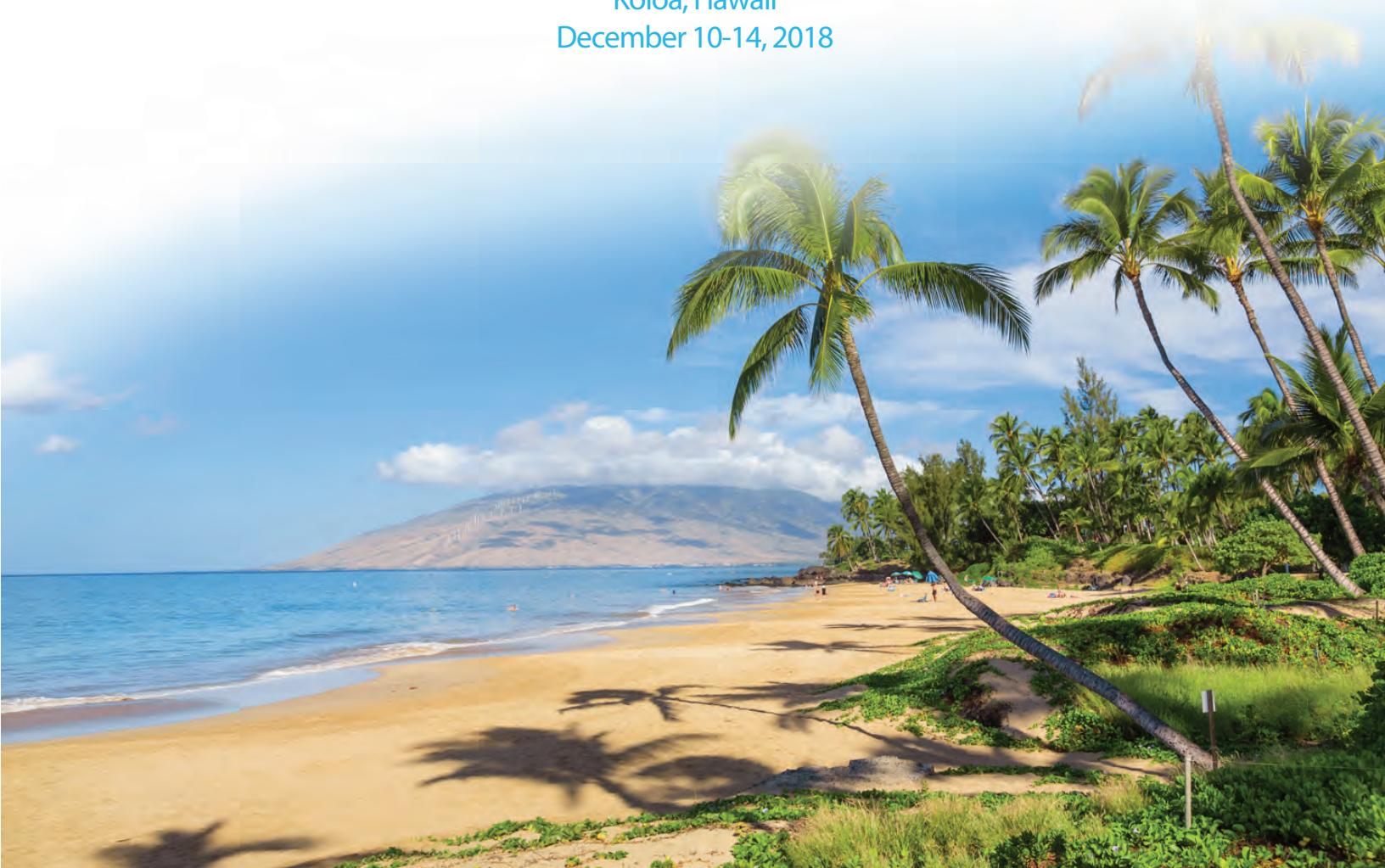
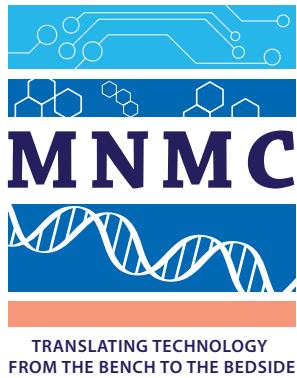


2018

EMBS Micro and Nanotechnology in Medicine Conference

Grand Hyatt Kauai
Koloa, Hawaii
December 10-14, 2018





IEEE EMBS Micro and Nanotechnology in Medicine Conference

10-14 December, 2018

Grand Hyatt Kauai, Koloa, HI

Conference Chairs

Dino Di Carlo, UCLA

Elliot Hui, UC Irvine

Sumita Pennathur, UC Santa Barbara



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#MNM18

Welcome Message

Aloha Colleagues:

We are very pleased to welcome you to the 4th IEEE EMBS Conference on Micro and Nanotechnology in Medicine. The goal of this conference is to foster interactions between scientists, engineers, entrepreneurs and medical researchers in the context of real-world medical needs and issues. We aim to promote and catalyze vigorous, open dialogue towards the development of cutting edge technologies for faster, more quantitative, and more affordable biomedical solutions by leveraging our collective expertise in various realms. Because this conference combines fundamentals of micro and nano science and engineering with their applications in medicine, we will be catalyzing conversations between otherwise disparate fields. Various biomedical grand challenges facing our society and the world can be addressed in part or in whole by interfacing biology and medicine with micro & nanotechnology. By drawing you, the leaders from each of these fields, together to discuss ways of addressing important medical issues with the most cutting edge technology in an intimate venue, we hope to enable progress at the interface of science, engineering, and medicine.

Commercialization also has a key role to play in providing a mechanism for directed and sustained effort and funding to traverse the long road from idea to product and to bring our innovations to the bedside. We further emphasize this aspect through including entrepreneurial leaders from all sectors as key stakeholders and participants in this meeting. Our focused session on “Advanced Patent and Licensing Strategies for Emerging Growth University Spin-out Companies” sponsored by law firm of Wilson Sonsini Goodrich and Rosati will delve into the detailed strategies that can aid entrepreneurs in securing IP from academic settings and setting the stage for further investment. We will also aim to explore more deeply this interface between academic innovation and commercialization, through a “Spin-out” panel with academic entrepreneurs sharing their wisdom.

Our previous conference was held in 2016 in Waikoloa, Big Island and was a resounding success! The conference included an incredible lineup of distinguished plenary speakers including Jim Heath, Donald Ingber, Suzie Pun, David Weitz, and David Walt. We also recognized John Rogers as the Trailblazer Award winner.

We are proud to continue this tradition of excellence and are delighted to again have a fantastic lineup of plenary and invited speakers. These include David Beebe from the University of Wisconsin, Tejal Desai from the University of California San Francisco, Shana Kelley from the University of Toronto, and Butrus Khuri-Yakub from Stanford – and we also have over 40 top researchers who are advancing the frontiers of research at the intersection of engineering and medicine at the micro and nanoscale. In an effort to hear the latest progress in translation from previous speakers at the meeting we introduced two new short talk sessions, that also provides time for new speakers to share new perspectives and technologies. This year we will also highlight up and upcoming junior leaders in the field with a special session and Young Investigator Award.

On behalf of the 2018 IEEE EMBS Conference on Micro and Nanotechnology in Medicine, welcome to Hawaii! Mahalo!



