LASER
BECKMAN LASER INSTITUTE

IN THE NEWS

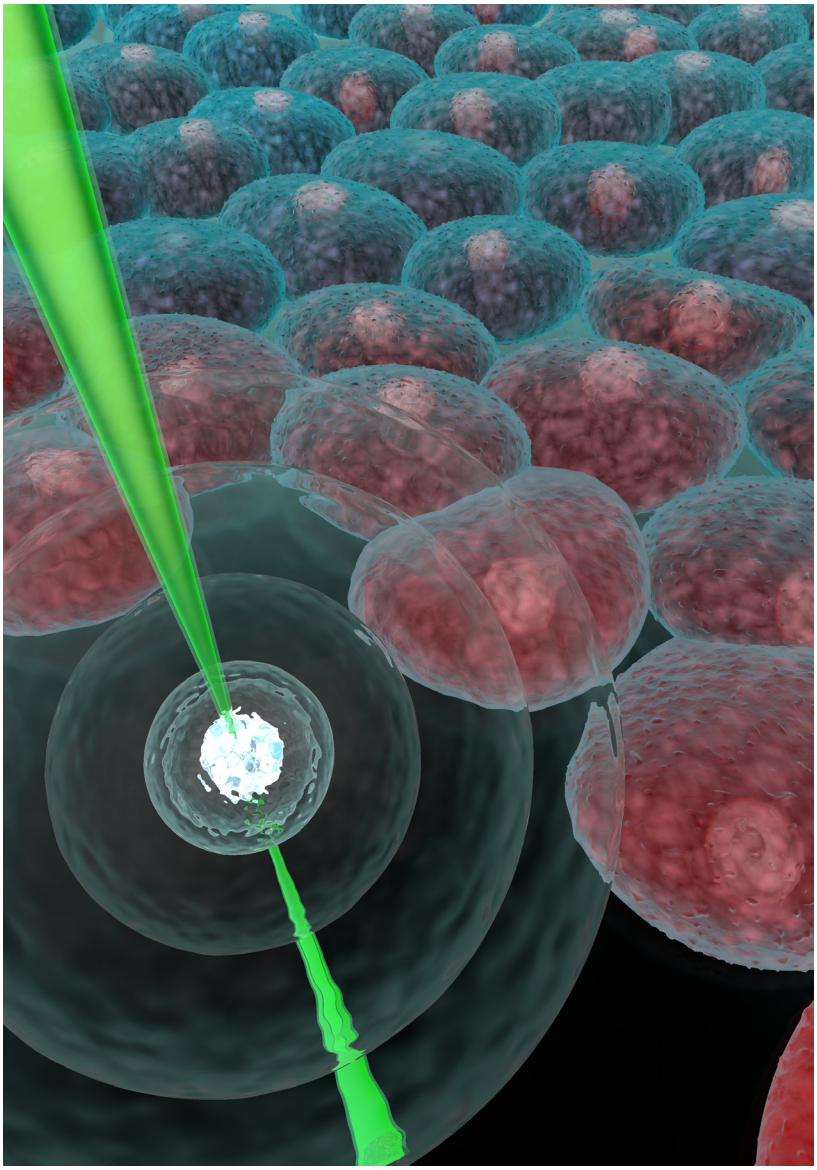
FALL 2014

Using Microtsunamis to Study Cellular Mechanotransduction

Many pathological conditions including hypertension, osteoarthritis, and tumor metastasis have been linked to the dysregulation of biochemical pathways that modulate cell behavior based on its local mechanical microenvironment. Unfortunately, no methods exist that can rapidly identify molecules that can interfere with these cellular mechanotransduction pathways. In "High-throughput optical screening of cellular mechanotransduction" by J. L. Compton, J. C. Luo, H. Ma, E. Botvinick and V. Venugopalan (*Nature Photonics*, published online August 3, 2014), the authors introduce an optical platform that combines pulsed laser irradiation and dynamic fluorescence imaging for rapid, high-throughput screening of exogenous molecules that affect cellular mechanotransduction. The method initiates mechanotransduction in adherent cells using single laser-microbeam generated microcavitation bubbles without requiring flow chambers or microfluidics. These microcavitation bubbles expose adherent cells to a microtsunami, a transient microscale burst of hydrodynamic shear stress, which can stimulate primary human endothelial cells over areas approaching 1mm^2.

