was triggered, transforming the flat substrate into a highly ordered wrinkled substrate (shown on the cover). Cell cytoskeleton stained with phalloidin (red) and cell nuclei stained with DAPI (blue) initially exhibited no preferrential orientation on the flat substrate (above), but reorganized after wrinkle formation, becoming highly oriented parallel to the wrinkle direction (cover). These results demonstrate the potential for shape-memory polymer substrates to control cell behavior and also to provide environments in which the mechanobiological response of cells to dynamic changes in the extracellular environment can be studied. Shape changing shape-memory polymer substrates and scaffolds are now being developed for the study of mechanobiology in two- and three-dimensions and for the application of mechanobiology in regenerative medicine.

Photo courtesy of Richard Baker, Pine Yang, Jay Henderson and Pat Mather of the Syracuse Biomaterials Institute and the Department of Biomedical and Chemical Engineering, Syracuse University.

From the Editor

Greetings fellow biomaterials scientists,

In this issue you'll find –

• ***Member news***: Members of SFB continue to be awarded top honors in the field. Find out who's taking home the awards in the Member News section.

• ***Industry news:*** Read about "white biotechnology" and how it's being used at the new BASF research center in Tarrytown, NY in the Industry News section.

• ***Technology news:***
  - Learn about neutron-based measurement techniques and how your "soft" hydrated biomaterial can be characterized in more thorough ways through collaboration with the National Institute of Standards and Technology (NIST). See the Government News section for more details.
  - Layer-by-layer self assembled films and their applications in drug and gene delivery are featured in an article from the Surface Characterization & Modification (SC&M) SIG.

• ***Educational news:*** This section features an interesting and provocative article about the changing face of education – cyber professor – here to stay? At what cost or benefit to the students? There's also a review of a book series called *Comprehensive Biomaterials*, published by Elsevier and edited by SFB member Paul Ducheyne, that is a remarkably complete reference series that will enhance both academic and corporate libraries.

I hope you enjoy the content we've assembled for you. Remember to send me your thoughts about the content you'd like to read about in a future issue to Lkuhn@uchc.edu and we'll work together to make it happen.

Best wishes from Connecticut,

Lisa Kuhn

From the President

I am pleased to pass the Society For Biomaterials (SFB) leadership torch to incoming President Joel Bumgardner. I have enjoying serving, and I look forward to working with our new President to forward SFB initiatives. The past year has been a busy and unique one, with an array of activities, including preparations for the World Biomaterials Congress. Over the past year we have worked to make our meeting abstracts accessible to the public and capitalize on their potential as marketing and educational tools. We are in the process of launching an electronic newsletter with biomaterials-focused press releases, and we are planning the development of Special Interest Group relevant webinars.

After a successful 9th World Biomaterials Congress in Chengdu, China, we are looking forward to the October 4-6, 2012, New Orleans Society For Biomaterials (SFB) symposium, with a Grand Challenges theme. We are also working to create a biomaterials X-like challenge for unveiling at a future meeting, as a means of actively engaging more students in the biomaterials community. Over the past year we had several highly attended Biomaterials Days events; my sincere thanks to everyone who worked to make these events a success. The positive feedback has been tremendous.

The *Journal of Biomedical Materials Research* editorial boards are working to create a special online issue to celebrate the 100th issue of the publication that we now know as the *Journal of Biomedical Materials Research A*. The issue will include a historical perspective of topics that have shaped the field. We hope you enjoy reminiscing with us.

Thank you to all of the SFB officers and volunteers, as well as the Association Headquarters staff members for working tirelessly to promote the Society. My thanks to all of you, the members, for the opportunity–it has been an honor to serve for the past year!

Best wishes from Clemson,

Karen J.L. Burg
Hunter Endowed Chair & Professor of Bioengineering
Interim Vice Provost and Dean of the Graduate School
Clemson University

Staff Updates from Headquarters

The Society's staff and many volunteer groups have had a busy quarter preparing for the World Biomaterials Congress in Chengdu, China, the Fall Symposium in New Orleans and working on the many activities that make SFB the vibrant organization it is today. Here is a brief rundown on some of the things being done on behalf of the membership:

Awards, Ceremonies and Nominations – Chair Anne Meyer

The committee has just completed its work on the 2012 elections and is preparing to start the 2013 award and officer nomination cycle. Watch for information on these nominations to come in mid-late June.

Bylaws – Chair Jiro Nagatomi

The SFB Bylaws, Long Range Planning and Membership Committees are investigating the removal of some barriers to membership in order to encourage a more open and engaged Society. Current bylaws requirements make joining the Society a rather arduous and painstaking endeavor. The committees agree that streamlining the membership process would encourage growth, but the changes needed to accomplish this are being examined in depth to make sure they are the right move for SFB now and in the future. Because 2012 is a World Biomaterials Congress year and proposed changes to the membership process are far-reaching, bylaws revisions in this area might be postponed until 2013 so that a larger proportion of the membership has a chance to discuss them at the Annual Business Meeting.

Education and Professional Development – Chair William Murphy

With the WBC in Chengdu coming up, Student Chapter Travel Awards for that meeting are being decided upon now. Later this year the committee will begin evaluating applications for 2013 Biomaterials Days events. An ongoing responsibility is reviewing applications for SFB endorsement of meetings in related fields. Three meetings coming up which have received Society endorsements are NanoBio Seattle 2012 (July), Rice University Advances in Tissue Engineering (August) and the New Jersey Center for Biomaterials (October). Other applications for endorsement are still under review.