Dino Di Carlo



Elliot Hui



Sumita Pennathur

General Conference Information

Registration

Registration is located in the Kauai Promenade and will be open Monday, December 10 through Friday, December 14. Staff will be able to assist you during the following time schedule.

Monday	2:00 PM – 6:30 PM
Tuesday	7:30 AM – 12:00 PM
Wednesday	7:30 AM – 12:00 PM
Thursday	7:30 AM – 12:00 PM
Friday	7:30 AM – 12:00 PM

Attendees must wear their badges at all times to gain access to the conference.

Poster Instructions for Authors

Poster Set-up (Kauai 2-3-4)

Monday, December 10 – Session I

2:00 pm – 3:00 pm

Wednesday, December 12 - Session II

7:00 am – 8:00 am

Poster Viewing (Kauai 2-3-4)

Monday, December 10 – Session I

9:00 pm - 10:00 pm

Tuesday, December 11 - Session I

9:30 am - 10:00 am

9:30 pm - 10:00 pm

Wednesday, December 12 - Session II

9:30 am – 10:30 am

Thursday, December 13 – Session II

9:45 am – 10:45 am

Friday, December 14 – Session II

9:30 am – 10:00 am

Onsite Information

Pushpins and/or Velcro will be provided to attach your posters to the boards.

Upon conclusion of Poster Session I and Poster Session II, please remove your poster, any remaining posters left behind will be discarded.

Oral Presentations

Speakers should arrive at least 15 minutes prior to the beginning of their scheduled session in the Kauai 1-6-5 room. Speakers are responsible for bringing their own laptop with presentation. There will be a backup laptop if required. You will need to have your presentation on a flash drive to use the backup laptop.

Meals

Breakfast: A Continental Breakfast will be served 7:00am – 8:00am in Grand 1,7,6 Tuesday – Friday (**breakfast is for conference attendees only**).

Lunch: Attendees will be on their own for Lunch.

Dinner: Attendees will be on their own, with the exception of the Welcome Reception on Monday night, December 10 from 6:30 pm – 8:00 pm in the Shipwreck Lagoon (weather backup Grand 1-7-6) and the conference banquet being held on Wednesday night, December 12 from 8:00pm – 10:00pm in the Ilima Garden, (weather backup Grand 1-7-6) immediately following the plenary session. (This event is a CASH BAR).

Tickets are available for companions for the Welcome Reception for \$35.00 and Conference Dinner for \$65.00 and can be purchased at the registration desk.

Organizing Committee

Conference Chairs:

Elliot Hui University of California, Irvine

Dino Di Carlo California NanoSystems Institute,
 University of California, Los Angeles

Sumita Pennathur University of California, Santa Barbara

Keynote Speakers



Butrus (Pierre) T. Khuri-Yakub, Stanford University

Monday December 10, 2018, 8:00 pm - 9:00 pm

Title: Capacitive Micromachined Ultrasonic Transducers (CMUTs): Invention to Commercialization

The capacitive micromachined ultrasonic transducer (CMUT), in its present most widely used configuration, was first published at the IEEE International Ultrasonic Symposium in 1994. The last 24 years have seen international adoption of the device, and its commercialization as a platform technology, in medical imaging and many other applications.

This presentation will start with a brief history of the invention of the CMUT and elucidate its principle of operation and merit based on basic principles. This will be followed by a discussion of the various activities necessary to realize devices: theory (analytic solution, finite element modeling); technology (sacrificial release, direct bonding); modes of operation (conventional, pull-in, permanent pull-in); electronic integration (CMUT on ASIC, flip-chip on ASIC, interposer); packaging (backing, focusing lens); and system integration.

Next, we present a few examples of using CMUTs medical imaging, and high intensity focused ultrasound therapy, and in airborne ultrasound applications such as gravimetric sensing. Finally, we will present the various entities that are presently commercializing CMUTs.

Bio:

Butrus (Pierre) T. Khuri-Yakub is a Professor of Electrical Engineering at Stanford University. He received the BS degree from the American University of Beirut, the MS degree from Dartmouth College, and the Ph.D. degree from Stanford University, all in electrical engineering. His current research interests include medical ultrasound imaging and therapy, ultrasound neuro-stimulation, chemical/biological sensors, gas flow and energy flow sensing, micromachined ultrasonic transducers, and ultrasonic fluid ejectors. He has authored over 600 publications and has been principal inventor or co-inventor of 103 US and international issued patents. He was awarded the Medal of the City of Bordeaux in 1983 for his contributions to Nondestructive Evaluation, the Distinguished Advisor Award of the School of Engineering at Stanford University in 1987, elected Fellow of the IEEE in 1995, the Distinguished Lecturer Award of the IEEE UFFC society in 1999, a Stanford University Outstanding Inventor Award in 2004, Distinguished Alumnus Award of the School of Engineering of the American University of Beirut in 2005, Stanford Biodesign Certificate of Appreciation for commitment to educate mentor and inspire Biodesgin Fellows in 2011, recipient of IEEE Rayleigh award 2011, and elected Fellow of the AIMBE in 2015



Tejal Desai, UC San Francisco

Tuesday, December 11, 2018, 7:00 pm - 8:00 pm

Title: Engineering Material "Structure" to Modulate the Therapeutic Response

The ability to deliver therapeutics across biologic barriers is a much sought after goal. Here, I will recent work highlighting the impact of material structure on therapeutic delivery. Examples include nanostructured interfaces to access epithelial barriers and microstructured materials to promote local immunomodulation. By creating discrete micro and nanoscale features, one can begin to interact with cell and tissue surfaces in a manner previously unattainable. These subtle interactions can modulate properties such as permeability, matrix production, and cell activation. By gaining a better understanding of how small scale topographies can influence the biological microenvironment, these structures can be harnessed directly for therapeutic use. Micro and nanostructured materials can add functionality to current drug delivery platforms while becoming an enabling technology leading to new basic discoveries in the pharmaceutical and biological sciences.

Bio:

Tejal Desai is the Ernest L Prien Endowed Professor and Chair of the Department of Bioengineering & Therapeutic Sciences, Schools of Pharmacy and Medicine at University of California, San Francisco (UCSF), director of the NIH training grant for the Joint Graduate Program in Bioengineering at the University of California, Berkeley (UCB) and UCSF, and founding director of the UCSF/UC Berkeley Masters Program in Translational Medicine.

Desai's research spans multiple disciplines including materials engineering, cell biology, tissue engineering, and pharmacological delivery systems to address issues concerning disease and clinical translation. She has published over 200 peer-reviewed articles. Her research is at the cutting-edge in precision medicine, enabled by advancements in micro and nanotechnology, engineering, and cell biology directed to clinical challenges in disease treatment. She seeks to design new platforms to overcome existing challenges in therapeutic delivery.

Her research efforts have earned recognition including Technology Review's "Top 100 Young Innovators," Popular Science's Brilliant 10, and NSF's New Century Scholar. She is Chair of the American Institute for Medical and Biological Engineering College of Fellows. In 2015, she was elected to the National Academy of Medicine.

Desai is a vocal advocate for STEM education and outreach to underrepresented minority students. She received her B.S. from Brown University in biomedical engineering and was awarded a Ph.D. in bioengineering jointly from UCSF and UCB.



David Beebe, University of Wisconsin

Wednesday, December 12, 2018, 7:00 pm - 8:00 pm

Title: Moving Engineered Organotypic Models Towards the Clinic

Cell-based assays for the prediction of patient-specific cancer response have not been widely adopted. However, it is timely to reevaluate their use, as numerous innovations, including micro-scale organ-on-a-chip models, may improve their predictive power and utility. We are exploring how different levels of organotypic complexity may be leveraged to recapitulate patient response in different disease states. And the tradeoffs between the model constraints for clinical use vs. mechanistic studies.