Current assays used for screening of small molecule libraries do not assess the ability of these molecules to modulate cellular responses to mechanical cues. The authors postulate the existence of classes of 'mechano-active' drugs that can target these pathways: drugs that remain undiscovered because there is no practical method to implement high-throughput screening.

The results of numerous studies support the important role of mechanotransduction in many vital processes, including tissue morphogenesis, stem cell differentiation, vascular regulation and tumor metastasis. Moreover, there is mounting evidence that disruptive mechanical cues and/or dysregulation of mechanotransduction pathways play important roles in the initiation and/or progression of numerous diseases, including atrial fibrillation, hypertension, osteoporosis, digestive diseases and cancer. ▪



MicroTsunamis (μTs) for rapid, high-throughput screening of exogenous molecules that affect cellular mechanotransduction. *A single pulsed laser-microbeam generates a microcavitation bubble. The rapidly expanding bubble displaces surrounding fluid to expose adherent cells to a μT, a transient microscale burst of hydrodynamic shear stress, which mechanically stimulates cells over areas approaching 1 mm^2. The μT is integrated into an automated fluorescence microscope and fluorescent markers of cell signaling (illustrated with red shading) can be quantified in response to the transient shear stresses.*

Reflections from a Whiteboard

by Michael W. Berns, Ph.D.
Arnold and Mabel Beckman Professor
Co-Founder, Beckman Laser Institute

I had a large whiteboard (we used to call it a blackboard) in my office. On it was scrawled a list of quotes I thought were "cool" and relevant to everyday life. I don't remember them all, but three stick in my mind.

The first was Arnold O. Beckman's rule 7: "Don't take yourself too seriously." At first blush, I thought it meant don't be a workaholic—have other interests. But as I thought about it, a different meaning emerged: "Don't be seduced by your own self-perceived infallibility; listen to others; get input from different perspectives before making a decision."

The second quote, "No bucks, no Buck Rogers," seemed self evident: "No money, no research." I don't remember the source of that quote, but it too had a deeper meaning other than "show me the money." To me, it meant be creative in finding the money, "turn over every rock," (an often used but relevant cliché) which again reminds me of something else Arnold Beckman said to me. He said, "Michael, there is no entitlement." That motivated me to turn over many rocks to find the money: government grants, private foundations, individual donors with specific interests—and if they didn't have an interest in what we were doing, create that interest. For example, the Photonic Incubator wing of the BLI was funded by a grant from the U.S. Department of Commerce. It was a small part of a larger application by Orange County in the early 1990s when the defense industry was in a major tailspin and the government was saying it wanted proposals that would convert some of the fancy defense technology to useful purposes for the public ("defense conversion"). The multimillion dollar County application was turned down—except for our little $1M section which was right on target. With that commitment, we were able to leverage donations from private individuals, foundations, the University, and companies to secure enough funds ($2.5M) to build the incubator (which today is incubating four companies).

The third quote has been around a long time: "Power corrupts." This is an insidious scenario because often it creeps into reality before one is totally aware that his/her power is being used improperly and even unethically. There are many examples around the world in the present day and throughout history. It is an axiom of every dictatorship that has ever existed. And academia is not immune, as is the case with every institution, public or private. The best way to mitigate the chances of corruption is to have adequate oversight and accountability. And on a personal level, realize the strength of your own power and how it can benefit as well as hurt others and their organizations.

These are only three of about twenty quotes, rules to live by, that were on my now-gone whiteboard. They are just as useful today as when I wrote them on the board 20 years ago. ▪

Newsbriefs

Department Chair Appointment

Vasan Venugopalan

Professor Vasan Venugopalan has been appointed Chair of the Department of Chemical Engineering and Materials Science.

BLI Professor named Associate Editor

Brian Wong, M.D., Ph.D., Professor, Vice-Chairman, and Fellowship Director in Otolaryngology-Head and Neck Surgery was named Associate Editor of *JAMA Facial Plastic Surgery.*

New Director of DOSI Lab

Tom O'Sullivan

Postdoctoral Researcher Tom O'Sullivan has been appointed Director of the Diffuse Optical Spectroscopy & Imaging (DOSI) Lab at the Beckman Laser Institute. DOSI is a technology designed to "see" metabolic tissue function and tissue architecture below the surface. DOSI provides high spectral resolution (as with MRS) with a low spatial resolution of functional qualities (as with PET) using a handheld probe and portable interface (as with ultrasound).