Liaison – Chair Molly Shoichet

Seven mini-committees, which will serve as liaisons to AADR, ACS, BMES, ISSCR, MRS, ORS and TERMIS are now submitting their recommendations to the Liaison Committee. These recommendations will be reviewed for possible implementation this year.

Long Range Planning – Chair Joel Bumgardner

The committee has made a lot of progress in creating a mission statement, vision statement and set of goals and objectives to guide the future direction of the Society. The committee plans to have a completed document outlining these strategic goals and objectives in time to present it at board of directors meeting at the World Biomaterials Congress in June.

Membership – Chair Horst von Recum

Working with the Long Range Planning and Bylaws Committees, the Membership Committee is looking at ways to streamline the membership process. In addition, plans have been made to sponsor banner ads on related societies' websites to promote SFB's Fall Symposium.

Program – Chair William Riechert

Three hundred and two abstracts were submitted for the 2012 Fall Symposium and reviewers have begun their work. A program planning meeting is being scheduled to create the sessions and the preliminary program. Registration and housing information for the symposium will be online soon.

Publications – Chair Ashutosh Chilkoti

Three responses were received to an RFP for a new SFB website. These have been carefully reviewed and discussed and a recommendation is being written up for consideration by the board at its meeting in Chengdu. SFB will be launching a new e-newsletter featuring a compilation of biomaterials field news and information, which is gathered from across the Internet by an independent service called Multibriefs. This e-newsletter will provide members with a fast, convenient way to stay current on all the latest developments.

Special Interest Groups – Representative Jeff Schwartz

The SIG officers have agreed to have co-sponsorships in selecting Student Travel Achievement Recognition (STAR) awards in order to provide an opportunity for all SIGs to be represented. Also, SIG officers will have access to participate in more evaluations, which is a benefit to the students who have signed up for consideration. Many SIG members submitted abstracts and/or are serving as abstract reviewers for the Fall Symposium. Ideas continue to be solicited from the SIGs for Biomaterial of the Month and *Forum* articles of interest.

If you have any questions, require any information or have suggestions for improved services, please feel free to contact the Society's headquarters office:

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2012 Award Winners

Founder's Award

Arthur Coury, PhD - Genzyme Corporation

The Founder's Award is based on long-term, landmark contributions to the discipline of biomaterials. Dr. Coury recently retired from Genzyme Corporation and currently serves as a consultant. He was elected to the National Academy of Engineering in 2009. Dr. Coury's research focuses on polymeric biomaterials for medical products such as implantable electronic devices, hydrogel-based devices and drug delivery systems. He holds more than 50 distinct patents and has been published widely in his field. Dr. Coury will be accepting his award at the World Biomaterials Congress in Chengdu, China.

C. William Hall Award

Dharam S. Dhindsa, DVM, PhD - National Institutes of Health

The C. William Hall Award honors members who have made a significant contribution to the Society and have an outstanding record in establishing, developing, maintaining and promoting the objectives and goals of the Society. Dr. Dhindsa recently retired from the National Institutes of Health, where he served more than 36 years in the Center for Scientific Review. He has enthusiastically participated in the Society For Biomaterials as both an active member and past member of the Executive Committee. Dr. Dhindsa will be accepting his award at the SFB Fall Symposium in New Orleans.

Society For Biomaterials Award For Service

Martine LaBerge, PhD - Clemson University

This newly established award honors significant service to SFB in establishing, developing, maintaining and promoting its objectives and goals. Dr. LaBerge is a professor and chair of bioengineering at Clemson University. She has served SFB as President (2007-2008); Board and Council Member for more than 15 years; Annual Meeting Program Chair; and Chair of the Publications and the Educational and Professional Development Committees. While President-elect, Dr. LaBerge helped guide a comprehensive strategic planning program. Additionally, she served as the Executive Editor of the *Biomaterials Forum* from 2000 to 2005. Dr. LaBerge is also a mentor to the SFB Clemson Student Chapter. She will be accepting her award at the SFB Fall Symposium in New Orleans.

Clemson Award for Basic Research

Andres Garcia, PhD - Georgia Institute of Technology

Dr. Garcia is professor and Woodruff Faculty Fellow, George W. Woodruff School of Mechanical Engineering at Georgia Institute of Technology. Nominees for this award must have contributed to the basic knowledge and understanding of the interaction of materials with biological molecules, cells and/or tissues. Dr. Garcia's research has led to advances across many areas of regenerative medicine (e.g. wound healing, tissue engineering), including applications related to the bone and cartilage, angiogenesis, neurogenesis, inflammation and implant integration with tissues. He will be accepting his award at the SFB Fall Symposium in New Orleans.

Clemson Award for Applied Research

Kam Leong, PhD - Duke University

Dr. Leong is currently a professor in the Department of Biomedical Engineering at the Pratt School of Engineering. Nominees for this award must show significant utilization or application of basic science to accomplish a significant goal in the biomaterials area. Dr. Leong is responsible for the development of surface-eroding polyanhydrides for controlled drug delivery, leading to the invention of Gliadel, a biodegradable wafer for the delivery of anti-cancer drugs for brain cancer therapy. Gliadel has been used in the treatment of thousands of patients worldwide. Dr. Leong has active roles in international collaborations and is on the editorial board of several peer-reviewed journals. He has presented his work at many symposia and was the keynote speaker at the Molecular Nanotechnology Symposium held in Nara, Japan. Dr. Leong will be accepting his award at the SFB Fall Symposium in New Orleans.