Bio:

David J. Beebe is a John D. MacArthur Professor, the Claude Bernard Professor of Biomedical Engineering. He has appointments in the Department of Pathology and Laboratory Medicine and the Department of Biomedical Engineering at the University of Wisconsin-Madison. From 2012-2017 he co-led the Tumor Microenvironment Program in the University of Wisconsin Carbone Cancer Center. He has published more than 250 archived journal articles with more than 30,000 citations (h-index of 72). He is the recipient of the IEEE EMBS Early Career Achievement Award, the Lab on a Chip Royal Society of Chemistry/Corning Pioneers of Miniaturization Prize, the Romnes Award and the Byron Bird Award for Excellence in a Research Publication at UW-Madison and is a Fellow of the American Institute for Medical and Biological Engineering and the Royal Society of Chemistry. David's current interests center around the creation and use of microfluidic tools to understand cancer biology and improve cancer diagnosis and monitoring. Prof. Beebe is also the co-founder of multiple biotechnology companies and over 30 issued patents. He has mentored over 70 graduate students, post-docs and visiting scientists in his laboratory over the past 20 years who have gone on to success in industry and academia (including faculty positions at Stanford, University of Washington, Iowa State, Vanderbilt, North Carolina State University, University of Pittsburgh and University of Illinois-Chicago).

Prof. Beebe's research has focused on the novel and simple use of microscale physics and phenomena to create tools and methods to further biological and medical goals ranging from basic science to research tools to diagnostics to drug delivery. He pioneered several areas including passive microfluidic mixing, embryo culture and manipulation in microchannels, autonomous microfluidic systems using stimuli responsive hydrogels and passive pumping in microfluidics. From 2004-2009 he completed a 5 year NIH funded retraining in cancer biology. His current research interests center on cellular scale phenomena from both a physical and biological sciences perspective. Specifically, engineering cellular scale systems and applying them to better understand basic cellular processes relevant to cancer. Current projects include analysis of circulating tumor cells from breast and prostate cancer patients, in vitro models of cancer invasion, development of tools to study chemotaxis and immune response, development of functional cell-based assays (adhesion, compartmentalized co-culture, cell-matrix interactions). Emerging research interests include multi-kingdom interactions and the intersection of stress, inflammation and mindfulness.



Shana O. Kelley, University of Toronto

Thursday, December 13, 2018, 7:00 pm - 8:00 pm

Title: Nanoparticle-Mediated Cell Profiling:
Applications in Diagnostics, Drug Development
and High-Throughput Genomics

Using a high-precision approach to cell profiling, we have developed a powerful tool for the characterization of rare cells, the isolation of therapeutic cell types and capturing transient phenotypes that emerge during high-throughput screening trials. The application of this technology to the development of liquid biopsy-based diagnostic tests and other emerging areas will be highlighted.

Bio:

Dr. Shana Kelley is a Distinguished Professor of Chemistry, Pharmaceutical Sciences, Biochemistry, and Biomedical Engineering at the University of Toronto. Dr. Kelley received her Ph.D. from the California Institute of Technology and was a NIH postdoctoral fellow at the Scripps Research Institute. The Kelley research group works in a variety of areas spanning biophysical/bioanalytical chemistry, chemical biology and nanotechnology, and have pioneered new methods for tracking molecular and cellular analytes with unprecedented sensitivity. Dr. Kelley's work has been recognized with a variety of distinctions, including being named one of "Canada's Top 40 under 40", a NSERC E.W.R. Steacie Fellow, the 2011 Steacie Prize, and the 2016 NSERC Brockhouse Prize. She has also been recognized with the ACS Inorganic Nanoscience Award, Pittsburgh Conference Achievement Award, an Alfred P. Sloan Research Fellowship, a Camille Dreyfus Teacher-Scholar award, a NSF CAREER Award, a Dreyfus New Faculty Award, and was also named a "Top 100 Innovator" by MIT's Technology Review. Shana is a founder of two molecular diagnostics companies, GeneOhm Sciences (acquired by Becton Dickinson in 2005) and Xagenic Inc. (acquired by General Atomics in 2017), and sits on the Board of Directors of the Ontario Genomics Institute and the Fight Against Cancer Trust. She is an Associate Editor for ACS Sensors, and an Editorial Advisory Board Member for the Journal of the American Chemical Society and ACS Chemical Biology.

Invited Speakers

Diagnostic Devices – Part I

- Paul Yager • CT Lim • Hywel Morgan • Anja Boisen • Ajay Shah

DNA Nanotechnology

- I-Ming Hsing • William Shih • Deborah Fygenson

Young Investigators

- Hirofumi Shintaku • Wei Gao • Anderson Shum • Angela Wu • Aaron Streets
- Jackie Linnes • David Wood • Carlotta Guiducci • Erkin Seker • Kiana Aran

Focus Session: Brain Sensing

- Kevin Plaxco • Andreas Hierlemann • Ellis Meng

Diagnostic Devices – Part II

- Catherine Klapperich • Scott Manalis • David Sinton

Progress in Translation – Part I

- Sunghoon Kwon • Brian Cunningham • Shoji Takeuchi

Imaging

- Keisuke Goda • Aydogan Ozcan

One New Thing – Part I

- Rashid Bashir • David Eddington • Ken Patel • Polly Fordyce • Dan Huh
- Tom Soh • Kristofer Pister

One New Thing – Part II

- Amy Herr • Noo Li Jeon • Winnie Svendsen • Ian Wong • Ashleigh Theberge
- Abe Lee • Michelle Khine

Cellular Technologies

- Nick Melosh • Cullen Buie • Nancy Allbritton

Progress in Translation – Part II

- David Issadore • Steven George • Elliot Botvinick • Ali Khademhosseini

Program at a Glance

Monday, December 10, 2018

2:00 pm – 3:00 pm

Poster Session I Setup – Registration Opens

Location: Kauai 2-3-4

3:30 pm – 4:00 pm

Opening Remarks from Conference Chairs

Dino Di Carlo, Elliot Hui and Sumita Pennathur

Location: Kauai 1-6-5

4:00 pm – 6:30 pm

Diagnostic Devices - PART I

Chair: Shana Kelley

- Paul Yager
- CT Lim
- Hywel Morgan
- Anja Boisen
- Ajay Shah

Location: Kauai 1-6-5

6:30 pm – 8:00 pm

Opening Reception

Location: Shipwreck Lagoon

8:00 pm – 9:00 pm

Keynote Speaker: Butrus T. Khuri-Yakub

Chair: Tom Soh

Location: Kauai 1-6-5

9:00 pm – 10:00 pm

Poster Session I

Location: Kauai 2-3-4

Tuesday, December 11, 2018

7:30 am – 12:00 pm	Registration Location: Kauai Promenade
7:00 am – 8:00 am	Continental Breakfast Location: Grand 1-7-6
8:00 am – 9:30 am	DNA Nanotechnology Chair: Sumita Pennathur <ul style="list-style-type: none">● I-Ming Hsing● William Shih● Deborah Fygenson Location: Kauai 1-6-5
9:30 am – 10:00 am	Poster Session I & Coffee Break Location: Kauai 2-3-4
10:00 am – 12:30 pm	Young Investigators Session Chair: Ken Patel <ul style="list-style-type: none">● Hirofumi Shintaku● Wei Gao● Anderson Shum● Angela Wu● Aaron Streets● Jackie Linnies● David Wood● Carlotta Guiducci● Erkin Seker● Kiana Aran Location: Kauai 1-6-5
12:30 pm – 7:00 pm	Break & Group Activities / Excursions (Lunch and Dinner on Your Own)
7:00 pm – 8:00 pm	Plenary Speaker: Tejal Desai Chair: Abe Lee Location: Kauai 1-6-5