New IGERT Trainees Selected

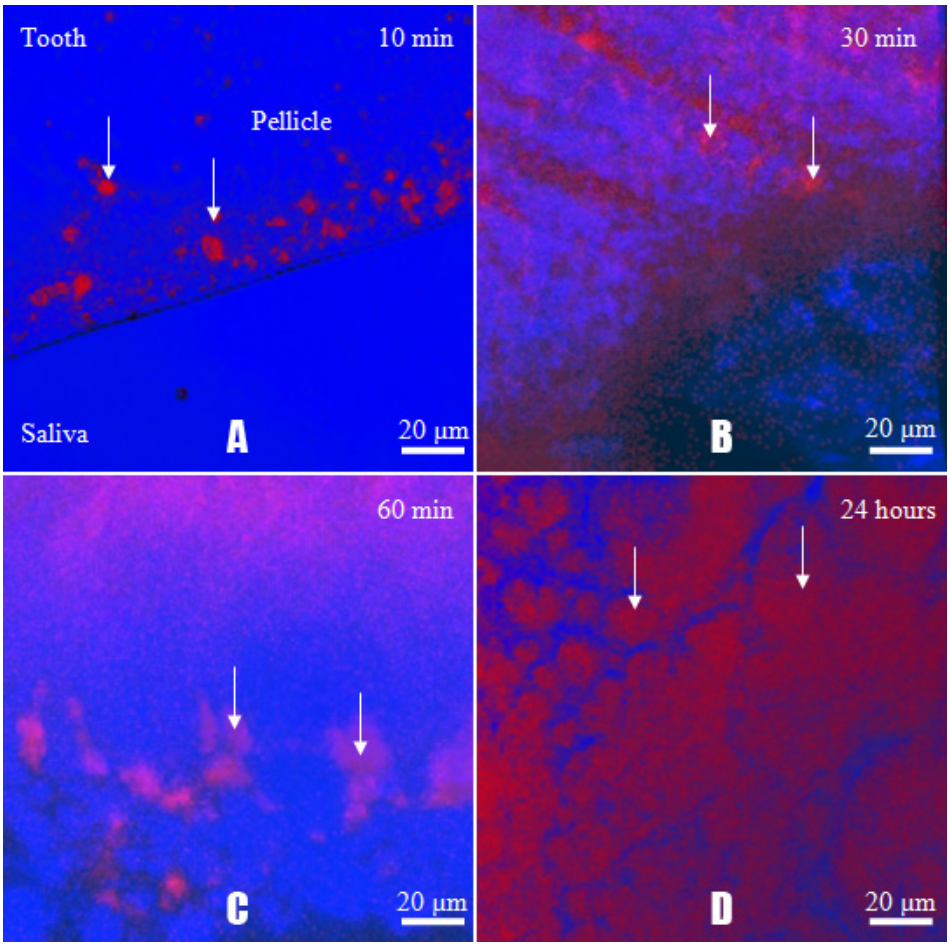
Four students have been selected as the third group of the IGERT (Integrative Graduate Education & Research Traineeship) program. The program exposes graduate students to the biophotonics field from different disciplinary perspectives that include microscopy and microbeams, wide-field functional imaging, diffuse optical spectroscopy and imaging, multiscale molecular probes, and biophotonics modeling and computation. The students are Andrew Heidari (Biomedical Engineering), Emma Mah (Chemical Engineering), Michael Ghijsen (Biomedical Engineering), and Jessica Kwong (Biomedical Engineering).

How to Improve Your Oral Health

A pilot study is being conducted to further the understanding of the dental pellicle and oral biofilm formation prior to toothbrushing, potential disruption and reformation after use of various toothpastes. The primary objective of the study is to investigate the pellicle thickness, coverage and microstructure after brushing with Zendium, a fluoride-containing toothpaste marketed by Farmaline, compared to a water control and a standard silica fluoride toothpaste. The second objective of the study is to investigate if there is a correlation in the pellicle thickness, coverage and microstructure with the levels of clinical erosion in the mouth, salivary pH, total protein, and salivary buffering capacity.

Novel noninvasive in vivo and ex vivo imaging techniques that have been developed at the Beckman Laser Institute in a collaboration between Dental Director Petra Wilder-Smith and Dr. Tatiana Krasieva, together with a unique plaque and pellicle model, will permit the characterization and quantification of location-specific pellicle and plaque over time as well as efficacy of various biofilm-control measures.