Clemson Award for Contributions to the Literature

Molly Shoichet, PhD, FRSC, O. Ont. - University of Toronto

Dr. Shoichet is a professor in the Department of Chemical Engineering and Applied Chemistry at the Institute of Biomaterials and Biomedical Engineering, University of Toronto. Nominees for this award must have made significant contributions to the literature on the science or technology of biomaterials. Dr. Shoichet's work focuses primarily on tissue repair, specifically spinal cord injury repair. Her lab has investigated and created materials that will gel upon injection while remaining biocompatible and biodegradable. Dr. Shoichet and her team have extended this concept to regions in the brain and, in so doing, are tackling local therapeutic delivery after stroke to stimulate endogenous stem cells. This research has attracted international attention and collaboration with industry and academia. Dr. Shoichet will be accepting her award at the SFB Fall Symposium in New Orleans.

Society For Biomaterials Young Investigator Award

Steven Little, PhD - University of Pittsburgh

The SFB Young Investigator Award recognizes an individual who has demonstrated outstanding achievements in the field of biomaterials research. Dr. Little is an assistant professor and Bicentennial Alumni Faculty Fellow in the departments of Chemical Engineering, Bioengineering, Immunology and The McGowan Institute for Regenerative Medicine. He is the Chair of SFB's Drug Delivery SIG. Dr. Little's research focuses on targeting multi-drug resistant cancers and combines his expertise in theoretical modeling, polymer fabrication and product formulation to produce and evaluate new systems for the predictable sustained delivery of bioactive molecules. He will be accepting his award at the SFB Fall Symposium in New Orleans.

Student Award for Outstanding Research –PhD Candidate

Mark Tibbitt - University of Colorado

Mr. Tibbitt is exploring the synthesis and characterization of photo-responsive polymer gels. His research involves tailoring material chemistry and properties in both a spatially and temporally defined manner so he can better understand how cells, particularly mesenchymal stem cells, send and receive information from their environment. Mr. Tibbitt has co-authored manuscripts that have appeared in *Advanced Materials* and in *Nature Protocols*. Even though Mr. Tibbitt is a second author on these manuscripts, he was instrumental in planning and completing the experiments, as well as writing significant portions. Mr. Tibbitt will be accepting his award at the World Biomaterials Congress in Chengdu, China.

Student Award for Outstanding Research –MD/PhD Candidate

Paschalia Maria Mountziaris - Baylor College of Medicine and Rice University Medical Scientist Training Program (MSTP)

Ms. Mountziaris' doctoral research involves investigations towards the development of biomaterials strategies to modulate inflammatory signaling. Targeted applications include prevention of joint damage in the setting of disease and promotion of bone regeneration following injury. Her background in both engineering and medicine has enabled her to examine and analyze medical, biological sciences and bioengineering literature, developing a fundamental understanding of both synthesis and characterization of novel drug delivery systems, particularly in the clinical management and intra-articular therapy of TMJ disorders. Ms. Mountziaris' preliminary results were recognized with a Student Travel Achievement Recognition (STAR) for Outstanding Contribution at the 2009 SFB Annual Meeting. Ms. Mountziaris will be accepting her award at the SFB Fall Symposium in New Orleans.

Student Award for Outstanding Research –Undergraduate

Anna K. Blakney - University of Colorado

Ms. Blakney is a senior undergraduate at the University of Colorado, Boulder, majoring in Chemical and Biological Engineering. Her interest in the field of biomaterials began early, and she has been working in the laboratory of Dr. Stephanie Bryant since the summer prior to her freshman year of college. Throughout her college career, Ms. Blakney has proven herself to be a motivated self-starter, successfully securing several of her own fellowships and grants, including a Sigma Xi Grant-In-Aid Research National Award, which generated $2,000 to pursue her research. She has also co-authored three manuscripts, which have been published or are in preparation for publication in peer-reviewed journals. Ms. Blakney will be accepting her award at the SFB Fall Symposium in New Orleans.

Attention Small Business Owners and Contract Research Organizations:

If you are involved with corporate preclinical testing programs, please consider sharing your list of contract research organization contacts with our other members. I'd like to start a running list of resources for our small business members that would be featured in every issue.

-Editor L. Kuhn, Lkuhn@uchc.edu

Gopinath Mani, Biomedical Engineering Program, University of South Dakota

Layer-by-Layer Self-Assembled Films for Making 3D Biomaterials

Introduction

Layer-by-layer (LBL) self-assembly is a surface modification technique which uses polyelectrolytes (polymers with positively or negatively charged groups) to build a thin film on a material surface[1]. The schematic of LBL self-assembly process is shown in Figure 1. A negatively charged material is immersed in a solution of positively charged polyelectrolyte (polyethyleneimine, chitosan, poly-L-lysine, etc.) in water. A layer of positively charged molecules is deposited on the material due to electrostatic attractions. Once sufficient molecules are adsorbed, the layer will start to repel additional molecules of the same charge. The material is then immersed in a negatively charged polyelectrolyte (polystyrene sulfonate, hyaluronic acid, polyacrylic acid, etc.) in water. This process is repeated several times to construct a thin film made of alternating layers of oppositely charged molecules.

