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IUPUI - Purdue School of Engineering & Technology

THE BME NETWORK

Newsletter of the Department of Biomedical Engineering

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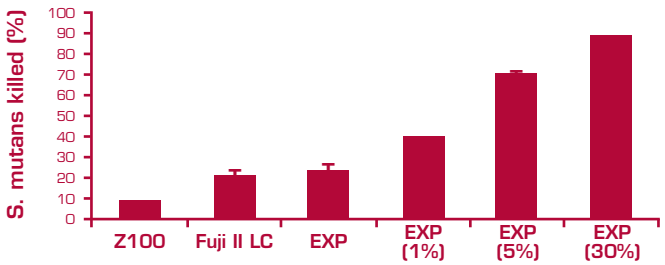
Reasearch on Advanced Dental Restoratives

It has been reported that half of all dental restorations fail within 10 years and replacing them consumes 60% of the average dentist's practice time. Secondary caries and fracture of the restoration are found to be the main reasons for restoration failure. Secondary caries are caused by acid-producing oral bacteria whereas fracture of the restoration results from the material failure. To increase restoration longevity, dental restoratives must be made strong and stable enough to withstand fracture as well as wear and antibacterial enough to prevent or reduce secondary caries.

Comparison among the experimental cement and commercial dental materials

Property	Z-100	Fuji II LC	EXP
Compressive strength [MPa]	365	213	326
Diametral tensile strength [MPa]	75	31	70
Flexural strength [MPa]	143	56	109
Knoop hardness	68	31	62
Abrasion wear depth [μm]	3.5	158	10
Attrition wear depth [μm]	10	197	78

Z-100 = commercial composite resin; Fuji II LC = commercial glass-ionomer cement; EXP = our experimental cement composed of star-shaped polymer



The percentage of S. mutans killed vs. the tested materials: After culturing with commerical composite resin, commercial GIC Fuji II LC and the experimental cement without and with adding 1%, 5% and 30% antibacterial polymers for 48 h, the S. mutans viability was determined. The S. mutans is a major acid-producing oral bacterium that is mainly responsible for oral cavity formation.

Dental restorative materials can be classified as direct and indirect materials. There are three fundamental categories of direct materials for dental cavity restorations: dental amalgam, dental composite resins and dental glass-ionomer cements (GICs). Currently use of dental amalgam in dental clinics has almost been abandoned in USA due to its color

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Dong Xie, Ph.D.

Dr. Xie received his Ph.D. in Polymeric Biomaterial/Oral Biology from The Ohio State University in 1998. After working as a postdoctoral fellow in the Department of Chemistry at University of Alabama at Birmingham for one year, he became a faculty member in the Department of Biomedical Engineering at UAB. In August, 2004, Dr. Xie joined the faculty of the Department of Biomedical Engineering at IUPUI and became an Associate Professor. Dr. Xie has received numerous research grants including NIH R01, NIH R21, NIH RC1, NSF EPSCoR awards and several industrial grants. Last year he was awarded a prestigious NIH challenge grant (1 of 200 in the nation) for developing an advanced high-performance dental restorative system for improved and long-lasting dental restorations. So far he has published more than 80 peer-reviewed papers and given over 50 presentations in national and international conferences. Dr. Xie teaches courses in the

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Message from the Chair

Edward J. Berbari
Professor, Chair
Biomedical Engineering

During the past fiscal year the faculty members in the Biomedical Engineering Department were awarded over $5.5 million in external funding (counting only single year amounts for multi-year grants). Some of this success can be attributed to federal stimulus funds, key among them a highly competitive NIH Challenge Grant received by Dr. Dong Xie. Dong is featured in the spotlighted cover article. His research in biomaterials has been leading edge and the dental applications have been well funded and the source of several patent applications over the years.

Our third class of 16 BSBME students graduated this Spring. The number of students continues to increase as we approach our class size maximum in the current sophomore class. Additionally, the dual degree program with Butler University has been contributing about 10 – 15 new students to the department. The first group of these dual degree students will graduate this Spring. This unique dual degree program offers these students the opportunity to earn a science degree from Butler and a Purdue engineering degree from our campus in a five year program.