Funded by a multi-year grant from Unilever entitled "Pellicle," Dr. Wilder-Smith will partner with the oral care research team at Unilever to provide novel insights into oral biofilm that will be directly transferrable to wound infection and other important clinical manifestations of biofilm. ▪



Progressive growth and development of biofilm (white arrows) on one tooth sample. *Top view of 3-D reconstructed NLOM (non-linear optical microscopy) images at progressive saliva incubation time points: A, 10 minutes incubation; B, 30 minutes incubation; C, 60 minutes incubation; D, 24 hours incubation. Blue signal originates from tooth and saliva; pink and red signal originates from biofilm. Over time, the number and diameter of biofilm islands gradually increased.*

2nd Annual Short Course in Computational Biophotonics

The second annual short course in Computational Biophotonics was held August 4-8, 2014, at the Beckman Laser Institute and Natural Sciences II. Course participation included 22 students and 13 faculty members. The disciplinary backgrounds of the faculty encompass physics, biomedical engineering, electronics, mathematics, dermatology, chemistry, optics, electrical engineering and chemical engineering. The organizers, Drs. Vasan Venugopalan and Jerome Spanier, believe that the course fills a major unmet need in national biophotonics training. Nationwide, research in the development and utilization of biophotonics methods and technologies is increasingly pervasive throughout the biomedical, physical sciences, and engineering communities. In fact, this year's Nobel Prize in Chemistry was for the development of nanoimaging using advanced biophotonics methods. The course focused on the underlying principles of these methods and the development of tools for biophotonics modeling and signal analysis which are critical for the proper deployment of biophotonics tools and interpretation of the

(Short Course continued on p. 7)

Noninvasive Optical Melanoma Screening

Currently, invasive biopsy and histopathologic analysis provide the only way to diagnose melanoma. There is a great need to noninvasively improve melanoma detection. Noninvasive diagnosis may also help detect melanoma earlier and avoid deadly late stage disease.

Dr. Kenneth Linden (left) training on the use of the Hyperspectral Dermatoscope with Dr. Daniel Gareau (right).

Dr. Daniel Gareau of the Laboratory of Investigative Dermatology at The Rockefeller University is applying new imaging technology and software algorithms to enable rapid, noninvasive, quantitative melanoma screening. He hopes to bring high diagnostic accuracy to both the clinic (by a physician) and into the field (by patients using their cell-phone camera or general care physicians using devices with intermediate complexity). He hopes that this will save lives and reduce treatment costs by detecting early disease. He is currently focusing on the simplest mode of noninvasive optical melanoma detection: diffuse light imaging.

Dr. Gareau says, "A dermatologist's ability to noninvasively classify or distinguish dysplastic lesions from melanomas is imperfect since only 3-25% of all biopsied, suspicious lesions are actually melanomas. Dermatologists with dermatoscopes achieve only a 10% average success rate identifying melanoma (in biopsied nevi) which is the same as currently available systems such as Melafind. Better diagnostics are needed in clinical medicine to diagnose deadly melanoma more effectively. Melanoma is the most fatal skin cancer which killed 9,200 Americans in 2012. Melanoma kills 65,000 worldwide annually. The overall five-year survival rate is 90.5%, ranging from 100% (stage 0 detection) to 16.2% (stage IV). Current therapies extend life for only about 9 months. Hence, the early lateral growth phase is a vastly preferable detection window to the subsequent phase of metastatic initiation."

A machine vision and learning algorithm is being developed by Dr. Gareau to analyze lesions for the degree of asymmetry, border irregularity, color variegation, and maximum diameter (ABCD acronym), and this information can in turn help in automatically detecting early disease. Thirty computer vision malignancy metrics were developed based on Red/Green/Blue dermoscopy images that build off the ABCD algorithm. These metrics combine to form a classifier to differentiate primary cutaneous melanomas versus nevi with mild or moderate dysplasia. After preliminary testing using this algorithm on lesions, the most interesting result was that among the color channels red, green and blue, there were significant differences in the diagnostic value of the malignancy metrics. Out of curiosity, a Monte Carlo simulation was created to mimic light transport in anatomically "correct" pigmented lesions. The results showed that particular wavelengths in the simulation were effective at probing particular morphologies, both malignant and common.