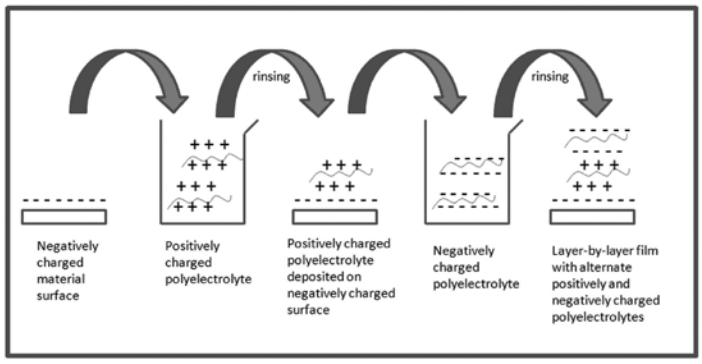

Figure 1. *Schematic of LBL self-assembly process*

The advantages of LBL self-assembly are its simplicity, inexpensive experimental setup, the use of aqueous solution for the film preparation, and its applicability to a wide range of materials[2, 3]. Conventionally, these films have been deposited on flat substrates. However, recent developments in this area have shown the use of these films on colloidal particles. The technique of coating LBL films on colloidal core particles followed by the destruction of core have led to the generation of three-dimensional (3D) micro or nanostructures. This mini review focuses on the biomedical applications of such 3D biomaterials generated by LBL films.

Drug Delivery

Lvov and coworkers[4] showed the encapsulation of furosemide drug crystals in polyelectrolyte microshell. The drug crystals were initially coated with a LBL film of poly(dimethyldiallyl ammonium chloride) and poly(styrenesulfonate) (PSS) followed by the second LBL film of gelatin and PSS layers. The release rate of furosemide from polyelectrolyte microshell was 50 to 300 times slower than that of uncoated drug crystals. Similarly, an anti-inflammatory drug dexamethasone was also sustained released from LBL microshells[5]. Thus, these studies demonstrated the use of polyelectrolyte microshells for sustained drug delivery.

DNA encapsulation and delivery

A versatile approach for encapsulating DNA in a polyelectrolyte microshell was developed[6]. In this study, manganese carbonate ($MnCO_3$) particles were used as a template core. DNA molecules were deposited on the surface of $MnCO_3$ particles followed by LBL deposition of chondroitin sulfate and poly(-L-arginine). The template particles were then dissolved to obtain microcapsules filled with DNA molecules. Thus, this study demonstrated the use of LBL film microshells for DNA encapsulation and delivery.

Biocompatible and biodegradable nanotubes

Free-standing micro or nanostructures have been prepared by depositing LBL films on a wide variety of 3D templates followed by template removal. Li and coworkers have made the nanotubes from human serum albumin (HSA) or a mixture of phospholipid (L-α-dimyristoylphosphatidic acid) and HSA by LBL approach[7]. In this study, a porous alumina was used as a template. The surface charge of HSA molecules can be made positive or negative by altering the pH of the solution. This paved the way for making LBL films just from HSA alone. Once the LBL films were deposited, the template was removed by immersing it in sodium hydroxide solution to obtain biocompatible nanotubes. Similar technique was used to make biodegradable nanotubes by depositing alternate layers of alginate and chitosan on the inner pores of polycarbonate template followed by template removal[8]. The thickness of the nanotube walls can be controlled by the number of layers deposited. These nanotubes were readily internalized by the cancer cells. The low toxicity of the obtained nanotubes has also been demonstrated.

Biosensors

LBL film coated 3D nanostructures were successfully used as biosensors to detect DNA adducts and reactive metabolites[9]. This was accomplished by coating negatively charged silica microbeads with positively charged polydiallyldimethylammonium chloride followed by sequential adsorption of DNA and enzymes such as cytochrome P450, 2E1, and myoglobin. The efficiency of enzyme-DNA coated 3D nanostructures was significantly greater than that of the traditional methods in detecting DNA adducts. In another study, high sensitive DNA immobilization and hybridization was achieved by functionalized nanotubes loaded with quantum dots by LBL deposition[10]. These novel nanotubes detected even very small changes in the signal during biological detection. The detection sensitivity of the nanotubes can be adjusted by varying the assemblies of quantum dots inside the nanotubes.

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Neutron Techniques for Biomaterial Measurement

What is so special about neutron-based measurement techniques? Neutron methods can be considered complementary to X-ray methods that probe electrons. Neutrons interact with atomic nuclei with some of the largest interactions (or contrast) taking place between relatively small atoms or their isotopes, like hydrogen and deuterium. Therefore, a single material in a multi-component system or a site within a component can be deuterated for selective contrast. Using a variety of techniques, length scales from sub-nanometer to centimeters, molecular dynamics from picosecond to microsecond, and process kinetics from 0.1 s – 1 h can be examined. Neutron measurements are also non-destructive. Lastly, since neutrons are transparent to many heavy atoms, sample chambers pose no obstacle to the measurement. The types of measurement techniques using neutrons are analogous to X-rays and photons. Radiography, elastic and inelastic scattering are performed.