8:00 pm – 9:30 pm

Focus Session: Brain Sensing
Chair: Bridget Queenan

- Kevin Plaxco
- Andreas Hierlemann
- Ellis Meng

Location: Kauai 1-6-5

9:30 pm – 10:00 pm

Poster Session I

Location: Kauai 2-3-4

Wednesday, December 12, 2018

7:30 am – 12:00 pm

Registration

Location: Kauai Promenade

7:00 am – 8:00 am

Continental Breakfast and Poster Session II Setup

Location: Grand 1-7-6 (Breakfast);
Kauai 2-3-4 (Poster Session II Setup)

8:00 am – 9:30 am

Diagnostic Devices – Part II

Chairs: Shana Kelley

- Catherine Klapperich
- Scott Manalis
- David Sinton

Location: Kauai 1-6-5

9:30 am – 10:30 am

Coffee Break and Poster Session II

Location: Kauai 2-3-4

10:30 am – 11:30 am

Progress in Translation – Part I

Chair: Amy Herr

- Sunghoon Kwon
- Brian Cunningham
- Shoji Takeuchi

Location: Kauai 1-6-5

11:30 am-12:30 pm

Imaging

Chair: Polly Fordyce

- Keisuke Goda
- Aydogan Ozcan

Location: Kauai 1-6-5

12:30 pm – 7:00 pm

Break & Group Activities / Excursions (Lunch on Your Own)

7:00 pm – 10:00 pm

Plenary Speaker: David Beebe

Introduction: David Eddington, Conference Banquet

Location: Plenary Kauai 1-6-5

Banquet Ilima Garden (weather back-up Grand 1-7-6)

Thursday, December 13, 2018

7:30 am – 12:00 pm

Registration

Location: Kauai Promenade

7:00 am – 8:00 am

Continental Breakfast

Location: Grand 1-7-6

8:00 am – 9:45 am

One New Thing – Part I

Chair: Hywel Morgan

- Rashid Bashir
- David Eddington
- Ken Patel
- Polly Fordyce
- Dan Huh
- Tom Soh
- Kristofer Pister

Location: Kauai 1-6-5

9:45 am – 10:45 am

Coffee Break and Poster Session II

Location: Kauai 2-3-4

10:45 am – 12:30 pm

One New Thing – Part II

Chair: Paul Yager

- Amy Herr
- Noo Li Jeon
- Winnie Svendsen
- Ian Wong
- Ashleigh Theberge
- Abe Lee
- Michelle Khine

Location: Kauai 1-6-5

12:30 pm – 7:00 pm

Break & Group Activities / Excursions (Lunch and Dinner on Your Own)

7:00 pm – 8:00 pm

Plenary Speaker: Shana Kelley

Chair: Michelle Khine

Location: Kauai 1-6-5

8:00 pm – 10:00 pm

Commercialization Panel: "Advanced Patent and Licensing Strategies for Emerging Growth University Spin-out Companies." Followed by Spin-out Panel Discussion

Matthew Breshahan, Partner, Wilson Sonsini Goodrich & Rosati

Sponsored by Wilson Sonsini Goodrich & Rosati

Location: Kauai 1-6-5

Friday, December 14, 2018

7:30 am – 12:00 pm

Registration

Location: Kauai Promenade

7:00 am – 8:00 am

Continental Breakfast

Location: Grand 1-7-6

8:00 am – 9:30 am

Cellular Technologies

Chair: Elliot Botvinick

- Nick Melosh
- Cullen Buie
- Nancy Allbritton

Location: Kauai 1-6-5

9:30 am – 10:00 am

Coffee Break and Poster Session II

Location: Kauai 2-3-4

10:00 am – 11:15 am

Progress in Translation – Part II

Chair: CT Lim

- David Issadore
- Steven George
- Elliot Botvinick
- Ali Khademhosseini

Location: Kauai 1-6-5

11:15 am – 12:15 pm

Young Investigator Award Speaker

Location: Kauai 1-6-5

12:15 pm – 1:00 pm

Closing Ceremony

Location: Kauai 1-6-5

Invited Session



Matthew Bresnahan, Partner, Wilson Sonsini Goodrich & Rosati

Thursday December 13, 2018, 8:00 pm – 10:00 pm

Title: Advanced Patent and Licensing Strategies for Emerging Growth University Spin-out Companies

Bio:

Matt Bresnahan is a partner in the San Diego and Los Angeles offices of Wilson Sonsini Goodrich & Rosati, where he has focused his practice over the past 10 years on all aspects of intellectual property, including strategic patent counseling, patent prosecution, licensing, and litigation. Matt is primary outside IP counsel to more than 50 life sciences companies within the biotechnology, molecular biology, pharmaceutical, diagnostic, and medical device fields in Southern California.

In this session, we will cover the following topics: (1) the most important university patent licensing terms from the perspective of a potential acquirer of the company; (2) life cycle management patent claiming strategies geared toward obtaining multiple patent families covering the products and services of the company, which will include a discussion of strategies for obtaining issuance of company-owned patents while paying special care to not diminish or disparage the earlier-filed university platform patent, including strategies for working with examiners and the important role the academic founder/PI can play in that examiner interview/meeting process; and (3) the importance of Freedom-To-Operate ("FTO") as the spin-out company moves toward a successful exit, and the critical assistance scientific advisory board members can play in this process. My goal is to present material that the attendees can utilize as they go back and work with their companies as founders, SAB members, advisors, and officers and Board member capacities.



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The field of interest of the IEEE Engineering in Medicine and Biology Society is the application of the concepts and methods of the physical and engineering sciences in biology and medicine. This covers a very broad spectrum ranging from formalized mathematical theory through experimental science and technological development to practical clinical applications. It includes support of scientific, technological and educational activities.

PUBLICATIONS

IEEE PULSE:A Magazine of the IEEE Engineering in Medicine and Biology Society
Transactions on Biomedical Engineering
Transactions on Neural Systems and Rehabilitation Engineering
Transactions on Medical Imaging
Transactions on NanoBioscience
Transactions on Biomedical Circuits and Systems
Transactions on Computational Imaging
IEEE Transactions on Radiation and Plasma Medical Sciences
Transactions in Medical Robotics
Reviews on Biomedical Engineering
Journal on Translational Engineering in Health & Medicine
Journal of Biomedical and Health Informatics
Journal on Electromagnetic; RF & Microwaves in Medicine and Biology

ELECTRONIC PRODUCTS

EMBS Electronic Resource (117,000+ documents)

CONFERENCES

Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)
IEEE EMBS Special Topic Conference on Neural Engineering (NER)
International Symposium on Biomedical Imaging (ISBI)
International Conference on Biomedical Robotics and Biomechatronics (BIOROB)
International Conference on Rehabilitation Robotics (ICORR)
Healthcare Innovation and Point-Of-Care Healthcare Technologies Conference (HICPT)
EMBS Micro and Nanotechnology in Medicine (MNM)
IEEE EMBS International Conference on Body Sensor Networks (BSN)
IEEE EMBS International Conference on Biomedical and Health Informatics (BHI)
IEEE EMBS Student Conferences: For Students, By Students
IEEE Life Sciences Conference

SUMMER SCHOOLS sponsored by EMBS

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International Summer School on Neural Engineering
International Summer School on Computer Modeling in Medicine
International Summer School on Medical Devices and Biosensors

Contributed and Abstract Papers

Posters

PGI

Micro/Nano Engineering for Extracellular Vesicle-Based Liquid Biopsy and Cancer Therapeutics

Zheng, Siyang

Biomedical Engineering and Electrical Engineering, The Pennsylvania State University, University Park, Pennsylvania, United States

Micro/nano engineering is an important tool to investigate biological system and provide new solutions for healthcare challenges. We have developed micro/nano technology solutions based on extracellular vesicles for cancer diagnosis and therapeutics.