(From left to right) Drs. Kristen Kelly and Brandon Coakley holding Hyperspectral Dermatoscopes.

To test these predictions, Dr. Gareau is embarking on a multi-site clinical trial which includes the UC Irvine Chao Comprehensive Cancer Center and Beckman Laser Institute. Kenneth Linden, Kristen Kelly and Brandon Coakley are UC Irvine physicians participating in the trial and Anthony Durkin is the engineering faculty engaged in the project. The Hyperspectral Dermatoscope will record calibrated reflectance maps under illumination from 21 LEDs in the visible and near-infrared wavelength range. The entire imaging process takes less than 5 minutes for the first lesion and less than one additional minute for imaging each additional lesion on any particular patient. Patients undergoing routine biopsy or excision of suspicious skin lesions will be invited to participate in the study which will include a brief hyperspectral imaging session before the biopsy. Comparing the gold standard histological result with the risk score generated by the machine vision algorithm will yield the receiver operator characteristic curve which will tell researchers whether the technique offers advantages over the current noninvasive screening techniques.

Staff Profile: Albert Cerussi

Albert Cerussi

After earning his Ph.D. in physics from the University of Illinois, Urbana-Champaign in 1999, Albert Cerussi accepted a postdoctoral position in Dr. Bruce Tromberg's lab to work on optical spectroscopy in breast cancer. Albert worked his way up to Associate Researcher in the Department of Surgery with an appointment as a faculty member of the Beckman Laser Institute (BLI). His main task was to run the Diffuse Optical Spectroscopic Imaging (DOSI) lab which featured work Dr. Tromberg performed in the early 1990s.

Selecting one accomplishment to summarize his time at BLI, Albert says, "I would say that with the help of many people over the years, I was able to make DOSI into a real clinical research device. We continually improved the instrument—making it smaller, faster and more powerful with more information content. We made multiple DOSI instruments that were featured in the first national multi-center clinical trial sponsored by the American College of Radiology Imaging Network (ACRIN), which has recently been completed, that noninvasively measured the metabolic responses of breast tumors to pre-surgical chemotherapy in nearly 60 patients. We miniaturized the instrument, enabling it to be distributed to other labs in the U.S. and Asia."

Soon after arriving in Irvine, Albert met his "true love," Natalie, whom he married in 2000. Through a "mixture of biology and adoption," they have five children—"enough for a starting basketball team."

Because of the cutting-edge work done in translational research featuring optical technologies, Albert was recently offered a job from Apple which he accepted, and he left BLI at the end of October. After 15 years, Albert will miss BLI, from its unique combination of basic science, engineering and a clinic all wrapped up into "one yummy enchilada" to the many colleagues, students and staff who have helped shape him into the scientist he is today. As he notes, "You can take Albert out of the BLI, but you can't take the BLI out of Albert."

While BLI wishes the best to Albert and his family as they embark on their new endeavor, his warm, friendly, always ready to help attitude will be truly missed. ■

Honors and Awards

Zhongping Chen, Ph.D.

Zhongping Chen

Professor Zhongping Chen was awarded a 4-year grant, "Phase resolved acoustic radiation force (ARF) optical coherence elastography for intravascular imaging," from the National Institutes of Health (National Heart Lung and Blood Institute) to build a better imaging system for looking inside the arteries. Working with Dr. Qifa Zhou of USC Viterbi School of Engineering and Dr. Pranov Patel of the UCI School of Medicine, Dr. Chen proposes to capture the benefits of three sophisticated imaging technologies: high resolution of optical coherence tomography, deep tissue penetration of ultrasound imaging and biomechanical contrast of optical coherence elastography. The funding will support his efforts to incorporate all three technologies into a single catheter device.

Anthony Durkin, Ph.D.

Anthony Durkin

Associate Professor Anthony Durkin is the Principal Investigator of two grants from the National Institutes of Health (NIH). The first grant, "Hyperspectral imaging based on multimode dermoscope for early melanoma detection," will fabricate and characterize tissue simulating phantoms and collect clinical data from pigmented lesions. The second grant, "Spatial frequency domain imaging for burn wound severity assessment," will develop spatial frequency domain imaging (SFDI) as a method that will provide objective parameters that can be used to determine severity of burn wounds.

Petra Wilder-Smith, D.D.S., Ph.D.