To increase the utility and adoption of neutrons, which can be difficult to access, the National Institute of Standards and Technology (NIST) in collaboration with the University of Delaware Center for Neutron Science (UD CNS) have created a consortium named "nSOFT". NIST is an agency within the U.S. Department of Commerce whose mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology. Located at the NIST Gaithersburg campus, the Center for Neutron Research (NCNR) is developing and applying cutting-edge measurements on soft materials using neutrons. Soft materials are generally complex fluids, polymers and most biological systems and, depending on the feature of interest, can be difficult to probe with traditional optical or electron based techniques. By most measures, the field of biomaterials is greatly underserved with these types of techniques relative to other fields of soft materials. However, this new consortium may provide a unique opportunity to leverage this powerful array of techniques.

Neutron radiography is similar to X-ray radiography with the contrast due primarily to beam attenuation. Hydrogen attenuates neutrons compared to the other atoms in the image, and neutron imaging has a current best spatial resolution of about 10 mm. The capacity to perform neutron imaging has been around since the 1930s but has not been strongly exploited in the area of biomaterials. To date, neutron imaging for medical diagnostics has been limited to *ex vivo* tissues and organs because of the concern over the duration of exposure to which a live subject would be exposed[1]. The power of neutron imaging is illustrated in Figure 1, which contains a photograph of the fuel cell (A) and the neutron image of water through the working fuel cell (B)[2]. The water is observed (in real time) flowing through the polymer membrane within an aluminum enclosure in Fig 1A , see http://www.ncnr.nist.gov/features/tomography_PEMFC.html.

Neutron scattering has played a much bigger role than imaging in examining biological systems and has had a limited role in

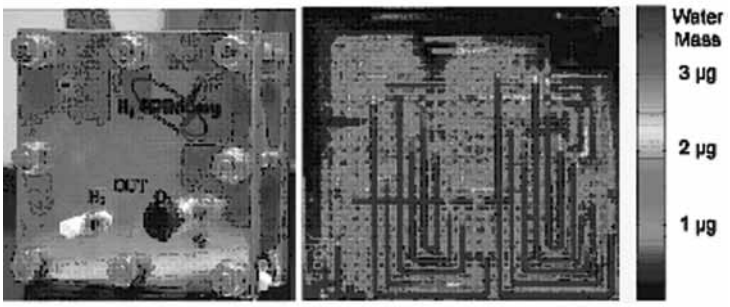

Figure 1. *Fully assembled single fuel cell (A), single time-point of a neutron image kinetic study of water moving through a polymer membrane (B)*

studying biomaterials. Neutron scattering provides information about the structure of the sample under examination. The specific neutron scattering technique selected is dependent upon the desired length scale to be probed, and there is both elastic and inelastic neutron scattering. Small-angle neutron scattering (SANS) is an elastic scattering technique that measures structures from (1 to 1000) nm on a sample that can be a crystal, powder, solid or solution. In scattering experiments, where hydrogen is abundant, deuterium is the atom of choice since its elastic scattering cross-section is >3 times larger than hydrogen. Isotopic substitution is therefore a useful tool to increase the penetration depth of the neutron beam, but is also used to highlight areas of specific chemistry. In new work by Luk et al.[3], SANS was used on amorphous (poly(D,L-lactic acid) and poly(lactic-co-glycolic acid), semicrystalline poly(lactic acid) and poly(glycolic acid), and hydrophobic and hydrophilic block copolymers containing poly(desaminotyrosyl-tyrosine ethyl ester) (DTE) and poly(ethylenegylcol) (PEG) to measure the distribution of water in these biomaterials. The authors were able to track the size, shape and distribution of the polymer hydrated domains over time and temperature starting at a length scale of 1 nm. Interestingly, using SANS, they were able to explain the increase in DTE-PEG copolymer modulus in the hydration range of (13 to 24) % that was observed in the literature. Within that concentration range, the hydrated PEG segments phase separate from the DTE and the DTE chains then primarily bear the applied load. The authors state that this work contributes to the understanding of the genesis and evolution of micrometer length scale channels that form during hydrolytic degradation of biomaterials.

This article has given a glimpse into how neutron techniques can be the advantageous for the study of soft materials. As mentioned at the beginning of this article, nSOFT was created to provide predictable, timely access to neutron facilities and research; to develop sample environments, methods, instrumentation, and data analysis techniques for specific

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Book Review

Review by Liisa Kuhn, PhD
Associate Professor
University of Connecticut Health Center

Comprehensive Biomaterials: Vols 1-6.

Editor-in-Chief: Paul Ducheyne
Co-Editors: Kevin Healy, Dietmar Hutmacher, David Grainger, C. James Kirkpatrick
Publisher: Elsevier. Copyright: 2011. ISBN: 978-0-08-055302-3

This new six-volume series is highly recommended as an essential component for any biomaterials library because the high quality and comprehensive nature of the content will enhance research and teaching endeavors. From my perspective, I believe this is a series that will be of continual use throughout many years due to the expertise of the editors and authors selected to write the chapters and the way the content has been assembled and organized into the following volumes:
Vol. 1: Metallic, Ceramic and Polymeric Biomaterials
Vol. 2: Biological Inspired and Biomolecular Materials
Vol. 3: Methods of Analysis
Vol. 4: Biocompatibility, Surface Engineering and Delivery of Drugs, Genes and other Molecules
Vol. 5: Tissue and Organ Engineering
Vol. 6: Biomaterials and Clinical Use

Each large volume has 500 pages or more and contains 23 to 32 chapters representing the efforts of hundreds of well-known, expert biomaterials scientists and engineers, hence the title of the series is very appropriate. The quality of the articles is superior, and the text is augmented lavishly by beautiful color images created particularly for this text, not just copied from another publication. Once again, just as I begin to think that the web provides everything I need for my research and teaching, I physically pick up and browse through a printed hard copy series like this and find exactly the article I've been looking for and wasn't able to find on the web. In this case, I found my missing article in Volume 5, Tissue and Organ Engineering, which has a chapter by Patrick Warnke on "Endocultivation: Computer Designed Autologous, Vascularized Bone Grafts." It describes the further success Dr. Warnke has had with his approach of using the muscles of the body as a human bioreactor to grow a vascularized tissue-engineered bone graft—in this case, an entire mandible.