PGI

Mobile Platform for Rapid Sub pg/mL, Multiplexed, Digital Droplet Detection of Proteins

Yelleswarapu, Venkata R., Baron, Jonathan, Inapuri, Eshwar, Issadore, David

Bioengineering, University of Pennsylvania, Philadelphia, Pennsylvania, United States

Digital droplet assays - in which biological samples are compartmentalized into millions of femtoliter volume droplets and interrogated individually - have generated enormous enthusiasm for their ability to detect nucleic acids and proteins with single molecule sensitivity. These assays have great untapped potential for point of care diagnostics but are currently confined to laboratory settings due to the instrumentation necessary to serially generate, control, and measure tens of millions of droplets / compartments. To address this challenge, we developed an optofluidic platform that both miniaturizes digital assays into a mobile format and that speeds up these assays by >100x, while maintaining the sensitivity and specificity of existing systems. This technology is based on three key innovations: 1. the parallelization of thousands of droplet generators onto a single chip to increase the droplet production rate by >100x 2. the fluorescence detection of droplets at >100x faster than conventional in-flow detection using time-domain encoded mobile phone imaging³, and 3. the integration of on-chip delay lines and sample processing to allow fully automated, sample-to-answer device operation.

PGI

Film Bulk Acoustic Resonator (FBAR) based Biosensor for Early Detection of Aggressive Prostate Cancer

Wajs, Ewelina¹, Rughoobur, Girish², Gnanapragasam, Vincent³, Flewitt, Andrew¹

¹*Electrical Engineering, University of Cambridge, Cambridge, United Kingdom*, ²*Microsystems Technology Labs, Massachusetts Institute of Technology, Cambridge, Massachusetts, United States*, ³*Dept. of Surgery & Oncology, Academic Urology Group, Cambridge, United Kingdom*

We demonstrate that the FBAR biosensor can detect PSA antigen successfully from PBS b!! buffered samples and clinical samples without chemical or fluorescent labelling. Proposed FBAR biosensor shows very high sensitivity and selectivity, without the interference of a non-specific binding. In detection range from 0.47ng/ml to 79.5 ng/ml for PSA antigen we obtained LOD below 0.8 ng/ml, what demonstrates clinical relevance for these sensors. The advantages of this devices are their high sensitivities, small size and low power, which makes them well suited to mobile sensing applications, such as point-of-care medical diagnostics.

Microfluidic Biochip Platform for Electrical Quantification of Plasma Proteins and Cells

Valera, Enrique, Berger, Jacob, Hassan, Umer, Jackelow, Aaron, Bashir, Rashid

Bioengineering, University of Illinois at Urbana-Champaign, Urbana, Illinois, United States

Brief Motivation, and Innovation

Sepsis, an adverse auto-immune response to an infection often causing life-threatening complications, results in the highest mortality and treatment cost of any illness in US hospitals. Several biomarker levels, including CD64 expression on neutrophils (nCD64), Interleukin 6 (IL-6), Procalcitonin (PCT) and C-reactive protein (CRP), have shown a high correlation to the onset and progression of sepsis. Currently, no technology diagnoses and stratifies sepsis progression using biomarker levels. To contribute in the early stratification of sepsis, we are developing a point of care (POC) device for the quantification of cells and plasma proteins based on the Electrical Differential Counting Technology.

Brief Methods

The device uses the Coulter counting principle, microfluidics, capture chambers and immunodetection to quantify cells and plasma proteins. The developed biochip can quantify CD64 expression levels on granulocytes + monocytes population from lysed whole blood by their specific capture in the biochip. To use the same device for the detection of nanometer size proteins, three sandwich immunoassays were developed for the detection of IL-6, PCT and CRP on the surface of different sizes magnetic beads ($O^- = 7B11\ B5m$, $9B11\ B5m$ and $12B12\ B5m$, respectively). The differential counting chip is composed of two electrode pairs and a capture chamber. The capture chamber contains symmetrically distributed pillars to increase the capture efficiency. The capture chamber is modified with antibodies and streptavidin to specifically capture the cells and the bead complexes. The cells first, and then the bead complexes, are enumerated at the entrance counter. After the entrance counting, the cells and the bead complexes (containing protein) are specifically captured in the chamber. Finally, the exit counter is used to count the remaining cells and the bead complexes.

Key Results

The three different sizes of beads used, provide different electrical signatures (Figure 1). By this method is possible to clearly distinguish the electrical signals corresponded to IL-6, PCT and CRP. After the proper functionalization, the capture chamber can capture cells and bead complexes (Figure 2).

Conclusions

The combined use of the Electrical Differential Counting Technology and magnetic beads of different sizes allows: 1) the multiplexed protein detection and 2) the quantification of monocytes expressing CD64 and plasma proteins from the same sample. This is a fundamental stepping stone towards a multimarker POC device for the combined detection of cells and proteins from whole blood clinical samples.

Rapid Label-Free Phenotypic Screening of Metastatic Cancer Cells

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We describe a quantitative approach for label-free dynamic phenotyping of cancer cells. Analysis of nano-scale cell-surface interactions, including adhesion and filopodia dynamics, allows discrimination between cancer cells of high/low metastatic potential. This capability enables the design of a new microfluidic platform for liquid biopsy analysis where highly invasive cancer cells can be rapidly identified using label-free biomarkers derived from this approach.

Porous Microneedles Supported by Hyaluronic Acid for ISF Collection

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Due to the high demand for an alternative to conventional hypodermic needles, microneedles (MNs) have been investigated as a hypodermic path to access biological information under skin in a minimally invasive manner. In order to realize continuous monitoring systems of clinically valuable biomarkers in interstitial fluid (ISF), MNs with specific configurations such as a porous structure should be integrated with the microfluidic system based on micro total analysis system (B5TAS) technologies. Here, we developed a porous MN array to extract and transport fluids into a custom-designed microfluidic chip. The fabricated MN array is capable of extracting water contained in the gel in a minimally invasive manner, with the reinforced mechanical property by the hyaluronic acid support. The extracted water is transported into the microfluidic chip, which indicates an applicability to the wearable continuous glucose sensor.

Printed Nanocomposite-Based Sensors for Sensitive Reagent-Free Electrochemical Detection of Hormone Cortisol

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We present a novel electrochemical sensor for sensitive detection of hormone cortisol without redox couples in analytes. The sensor utilizes a bioresponsive electrode consisting of a stack of cortisol-selective molecularly-imprinted polymer (MIP) and redox-active polymer (RAP) printed on a carbon electrode to achieve reagent-free electrochemical detection of cortisol. A detection limit of less than 100 pM and a dynamic range more than 1 B5M were achieved. The facile sensing scheme and sensitive detection make the sensor suitable for ambulatory monitoring of cortisol levels in saliva and sweat in a wearable configuration.