Our initial accreditation visit is scheduled for this September. This assessment based process requires many measurements of our Program Educational Outcomes as well as our Program Objectives. These are all outlined on our website. (www.engr.iupui.edu/bme)

The BME department has made two recent hires, Dr Chien-Chi Lin and Dr Joey Wallace; both of whom are featured in this issue of the newsletter. At the time of their hire the department reached a milestone with the full complement of 13 faculty as originally planned at the inception of the department.

Sadly this did not last long. Dr Charles Turner, a key member of the faculty and a Chancellor's Professor, lost his battle with cancer in mid-July. Charles was a major contributor to the design and development of the department and he also served as our Associate Chair. Dr. Turner was an internationally renowned expert in musculoskeletal biomechanics and bone biology, with particular interests in how bone responds to mechanical loading and skeletal genetics. He published over 250 scientific papers and gave over 100 invited presentations worldwide. This was a major loss for our department and the BME community. We will all miss him.

FACULTY SPOTLIGHT

Chien-Chi Lin, Ph.D.

Dr. Lin joined the Department of Biomedical Engineering at IUPUI in Fall 2010 after 3 years of postdoctoral training in Dr. Kristi Anseth's group in the University of Colorado at Boulder and Howard Hughes Medical Institute. He has earned several academic awards, including Clemson University's Outstanding Graduate Researcher Awards, Colorado Clinical & Translational Sciences Institute CO-Pilot Award, and American Institute of Chemists Postdoctoral Award.

Dr. Lin's major research interests include the use of functional hydrogels for tissue regeneration and drug delivery applications. Hydrogels have evolved as promising materials for cell/tissue encapsulation and carriers for delivering biomacromolecules such as proteins, peptides, and nucleic acids. Functional hydrogels have many potential applications, including the treatment and/or prevention of musculoskeletal and neuronal degeneration, cardiovascular complications, and immune/inflammation related diseases. Dr. Lin's research group utilizes various bioconjugation techniques to fabricate functional biomaterials with spatially and temporally patterned moieties to regulate cell fate processes, including differentiation, proliferation, and apoptosis.

Joey Wallace, Ph.D.

Dr. Wallace joined the BME Department at IUPUI after completing Ph.D. and postdoctoral fellowships at the University of Michigan where he studied the impacts of disease and mechanical loading on bone structure and mechanical function. Primary research interests include understanding factors that influence the organization and assembly of bone. His goal is to translate findings into rational and clinically-relevant diagnostic and treatment options for defects, damage and disease of musculoskeletal tissues. His work focuses on tying morphology and composition to mechanical function at discrete size scales throughout bone's hierarchy. Nanoscale methods include using electron and atomic force microscopies to probe collagen morphology and mechanics. Investigations of tissue composition using Raman Spectroscopy are coupled with nanoindentation at the microscale. Whole bone structure and mechanical function are assessed using μCT, histomorphometry and whole bone mechanical testing.

Dr. Wallace is a member of the American Society of Bone and Mineral Research, the Orthopeadic Research Society, the Materials Research Society and the Biomedical Engineering Society.

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mismatch with natural tooth and potential toxicity from mercury. Dental composite resins are popularly used in dental clinics because of their high mechanical strength and better wear-resistance comparable to natural tooth. Nevertheless, dental composite resins cannot directly bond to the tooth without help of an adhesive. Dental composite resins lack fluoride release, shrink and have a higher thermal expansion coefficient than natural tooth. Dental GICs, another potential alternative for traditional dental amalgam, show numerous advantages over dental composite resins. GICs are superior to dental composite resins in many properties including direct adhesion to tooth and base metals, anticariogenic properties, thermal compatibility with tooth, self-healing, long-term stability, and lower microleakage. However, their low mechanical strengths and poor wear-resistance have restricted their uses only at low-stress and low-wear bearing sites. To improve dental GICs, Dr. Xie proposed to change the nanostructures of the polymers in GICs by synthesizing star-shaped or highly branched macromolecules via advanced ATRP technologies and formulating them into GICs. This project was sponsored by the NIH exploratory grant (DE018333). As a result, the innovative GIC system showed much higher mechanical strengths and wear-resistance as compared to current commercial GICs. More excitingly, the strengths and wear-resistance are comparable to those of current commercial dental composite resins, indicating that dental GICs can be used as a better alternative for dental amalgam (see Table). Recently with the newly awarded NIH challenge grant (DE020614), Dr. Xie's research group is developing a novel antibacterial GIC system with permanent antibacterial functions (see Figure). This system will make development of advanced long-lasting dental restoratives possible. By combining the high-strength and high-wear-resistant polymers that Dr. Xie's group has developed with polymers having antibacterial functions, the new system can significantly reduce dental patients' pain and expense as well as the number of visits to dental offices. Successful achievement of the goal of this project will greatly impact the field of restorative dentistry and benefit those patients who need long-lasting dental restorations.