BLI Dental Director Petra Wilder-Smith has received a grant from Unilever, "Pellicle," to understand dental pellicle and oral biofilm formation (see Research Update, page 3). Dr. Wilder-Smith has also received a grant from EPIEN Medical, Inc., "Development of imaging techniques for oral biofilm," to further research into innovative means of imaging wounds, wound healing and biofilms.

(Honors and Awards continued on p. 8)

RECENT PUBLICATIONS

"High-speed intravascular photoacoustic imaging of lipid-laden atherosclerotic plaque enabled by a 2-kHz barium nitrite Raman laser" by P. Wang, T. Ma, M. N. Slipchenko, S. Liang, J. Jui, K. K. Shung, S. Roy, M. Sturek, Q. Zhou, Z. Chen and J.-X. Cheng in *Scientific Reports* 4: 6889, 2014.

"Quantitative short-wave infrared multispectral imaging of in vivo tissue optical properties" by R. H. Wilson, K. P. Nadeau, F. B. Jaworski, R. Rowland, J. Q. Nguyen, C. Crouzet, R. B. Saager, Bernard Choi, B. J. Tromberg and A. J. Durkin in *Journal of Biomedical Optics* 19: 86011, 2014.

"Quantitative assessment of graded burn wounds in a porcine model using Spatial Frequency Domain Imaging (SFDI) and Laser Speckle Imaging (LSI)" by A. Ponticorvo, D. M. Burmeister, B. Yang, B. Choi, R. J. Christy and A. J. Durkin in *OSA Biomedical Optics Express* 5: 3467-3481, 2014.

"Rapid computation of the amplitude and phase of tightly focused optical fields distorted by scattering particles" by J. Ranasinghesagara, C. Hayakawa, M. Davis, A. Dunn, E. Potma and V. Venugopalan in *Journal of the Optical Society of America* A 31: 1520-1530, 2014.

"Comparative analysis of discrete and continuous absorption weighting estimators used in Monte Carlo simulations of radiative transport in turbid media" by C. Hayakawa, J. Spanier and V. Venugopalan in *Journal of the Optical Society of America* A 31: 301-311, 2014.

"Sustained activation of c-Jun N-terminal and extracellular signal-regulated kinases in port-wine stain blood vessels" by W. Tan, M. Chernova, L. Gao, V. Sun, H. Liu, W. Jia, S. Langer, G. Wang, M. C. Mihm, Jr., and J. S. Nelson in *Journal of the American Academy of Dermatology* 71: 964-968, 2014.

"Topical axitinib suppresses angiogenesis pathways induced by pulsed dye laser" by L. Gao, D. M. Nadora, S. Phan, M. Chernova, V. Sun, S. M. O. Preciado, W. Jia, G. Wang, M. Mihm, J. S. Nelson and W. Tan in *British Journal of Dermatology* (published online October 5, 2014).

"Topical rapamycin systematically suppresses the early stages of pulsed dye laser-induced angiogenesis pathways" in *Lasers in Surgery and Medicine* 46: 679-688, 2014.

"Non-invasive optical cytochrome c oxidase redox state measurements using diffuse optical spectroscopy" by J. Lee, J. G. Kim, S. B. Mahon, D. Mukai, D. Yoon, G. R. Boss, S. E. Patterson, G. Rockwood, G. Isom and M. Brenner in *Journal of Biomedical Optics* 19: 055001, 2014.

"The vitamin B12 analog cobinamide is an effective hydrogen sulfide antidote in a lethal rabbit model" by M. Brenner, S. Benavides, S. B. Mahon, J. Lee, D. Yoon, D. Mukai, M. Viseroi, A. Chan, J. Jiang, N. Narula, S. M. Azer, C. Alexander and G. R. Boss in *Clinical Toxicology* (Philadelphia, PA) 52: 490-497, 2014.

"Method measuring oxygen tension and transport within subcutaneous devices" by J. Weidling, S. Sameni, J. R. T. Lakey and E. Botvinick in *Journal of Biomedical Optics* 19: 087006, 2014.

"Multimodality imaging of the effects of a novel dentifrice on oral biofilm" by J. Ajdaharian, M. Dadkhah, S. Sabokpey, J. Biren-Fetz, N. E. Chung, C. Wink and P. Wilder-Smith in *Lasers in Surgery and Medicine* 46: 546-552, 2014.