The articles are written in a style that is accessible to a novice biomaterials scientist, but most importantly, it has the in-depth content that will be appreciated by the veteran biomaterials scientist. As such, the chapters could easily be used to augment a biomaterials course, as well as be used to support grant proposal preparation, or to help with your interpretation and direction of an existing project.

Remember, Elsevier offers discounts to SFB members.

Special Interest Group News

Continued from page 6

Conclusions

The LBL self assembly films provide a robust method to generate 3D structures including but not limited to microshells, nanoshells, microtubes, and nanotubes. These 3D biomaterials have tremendous applications in drug, gene, DNA, and protein delivery, and biosensor systems.

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Biomaterials Professors: Added Value or Outdated Relics?

For the past decade, educators, students and administrators have been vigorously discussing the ways the university classroom experience has been changing and should be changed. As technology advances, a whole range of new options for communicating course content has become available. In addition, students are using technology in new and expanding ways outside the classroom, and their learning style may have changed. Biomaterials courses are also affected by these trends, and it is worth considering how they impact our teaching of this material.

One of the predictions made about the march of technology into the classroom is that lectures, and even professors, will become a thing of the past. Certainly there has been a dramatic increase in the amount of recording of lectures, as well as the use of recorded material in lectures. Webcasts and podcasts have made it possible to deliver live and prerecorded content, and many lectures are now available online via YouTube or iTunes U. Several very prominent universities have made the decision to offer a wide range of educational materials online, often without cost or restriction of access.

Is there a clear benefit in having a professor standing before the class? Are recorded lectures a suitable substitute for live experiences? In particular, is biomaterials science a topic that benefits from professors and live lectures? Perhaps the more salient question is whether the added valued of a professor in the classroom exceeds the convenience and flexibility of technology-based delivery.

There is no unique answer to any of these questions, and certainly there is a place in the classroom for the more-engaging aspects of technology. However, the case can be made that there are some components of the educational experience that can only be properly conveyed through human interactions. Biomaterials themselves are a literally tangible thing. They only function in the physical world, and the majority of their uses in medicine involve interaction with living systems. It stands to reason that they are therefore best described in the context of how they interface with humans, which may be something only a human can do.

The best lectures and lecturers rely on a dynamic with the audience that brings out key points and leverages different perspectives on a topic. We have all had teachers who can create this environment, and their impact can be transforming, taking what are seemingly mundane topics and giving them life. The teaching of biomaterials is no different. Professors with practical experience in the field bring an understanding of, and a commitment to, their subject. Their "war stories," when used appropriately, enliven the class and engage the students. It is difficult, if not impossible (so far), to recreate this environment consistently using online or recorded materials.

Lab classes are also migrating online, with "virtual labs" and simulations available for students to explore concepts and test assumptions. These tools can be valuable additions to the learning environment, particularly in lower level classes where fundamentals are taught and need to be understood before progressing. But biomaterials characterization and testing is an inherently hands-on process. Anyone who has performed materials testing knows that the quality of the experimental set-up and the skill of the operator are key ingredients in obtaining meaningful data. These components of the experience are difficult to simulate.

The presence of other students in the classroom is another key aspect of the learning environment. There is more motivation when a group is learning something together. In my experience, students learn more from each other than they do from the professor, but this only happens in a setting where the professor guides the class and lays the foundation for students to learn from each other. This combination of student/professor and student/student interactions is integral to learning in many classes. While technology based learning currently lacks or falls behind in this dynamic, new communication and collaboration tools are continually being introduced, and uptake by students has been rapid.

Few would argue that a really good, engaged and experienced biomaterials professor can add value to a class and animate a topic more adequately than any technology. But maybe the better comparison is between what technology can very

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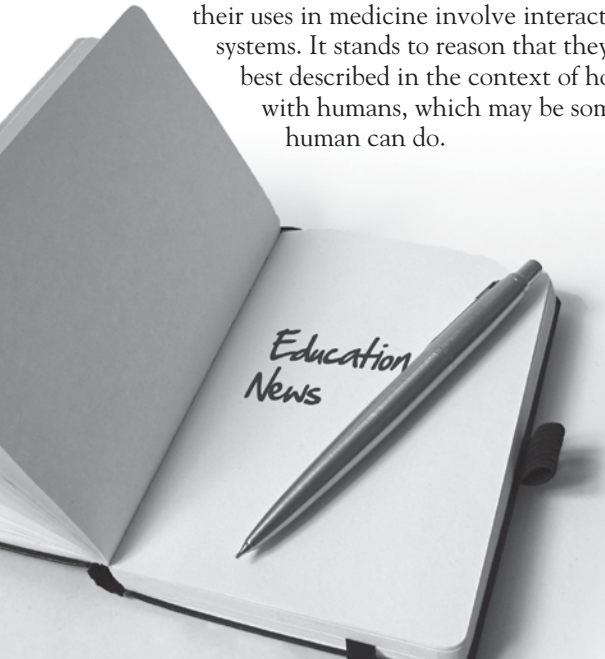