[Xie] Continued from page 1

area of biomaterials including implantable biomaterials, biomaterial science and engineering, polymers for biomedical applications and advanced biomedical polymers. Dr. Xie's main research interests are to develop functional biomaterials for dental restorations and orthopedics, develop biodegradable polymers for tissue engineering, and develop functional polymers for regenerative medicine.

Awards presented to BME Seniors at the annual Engineering & Technology's Honors Convocation in April

Outstanding Performance in the Senior Year:
Jonathan Landes & Sam Whipple

Exemplary Internship or Research Experience:
Nichole Leahy

BME Service Award:
Adam Hooker

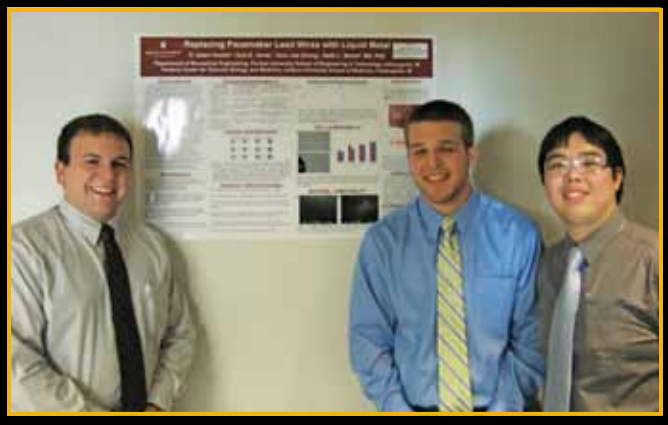
BME's Class of 2010

Congratulations to the third graduating class from the BME Department.

ChiaLei Ang
Mikias Ayalew
Voon Joe Chong
Blair Coats
Paul Curtis
Michael Hendon
Adam Hooker
Kyle Jones
Kellen Knowles
Jonathan Landes
Nichole Leahy
Mustafa Mavi
Tyler Nelson
Khalid Serhani
Muller Soliman
Sam Whipple

Senior Design Day

Senior BME majors gathered in May to present their senior design projects. These students, who were enrolled in BME 49200 Biomedical Engineering Design instructed by Bill Combs, delved into topics ranging from cell research chambers to patient software assessment tools and chronic implantable leads. The Outstanding Senior Design Team award went to ChiaLei Ang, Mikias Ayalew, Brandon Brugard, and Mustafa Mavi for their outstanding work.



TOP – Adam Hooker, Kyle Jones and Voon Joe Chong stand by their poster after presenting a summary of their project.

RIGHT – Courtney Robertson explains the theory behind his group's design to an audience gathered near the BME office.

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BME Seminar Schedule 2010-11

Sep 10	Jong Hyun Choi	Mechanical Engineering, Purdue University
Oct 8	Yunlong Huo	Biomedical Engineering, IUPUI
Nov 19	Richard Day	Cellular and Integrative Physiology, IUPUI
Dec 3	Christoph Naumann	Chemistry and Chemical Biology, IUPUI
Jan	TBA	
Feb	TBA	
Mar	TBA	
Apr	TBA	

Research Areas of BME Faculty

BIOMATERIALS
Dong Xie, Ph.D., *Associate Professor*
Chien-Chi Lin, Ph.D., *Assistant Professor*

BIOMEDICAL INSTRUMENTATION
Edward Berbari, Ph.D., *Professor and Chairman*

CARDIOVASCULAR ENGINEERING
Ghassan Kassab, Ph.D., *Professor*
Julie Ji, Ph.D., *Assistant Professor*
Bill Combs, MSEE, *Clinical Assoc. Professor*

MECHANOBIOLOGY
Joseph Wallace, Ph.D., *Assistant Professor*
Sungsoo Na, Ph. D., *Assistant Professor*

NEUROENGINEERING
John Schild, Ph.D., *Associate Professor*
Ken Yoshida, Ph.D., *Associate Professor*
Karen Alfrey, Ph.D., *Instructor*

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