Semi-Automated DNA Extraction Device for Point-of-Care-Testing in Molecular Diagnostics

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Recently, the importance of point-of-care (POC) molecular diagnostics has increased significantly for rapid diagnosis of infectious diseases. For POC molecular diagnostics, nucleic acid should be separated from clinical samples to eliminate PCR inhibitors. Nucleic acid extraction methods currently used in clinical diagnosis require several liquid exchanges using pipetting and also need a centrifuge or a magnetic bar to collect materials. Although an automated nucleic acid extraction equipment have been developed, it has been used only in hospitals and laboratories because it requires high cost and large machine. In this work, we designed a new nucleic acid extraction device to easily extract nucleic acid in the field without pipetting, centrifuge or magnetic bar. To capture and release DNA from the specimen, the poly(3,4-dihydroxyphenylalanine) (poly(DOPA)) was synthesized on a nylon brush or swab.¹ The poly(DOPA) has the ability to capture and release DNA according to pH.² We also developed a device in which containers containing DNA binding solution, wash solution 1, 2, and elution solution were separated by a membrane. The DNA can be extracted simply by passing the poly(DOPA)-modified brush of swab through each container in the device. The modified swab(29.7B14.2%) had better DNA recovery efficiency than modified nylon brushes(10.8B11.4%), which was higher than that using MB(23.3B10.7%). In addition, the volume of sample did not affect up to 450 N

Biomolecular Pre-Concentration by Adjusting the Electric Double Layer in Nanochannels

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In order to pre-concentrate biomolecular, we built a nanochannel with an embedded electrode to create a nonlinear electroosmotic flow (EOF) for stacking a biological analyte of interest. In this work, we are able to directly change the properties of the electric double layer (EDL) by applying an electric field on the embedded electrodes. Due to the mass conservation, the sample molecules are trapped at the junction between two different EDLs by an induced pressure gradient. This novel technique provides several advantages, including the use of only one electrolyte solution, the ability to directly modulate the EDL by applying potentials on the embedded electrodes, and the production of predictable sample plugs.

Injectable Microporous Scaffolds for Continuous Analyte Sensing

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This work demonstrates encapsulation of functional sensor microparticles in an injectable microporous scaffold formed by monodisperse microgel building blocks covalently linked *in situ*.

Microfluidic Detection of Drugs of Abuse in Biological Fluids using Surface-Enhanced Raman Spectroscopy

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A microfluidics-based Surface-Enhanced Raman Spectroscopy (SERS) chip is used for rapid detection of drugs of abuse in saliva. The assay is capable of detecting methamphetamine at physiologically-relevant concentrations in under 2 minutes and can be reused multiple times. The assay is further expanded for detection of trace concentrations of fentanyl when other drugs such as heroin are also present at higher concentrations.

A Non-Enzymatic Glucose Sensor Enabled by Bioelectronic Ph Control

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Here, we introduce a non-enzymatic metal oxide glucose sensor that functions in neutral fluids by inducing a reversible and localized pH change. This device is able to detect glucose at physiologically relevant concentration in a sweat mimic and is fully integrated with a circuit board capable of wireless transmission.

Digital Amplification from Whole Blood in Micowell Array

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Nucleic acid amplification (through LAMP reaction) of a target analyte such as bacterial DNA can be carried out from dried whole blood without processing for purification or isolation of DNA. Our approach utilizes a silicon chip etched with 100um well in which LAMP reactions can be carried out, allowing for digitization and quantification of the copy number of analytes without requiring a standard curve in less than 1 hour.

Conductive Nonwoven Carbon Nanotube-PLA Composite Nanofibers

Towards Wound Sensors via Solution Blow Spinning

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This paper characterizes the use of solution blow spinning technique to create conductive carbon nanotube-PLA composite nanofibers. Poly(lactic acid) (PLA) and multi-walled carbon nanotubes (MWCNT) were combined in various solvents to produce conductive fiber mats. The conductivity of the fiber mats were increased by modifying the MWCNT concentration and polymer content. Conductive fiber mats were able to reach conductivity values as high as 474 S/cm. Conductive fiber mats will be later used as sensors in wound healing applications and was implemented in a simple light emitting diode circuit featuring the fiber mat to demonstrate its use.

Towards Early Detection of Hypoxia: Fabrication of Facile, Robust, Cobalt

Doped ZnO Nano Fiber for *in situ* Sensing of Dissolved Oxygen

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Hypoxia is associated with many diseases, such as cancer, neurodegeneration and diabetes, and this leads to a demand for *in situ* oxygen sensing for biomedical applications. Although, in the past, various metal oxide nanofibers have been used successfully for sensing gaseous oxygen at higher temperature, sensing gaseous as well as dissolved oxygen at room temperature remains challenging. In this work, we have developed a common framework for sensing gaseous and dissolved oxygen using metal oxide nanofibers, and have presented a proof of concept towards oxygen sensing in aqueous medium. Herein, we propose oxygen sensing using Co doped ZnO nanofiber and have investigated oxygen sensing dynamics. Characterization of the fibers have been performed using scanning electron microscopy. It has been observed that Co doping yields lower resistance values for the composite nanofiber and hence improves its sensitivity. In order to obtain hydrophilic surface for sensing dissolved oxygen, we have performed plasma treatment of the nanofibers. In relation to dissolved oxygen sensing, the proposed sensor accounts for a response time close to 60 seconds. The proposed miniaturized sensor has the potential for sensing oxygen in body fluid as well as tissue models.

Feasibility Study of a Microfluidic Solenoid for Discrete Quantitation of Magnetized Cells

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In this paper a cell quantitation system is proposed based on a new microfluidic solenoid design. The design is simulated in COMSOL and a scaled version of the prototype is built and the induced voltage due to the passage of a magnetic material is measured using a low-noise amplifier and converted to a digital signal using a DSP chip. Simulation results show approximately 16 nV induced voltage across the solenoid and the measurement results for a scaled version of the solenoid outputs 125 mV peak voltage. A microfluidic fabrication process demonstrates a successful prototype of a microfluidic solenoid.

Multidimensional Mapping of Brain-derived Exosomal RNA

Biomarker for Traumatic Brain Injury Diagnostics

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To discover exosomal RNA biomarkers for traumatic brain injury, we combined next generation sequencing with a immunomagnetic nanofluidic-based sorting technology - Track Etched Magnetic Nanopore system. Using the map of exosomal RNA biomarkers, machine learning algorithms were used successfully to classify specific states of brain injury both in mouse models and clinical samples.

Motor-Driven Microfluidics for Droplet Sorting

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Introduction: In the past two decades, researchers envisioned a viscous micro-pump set-up to drive and control flow in handheld microfluidic devices (1). Many theoretical models were studied, but at that time it was difficult to manufacture and integrate micro-motors for microfluidic applications (2). In this study, we designed and built a micro-motor system to operate a practical viscous micro-pump to drive and shape flow in open microfluidic devices for droplet sorting applications.

Materials and Methods: Coreless micro-motors powered by DC voltage are used to build the viscous micro-pump set-up. A configuration of motors is fixed on top of a fluid container at different distances and the rotation speed and direction are used to drive flow in a defined manner. Glycerol is used as a viscous carrier fluid in the micro-pump set-up. Sample fluid was fluorescently labeled with rhodamine and fluorescein to track flow of a sample fluid in the glycerol surrounding fluid driven by the motors.