"Effects of a novel dental gel on plaque and gingivitis: a comparative study" by M. Dadkhah, C. Wink, N. E. Chung, J. Ajdaharian, J. Holtzman, P. Klokkevold, R. Bhushan and P. Wilder-Smith in *Dentistry* 4: 239, 2014.

"Assessment of early occlusal caries pre- and post-sealant application—an imaging approach" by J. S. Holtzman, J. Ballantine, M. Fontana, A. Wang, A. Calantog, E. Benavides, C. Gonzalez-Cabezas, Z. Chen and P. Wilder-Smith in *Lasers in Surgery and Medicine* 46: 499-507, 2014.

"Photochemical internalization-mediated nonviral gene transfection: polyamine core-shell nanoparticles as gene carrier" by G. Zamora, F. Wang, C.-H. Sun, A. Trinidad Y. J. Kwon, S. K. Cho, K. Berg, S. J. Madsen and H. Hirschberg in *Journal of Biomedical Optics* 19: 105009, 2014.

"Damage to a single chromosome end delays anaphase onset" by B. A. Silva, J. R. Stambaugh, K. Yokomori, J. V. Shah and M. W. Berns in *Journal of Biological Chemistry* 289: 22771-22784, 2014.

"Optical imaging in an Alzheimer's mouse model reveals amyloid-β-dependent vascular impairment" by A. J. Lin, G. Liu, N. A. Castello, J. J. Yeh, R. Rahimian, G. Lee, V. Tsay, A. J. Durkin, B. Choi, F. M. LaFerla, Z. Chen, K. N. Green and B. J. Tromberg in *Neurophotonics* 1: 011005, 2014.

"Determination of motility forces on isolated chromosomes with laser tweezers" by N. Khatibzadeh, A. B. Stilgoe, A. A. M. Bui, Y. Rocha, G. M. Cruz, V. Loke, L. Z. Shi, T. A. Nieminen, H. Rubinsztein-Dunlop and M. W. Berns in *Scientific Reports* 4: 6866, 2014.

"Coupled forward-adjoint Monte Carlo simulation of spatial-angular light fields to determine optical sensitivity in turbid media" by A. R. Gardner, C. K. Hayakawa and V. Venugopalan in *Journal of Biomedical Optics* 19: 065003, 2014.

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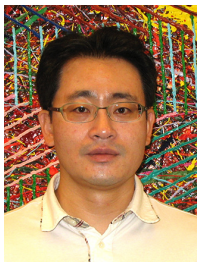
Arrivals and Departures

ARRIVALS


Kyoungrai Cho

Kyoungrai Cho, M.D., Ph.D., Assistant Professor of Otolaryngology Head & Neck Surgery, Sanggye Paik Hospital, Inje University College of Medicine, Seoul, Korea, has joined the lab of Dr. Brian Wong as a Visiting Scholar for one year. Dr. Cho will be studying nasal airflow, mechanics and surgical simulation.


Gordon Kennedy

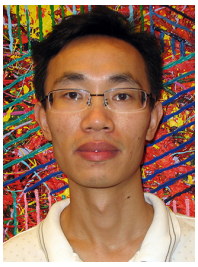
Gordon Kennedy, Ph.D., has joined the lab of Dr. Anthony Durkin as a Project Scientist. Dr. Kennedy will be working on burn wound assessment using spatial frequency domain imaging (SFDI).


David Lopez

David Lopez, B.S., L.V.T., R.L.A.T.G., has been hired as Animal Health Technician. David previously worked as the Coordinator of Veterinary Clinical Services at the University of Arizona, Tucson.


Kyungjin Oh

Kyungjin Oh, M.D., Ph.D., is a urologist from Chonnam National University, Gwanju, South Korea, who will be working in the labs of Drs. Matthew Brenner and Zhongping Chen as a Visiting Scholar. Dr. Oh will be doing a study on the ability to perform optical coherence tomography (OCT) evaluation of biofilm formation in Foley catheters.


Lyuming Zeng

Lyuming Zeng is a Visiting Scholar from Jiangxi Sciences and Technology Normal University, China, who will be working in Dr. Zhongping Chen's lab on photo-acoustic imaging.

DEPARTURES

Rui Li, Ph.D., a postdoctoral fellow in Dr. Zhongping Chen's lab, has accepted a position with Apple in Cupertino, CA.