Education Quote of the Quarter:

"The main part of intellectual education is not the acquisition of facts but learning how to make facts live." **— Oliver Wendell Holmes**

Updates In Industry

1. German chemical giant **BASF** has opened a white biotechnology and microbiology research center in Tarrytown, N.Y. In the laboratory, biologists and biotechnologists will work to develop more efficient biotechnological production processes and – together with material researchers – develop new antimicrobial products for medical technology, hygiene and healthcare. With more than three decades of experience in "white biotechnology," BASF uses living cells—from yeast, molds, bacteria and plants—to produce products such as vitamins, enzymes and pharmaceutical intermediates that are easily degradable, require less energy and create less waste during their production. One focus of the research laboratory work is to develop even more efficient and resource-conserving production processes. The use of metabolic engineering – the targeted modification of metabolism – is set to enhance the efficiency of the microorganisms used in these production processes.

2. **Former Medtronic Inc.** CEO Bill Hawkins has signed on as the inaugural chairman of a new public-private partnership that aims to bring a new regulatory sciences center for medical technology to Minnesota. The partnership brings together Minnesota's medical technology community, the FDA's Center for Devices and Radiological Health (CDRH), and the University of Minnesota. It started after LifeScience Alley, a local trade association, hosted senior members of CDRH in the Twin Cities this past August, and it was formalized in December with the signing of a memorandum of understanding between Dr. Jeffrey Shuren, CDRH director, and LifeScience Alley. LifeScience Alley CEO Dale Wahlstrom said the goal of the regulatory sciences center project is to improve the development, testing and approval process for medical devices. A computer modeling project at the University of Minnesota's Medical Devices Center will be the first effort to come out of the center, he said.

3. Japan's **Asahi Kasei Corp** will buy U.S. medical equipment maker Zoll Medical Corp for $2.21 billion in a cash deal for $93 a share as it looks to build a global healthcare business and reduce reliance on its chemicals and fibers operations. The deal is Asahi Kasei's biggest acquisition by far. The transaction, which adds to about $200 billion that Japanese firms have spent on overseas acquisitions in the past four years, is expected to close in the second quarter, the companies said. Asahi Kasei said it will finance the deal with loans. Asahi Kasei derives more than half its sales from its chemicals and fibers businesses and almost a third from homes and construction materials. Combined, those businesses generate close to 90 percent of operating income. Healthcare makes up just 7 percent of sales and 8 percent of operating income, but President Taketsugu Fujiwara said the 80-year-old company has identified the sector as a growth area.

4. **Proteus Biomedical** (Redwood City, Calif.) announced that it would be launching a "digital health product" in the United Kingdom in collaboration with the pharmacy chain Lloydspharmacy. This product, called Helius, will include "sensor-enabled tablets" to monitor patients' medication use. Compliance with doctors' instructions has been identified as a problem area in medicine, especially when patients are prescribed multiple drugs that may need to be taken at different times. For the system, **Proteus** has designed sensors called "ingestible event markers", which can be taken with pills or incorporated directly into medicines as part of the manufacturing process. In this system, the sensors will be embedded in a placebo to be taken alongside a medicine. Lloydspharmacy hopes to make the system, which will be marketed to people with chronic conditions, available in September.

5. Of 2,000 consumers surveyed by **PricewaterhouseCoopers** in 2010, 40 percent said they would willingly buy a device and pay a monthly fee to automatically send their heart rate, blood pressure, blood sugar and weight data to their doctors. And Connecticut research firm **Nerac** estimates that by 2020, "at least 160 million Americans will be monitored and treated remotely for at least one chronic condition." That represents a big business opportunity. **Juniper Research** has predicted the global market for remote patient-monitoring gadgets will hit nearly $1.9 billion in 2014. Another research firm, **Park Associates** of Dallas, has put the U.S. market alone this year at $4.4 billion. Either way, it's a big business opportunity in healthcare.

6. China's domestic medical and pharmaceutical industries are looking very attractive to investors these days. More than 100 healthcare entities attracted a collective investment amount of RMB 25 billion in 2011. The medical technology industry was the fourth largest recipient of investment capital in the country and achieved a compound annual growth rate of more than 20%. China's medical device market is forecast to grow by 17% in 2012. The trend is towards more international-oriented, capital-based, brand-focused and chain-operated organizations. By 2025, there will be nearly 300 million senior citizens in China, and this aging population will require medical services. At the other demographic extreme, those in the 0 to 14 bracket are forecast to represent 16.6% of the population, reaching a total number in the neighborhood of 222,500,000. Currently, there are only 60 children's hospitals in China, a mere 0.52% of the total number of hospitals. Therefore, there is great potential to invest in nursing homes for the elderly and in children's hospitals.

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SFB Members Elected to the National Academy of Engineering

The National Academy of Engineering (NAE) recently announced the election of 66 new members, including six (6) SFB members. These individuals were honored for outstanding contributions to "engineering research, practice, or education," "significant contributions to the engineering literature," or "pioneering of new and developing fields of technology, making major advancements in traditional fields of engineering, or developing/implementing innovative approaches to engineering education."