Results: Flow was characterized by controlling the velocity (μ N8), orientation (N) and lateral distance (D_x) of two co-axial motors rotating in an opposite sense immersed in viscous fluid. A downstream micro-motor ensemble will result in sculpting of the fluid flow to the shape of interest (Fig. 1a). The minimal lateral distance ($D_x=1000 \text{ N}$)

Conclusions: We developed a novel open stand-alone microfluidic technology to drive flows and sort objects using small micro motors. This method enables precise spatio-temporal control of sample fluid, micro-particles, single cells and droplet motion at a micro-scale.

Development of Three Dimensional Paper Sensor with Nanoparticles Detecting Tear Glucose

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The developed non-enzymatic paper-sensor was sensitive and accurate enough to characterize the chemical reaction for detection of the tear-biomarker by colorimetric analysis. Tear-fluids include a lot of biomarkers for ophthalmologic diseases and even for systemic disorder. Tear-glucose is a potential biomarker for diabetes due to considerable correlation with blood-glucose level and accessibility in sampling tear-fluids. In this work, tear-glucose in artificial samples were quantified by the colorimetric and non-enzymatic paper-based diagnostic tool. Tear-glucose was utilized in paper-on-synthesis of gold nanoparticles, generally called *in-situ* reducing method, as role of reductant. Any other components influential to the quantification like halogen ion and ascorbic acid, protein were merged to the synthesis. Color-development by the synthesized nanoparticles was analyzed with a commercial scanner and open-sourced software. In morphological study, increasing in the number and decreasing in the size of gold nanoparticles was observed by rising glucose concentration, while the particles were deposited and mono-dispersed on paper surface. By the proposed colorimetric method, the calculated values configured sigmoid curve while reflecting signal more than two below to decimal point. The color signal became observable when chloride concentration increased by 200mM. Also, color intensity is strong enough to detect at tear-physiological concentration of chloride. Matrix effect by increasing ascorbic acid was not observed at low glucose concentration showing Pearson correlation coefficient of -0.104 between color value and ascorbic acid concentration. In artificial tear-glucose sensing, high correlation and low LOD was resulted. The three-dimensional paper sensor is potable, selective and easy-to-use analytic device for first screening detection and quantitative analysis of glucose in tear sample.

RNA Extraction from Single Cells via Focused Electric Field at a Hydrodynamic Trap in a Microfluidic Channel

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We report a finite element analysis on RNA extraction from single cells under a focused electric field. We developed a microfluidic system that leveraged a hydrodynamic trap (3 N

Studying Paracrine Signaling of Human Kidney Cells using Open Microfluidic Coculture

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The understanding of the interplay of human kidney tubular epithelium and adjacent peritubular endothelium is significant for people to investigate kidney disease regulation and microvessel repair. To study the cross talk, we created an open microfluidic coculture platform that consists of center and side culture chambers segregated by a half wall. Primary human kidney peritubular microvascular endothelial cells (HKMECs) and human kidney tubular epithelial cells (HPTECs) are seeded in separate chambers and

placed into paracrine signaling contact by addition of shared media over the half wall. We showed that in media without exogenous vascular endothelial growth factor (VEGF), the presence of HPTECs supports HKMEC maintenance of cell-cell contact and fenestrae, and leads to more activated and organospecific HKMEC genotype. The result indicated that HPTECs secrete soluble factors that assist HKMECs to grow in media without VEGF. The coculture device provides a simple platform to study paracrine signaling mechanisms between different cell types when utilizing limited and precious primary human cells.

PGI

Binary Addressable Droplet-on-Demand Array for Combinatorial Droplet Generation

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Arrays of droplet-on-demand dispensers are reported for the creation of combinatorial reagent libraries. On-chip pneumatic logic is employed to decode binary inputs, addressing N droplet dispensers with only $\log_2(N)$ control lines and enabling large addressable arrays. We demonstrate 64 independently addressable droplet dispensers, each drawing from a separate reagent reservoir, under the control of just 6 address lines. On-demand dispensing into a common channel is combined with droplet synchronization by machine vision in order to combine reagents from multiple dispensers.

PGI

Impedance Flow Cytometry for Microbial Analyses

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Bacteria detection and analysis are of great importance in several fields such as research, diagnostics and industry. Here, we present multi-frequency electrical impedance cytometry (IFC) as a fast, simple and reliable method for viability assessment of bacteria samples.

PGI

Development of a 3D Vascularized Cancer-on-a-Chip Platform using hiPSC-Derived Endothelial Cells

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Vascular networks are essential to maintain cellular viability and functions; however, current 3D culture models lack a vascular system. Engineering perfusable vascular networks that can deliver reagents and blood cells to 3D cell constructs could be a powerful platform to recapitulate cellular microenvironments and tissue-level cell functions. Here, we describe a microfluidic method to form a vascularized tumor-like cancer spheroid to model cellular interactions through a vascular network using human induced pluripotent stem cell-derived endothelial cells (hiPSC-ECs). A cancer cell spheroid containing endothelial cells and lung fibroblasts was embedded within a fibrin-collagen gel inside a microchannel, and then endothelial cells were seeded into both sides of the hydrogel so that angiogenic sprouts from the cell spheroid and the microchannels were anastomosed to form a 3D vascular network. We confirmed that peripheral blood mononuclear cells can be perfused inside a

cancer spheroid through a vascular network. Thus, we used this system to model the interaction between cancer cells and immune cells through blood vessels. To study the interaction between cytotoxic T cells and cancer cells, allo-reaction between endothelial cells and T cells by mismatching of their HLA will be problematic. Therefore, we engineered 3D vascular networks using hiPSC-ECs. We confirmed that our hiPSC-ECs can form 3D vascular networks which can be perfused with blood cells including T cells. CD8⁺ T cells primed by HUVECs exhibited higher cytotoxic activity toward HUVECs than autologous hiPSC-ECs, demonstrating the potential value of this vascularized cancer on-a-chip for modeling the interaction between T cells and a tumor-like spheroid through a vascular network.

PGI

A Method to Quantify and Normalize Optical Artefacts in Partition Coefficient Measurements for Tunable Hydrogels

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Hydrogels are diverse materials, finding biomedical utility as drug delivery vehicles, cell culture and tissue matrices, and immunoassay scaffolds for diagnostics. Their utility in all of the above cases is dependent on their thermodynamic partitioning behavior (quantified by a partition coefficient, K), which governs how much solute can be loaded into and released from a hydrogel. Given the importance of thermodynamic partitioning on hydrogel performance in biomedicine, high-precision, quantitative tools are needed. Established microscopy-based techniques to measure K are limited in their accuracy by neither measuring nor addressing optical artefacts. In this study, we describe and validate a method to directly measure K in hydrogels using laser scanning confocal microscopy (LSCM) that also directly quantifies and normalizes optical artefacts. This technique will enable researchers to readily obtain accurate measurements of K so that they can understand and tune their hydrogel's partitioning properties for the highest translatable impact.

PGI

High-Speed Suspended Microchannel Resonator Arrays for Precise Particle and Cell Sizing

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Measuring size distributions of nano- and micro-scale particles and cells is of central importance for a wide range of industrial and biological applications. Suspended microchannel resonators (SMRs) offer extreme precision for measuring mass, but low throughput has limited their application for general particle and cell sizing. We describe two major technical advancements that increase the throughput of SMRs by up to two orders of magnitude: (1) parallel SMR arrays in which many sensors are operated in parallel on the same microfluidic device, and (2) a computational deblurring algorithm to allow mass measurements to be extracted from faster-flowing particles.