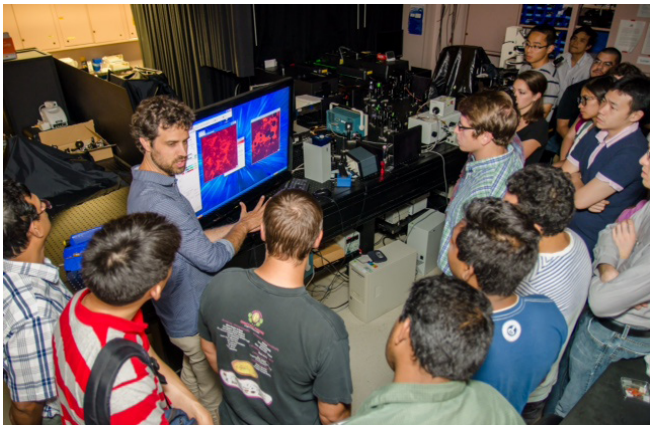
Laurie Newman, A.H.T., has taken a job at the UC Irvine Laboratory Animal Resources.

Short Course *(cont'd from p. 3)*

measured optical signals.

Day 1 introduced to the students physical and mathematical models for light transport in cells and tissues and computational resources to be used in the laboratory sessions. The focus of Day 2 was to introduce the principles and applications of linear and non-linear optical microscopy for 3-D structural and functional imaging of thick cellular and tissue samples. Emphasis was placed on modeling the effects of scattering on focal field distortion signal generation and propagation. The focus of Day 3 was on optical dosing in phototherapy and the connection between internal light fields and optical reflectance and transmission that forms the basis of optical diagnosis and imaging. Day 4 introduced the use of continuous light sources for tissue imaging and spectroscopy. Day 5 considered time-resolved and temporal frequency domain approaches used in diffuse optics.

Dr. Spanier added, "We were very pleased with the positive feedback we received from the students, faculty and the external evaluator. This year we broadened our Short Course audience by enrolling 5 students from two local companies that are deeply involved with biophotonics. Their participation in the discussions provided a refreshing non-academic point of view that added much to the scope of the Short Course material. A new feature this year was to close each day with a computational laboratory session in which students worked through the exercises we provided in 2-person teams and gave brief oral reports on their laboratory findings. All in all, Short Course in Computational Biophotonics 2014 was a great success." ■


Dr. Eric Potma gives a tour and demonstration of his optical microscopy facilities.

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Honors and Awards *(cont'd from p. 5)*

Anthony Durkin, Ph.D., Kristen Kelly, M.D., and Vasan Venugopalan, Ph.D.

Associate Professor Anthony Durkin, Professors Kristen Kelly and Vasan Venugopalan have been awarded a UCI ICTS Triumvirate Grant entitled "A portable, quantitative imaging device for noninvasive melanoma screening/detection." The funds will support construction of a handheld spatially modulated quantitative spectroscopy device and initial clinical data collection.

Soroush Mirzaei Zarandi, Ph.D.

Soroush Mirzaei Zarandi

Soroush Mirzaei Zarandi, who worked in the lab of Drs. Bruce Tromberg and Albert Cerussi, presented his dissertation defense, "Portable, real-time tissue functional imaging using frequency domain and continuous wave diffuse optics," on December 9, 2014. Soroush has accepted a job with Intel in Portland, OR.

John Weidling, Ph.D.

John Weidling

John Weidling, who worked in Elliot Botvinick's lab, presented his dissertation defense, "Transdermal microimplant for critical care monitoring," on November 6, 2014. John has formed a company, Canary Medical Inc., with Drs. Elliot Botvinick and Sean White which will incubate its technology for the commercialization of an early trauma alarm at the Beckman Laser Institute.

Caitlin Regan, B.S.

Caitlin Regan

Biomedical Engineering graduate student Caitlin Regan was selected as a Roche/ARCS Scholar for academic years 2014-2017. The National ARCS (Achievement Rewards for College Students) Foundation, Inc., is a unique volunteer organization of women dedicated to providing scholarships to academically outstanding U.S. citizens studying to complete their degrees in science, medicine, and engineering. Beginning in 2014-15, the ARCS Foundation is partnering with the Roche Foundation to reward outstanding graduate life science students with the Roche/ARCS Scholar Award. Caitlin works in the lab of Dr. Bernard Choi.