SFB members, and the brief NAE citation describing their principal engineering accomplishment, include:

Barbara D. Boyan, Ph.D. Georgia Institute of Technology
- for engineering implant technologies for bone and cartilage repair

Denis E. Discher, Ph.D. University of Pennsylvania
- for elucidation of the effects of mechanical forces on cell physiology and stem cell development

Antonios G. Mikos, Ph.D. Rice University
- for advances in tissue engineering, regenerative medicine, biomaterials, and drug delivery including development of biodegradable polymers

Samuel I. Stupp, Ph.D. Northwestern University
- for advances in processes of self-assembled polymers for biomedical applications

Elazer R. Edelman, M.D., Ph.D. Massachusetts Institute of Technology
- for contributions to the design, development, and regulation of local cardiovascular drug delivery and drug eluting stents

Leonard Pinchuk, Ph.D., D.Sc. Innovia LLC & Related Companies
- for development of biomedical polymeric materials for angioplasty balloons, drug eluting stents, and other devices

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The official NAE announcement can be accessed at:
http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=02092012

Ali Khademhosseini, Ph.D., has been awarded the 2012 Curtis W. McGraw Award from the American Society of Engineering Education (ASEE). Dr. Khademhosseini, an Associate Professor in the Department of Medicine, Harvard Medical School Division of Health Sciences and Technology, was recognized for significant contributions in applying engineered biomaterials and microfluidic approaches to micro- and nanotechnology for biomedical and biological applications. His primary research focus is on microengineering techniques and biomaterials for diagnostic systems.

Government News

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problems; and to increase "comfort" with neutron techniques through training programs and co-development of solutions. If you would like further information on this new consortium, please contact the nSOFT Director Ronald Jones (ronald.jones@nist.gov) or visit www.nist.gov/nsoft.

1 Watkin KL, Bilheux HZ, Ankner JF. Probing the Potential of Neutron Imaging for Biomedical and Biological Applications. In: Anderson et al. editors. Neutron Imaging and Applications. New York: Springer Science; 2009. p. 253-264.

2 Image provided by Dan Hussey, NCNR.

3 Luk A, Murthy NS, Wang W, Rojas R, Kohn J. Study of nanoscale structures in hydrated biomaterials using small-angle neutron scattering. Acta Biomaterialia 2012; 8:1459–1468.

William Reichert,
Program Chair

Grand Challenges in Biomaterials

The Society For Biomaterials typically hosts an all-encompassing annual event of interest to the biomaterials community at large. Because it is co-sponsoring the 9th World Biomaterials Congress in Chengdu, China, the Society has selected an exciting theme for a domestic meeting by building upon the National Academy of Engineering's Grand Challenges for the 21st Century to create Grand Challenges in Biomaterials. The program committee for this 2012 Fall Symposium is preparing a lineup of topics that are game changers, not just the usual reports on developments in the field. All sessions are designed to spark lively discussion and provoke thought about the future of biomaterials translational science and technology. This unique environment is one in which every exhibitor is regarded as both a valuable contributor to the meeting and an important colleague. We are expecting that this event will be sold out as the capacity for the venue is limited to 500 participants. Please contact Dan Lemyre for 2012 sponsorship opportunities.

Education News

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consistently and conveniently offer, compared to what the "average" professor brings to a class. Webcasts and podcasts make it possible for everyone to learn from the most effective professors. But is the environment really the same?

Similarly, few would argue that technology has no place as a learning tool. There are many examples of how it can be used to enhance the learning experience and improve outcomes. In particular, there are now many more ways in which students and professors can interact, both in real time and in recorded formats. Students are changing the ways they access and use information, and perhaps our classrooms need to reflect these changes more directly.

As Education Editor of the *Biomaterials Forum*, I would be very pleased to hear about how SFB members have been using, avoiding, developing or adapting technology to suit their courses in biomaterials science. Clearly, it is to our advantage to intelligently incorporate these methods into our educational programs, but the best practices are far less clear.

Industrial News

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7. **Biomet, Inc.** (Warsaw, Ind.), a global leader in the manufacture of musculoskeletal medical products, announced that it has made a binding offer to acquire the worldwide trauma business of DePuy Orthopaedics, Inc. Under the terms of the offer, which is subject to exclusivity protection, Biomet will pay approximately $280 million in cash. The binding offer was made in order to permit **DePuy Orthopaedics** to comply with its consultation obligations with various European works councils prior to entering into a negotiated, mutually binding purchase agreement. The binding offer expires on June 1, 2012 but can be extended under certain circumstances. The transaction is subject to receipt of regulatory approvals, completion of required employee consultation procedures and other customary closing conditions.

8. Researchers at the **Fraunhofer Institute for Ceramic Technologies and Systems**, IKTS, (Hermsdorf, Germany) have succeeded in wirelessly transmitting power from a portable transmitter module to a mobile generator module. Using this portable device, the researchers can supply power to implants, medication dosing systems, and other medical applications remotely without touching them—such as ingestible endoscopic capsules that migrate through the gastrointestinal tract and transmit images of the body's interior. Radio-wave-based and inductive systems are most commonly used to power many electronic implantable devices. The problem with such systems is that they perform differently depending on a range of factors, including their location, position, and the movement of the body. In addition, they often have limited range. To address this deficiency, the Fraunhofer scientists have developed a power transfer system using magnetic coupling that wirelessly transmits power from a portable transmitter module to a mobile generator module—the receiver.

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Special Interest Group Application

Please note: You must be a member of SFB to join a SIG

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*Each Special Interest Group is $10 per year (**free for Student Members**)*

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