Development of a Human Corneal Model using a Blinking Eyelid Device

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Dry eye disease is one of the most prevalent eye diseases. Irregular production of any of the three component layers of the tear (mucin, aqueous, and lipid) causes the tear film to become unstable. The continuous blinking motion of an eyelid helps spreading the tear onto the surface of the cornea. However, this layer ruptures quickly on dry eye patients, exposing the cornea to the external environment. Most in vitro corneal models used for evaluating dry eye disease use static cell culture models. Since blinking motion and eyelid pressure are essential factors that are responsible for maintaining a healthy cornea, we have developed a linear blinking eyelid device consisting of a linear actuator that is programmed to simulate the velocity profile of human blinking motion. This dynamic model also has an integrated cantilever based eyelid force measurement system, and uses a custom designed bright field mini microscope to capture the real time effect of the eyelid motion on the corneal cell surface.

Microfluidic Manifolds for Automated Operation of Organ-on-Chip Devices

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This paper presents an automated approach for reagent delivery and flow control for organ on chip devices. We fabricated and characterized microfluidic manifolds that automate essential functions for operating organ-on-chip devices. Flow in the manifold is created on-board valves and pumps that reproduce a peristaltic sequence. Design and materials are compatible and can be interfaced with all standard organ-on-chip devices. Microfluidic manifolds increase the number of data points gathered per unit time.

Pneumatically Actuated Microfluidic Trap Array

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We will present a novel microfluidic trap design composed of a stretchable roof such that microfluidic samples can be actively withdrawn and released from the trap using pneumatic actuation. The design will demonstrate the ability to perform complex serial processing in microfluidic traps to facilitate intricate biological/chemical assays that may not be possible with the current state of the art.

Fabrication of PLGA Biodegradable Porous Transparency

Microneedles of PLGA

Morishita, Yasuhisa, Takeuchi, Kai, Tacoma, Nobuyuki, Kim, Beomjoon

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We investigated biodegradable and permeable porous microneedles of PLGA for sampling interstitial fluid (ISF). PLGA porous membranes were fabricated by heating mixture and salt leaching method. 70 % porosity membrane shows enough permeability for absorbing ISF. Furthermore, biodegradable and sponge-like porous microneedle can be fabricated by using heating press to PDMS mold, and it is very promising to realize wearable, non-invasive glucose sensor devices.

Establishment of Cell Culture Method using Ultrasonic Atomization

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In vitro drug screening assay is recently replacing animal test. Because it is possible to assay with each person's cell and has no ethical problem. However, cells are cultured in culture medium, and some screenings cannot be performed. Thus, in order to develop a system culturing cells exposing to the atmosphere with nebulization, we developed such culture system by using ultrasonic atomization.

Our cell culture system atomizes culture medium by an ultrasonic transducer in a 25-cm² cell culture flask and exposes the cells to atmosphere. The flask is placed over an ultrasonic transducer and raised.

1.8C¹ 105 C2C12 were seeded in the flask and let to attach to the culture surface with 24-hr conventional incubation. The cells were then cultured for another 24 hr with and without ultrasonic atomization. As a result, cells cultured by the proposed method stably proliferated, and the ratio of the number of dead cells to the number of living cells by the proposed method was 0.05.

Furthermore, this system can create a culture environment with low risk of contamination and maintain a temperature at 37 easily. So, this system has a huge potential to become an essential technology for drug screening.

Ionic Liquids with Wafer-Scalable Graphene Sensors for Biological Detection

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Ionic liquids, known as non-volatile solvents, have potential for realizing microanalysis with a minute quantity of sample. Here we report the measurement of the I_d - V_g characteristics during the enzymatic catalytic reactions and streptavidin-biotin binding in ionic liquids by using the graphene FET sensors we fabricated, and successfully monitored the biological reactions in much smaller amount of solvents. These findings suggest the possibility of ionic liquids for application in bio-microanalysis with high sensitivity.

Mass Single Floating Cell Isolation in a Micro-Sieves Array

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Abstract: In this paper, we report a microfluidic strategy to implement mass isolation of single floating immune cells in defined separated positions in a microfluidic device. This device consists of a series of focusing micropillar structures and a downstream array of micro-sieves to encapsulate each of the floating cells in a micro-sieve with an efficiency of 80 %. Cell viability can be maintained in the device as >95 % for at least 72 h. Additionally, this microfluidic strategy can be combined with the coating of antibody over the micro-sieve surfaces for specific cell isolation. By coating the micro-sieves with anti-CD14 antibody, we demonstrate that the isolated immune cells (THP-1) can be specifically bound on the micro-sieves. Such target immune cells can be maintained in the micro-sieves whereas other mismatched cell types can be removed by a backward flow, driven by a pressure of 1 psi. With further development of the microfluidic device, we believe that it can achieve the single-cell isolation of multiple cell types in different microfluidic sites, in order to facilitate the more detailed immune cell analysis as well as general cell research.

An Optofluidic Platform for Direct Measurements of CTC Dynamics in Blood

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Despite the usefulness of circulating tumor cells (CTCs) in cancer research, understanding of their role in metastasis has been limited by the extreme difficulty of characterizing CTC populations over time and linking them to metastases that occur during natural tumor progression. We developed a technology that enables CTCs to be monitored dynamically and longitudinally in genetically engineered mouse models (GEMMs). Using our system, we will be able to have a much better understanding of how progression to metastasis correlates with, and could be explained by, the circulatory dynamics and physical properties of CTCs, including any change in their abundance in circulation as tumors progress to metastasis, their rate of generation/intravasation, their half-life time in circulation, and the correlation of their physical deformability to their ability to remain in blood circulation.

Centrifugal Microfluidic Disk Platform Enabling RNA Enrichment from Cells and Exosomes

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RNA enrichment is a vital technique in clinical research. Most RNA enrichment approaches are manually operated, which are time-consuming and operator-dependent. For those few methods are automated, high-throughput devices, capital investment often become a barrier. This paper presents a novel microfluidic disk which enables automated enrichment of RNA from cells and exosomes with low cost and high efficiency.

A disk-based RNA isolation was designed motivated by the ease of fluid manipulation via centrifugal force. Modified protocol from CatchGene™ Cell/Exosome miRNA Kit was used. The disk was built with microfluidic channels to transport reagents and chambers to contain and mix reagents. Operationally, multiple steps of the protocol require mixing reagents and washing off contamination. To mix reagents, the system change the rotating direction 2 times in a second. To wash off contamination, the buffers is loaded from the well at the center and the rotating speed will be low until all of the buffer is accumulated in the column, then the rotating speed will increase to 3000 rpm. The mixing ability of the disk was tested and compared with that from the standard kit protocol.

The validations of the system were performed from either MCF7 cells lysed on-disk or exosomes from 0.2ml to 6.4ml human plasma. For characterization, we compared RNA yield obtained by using the device with that enriched by conventional approach. Results show the device could enrich RNA with high efficiency, the integrity of cellular RNA was confirmed with gel electrophoresis and the genomic profile analyzed by qPCR with 1 house-keeping gene of human cell and 3 cancer-related biomarkers: RPP30, ER, HER2 and KI67. The amount of exosomal RNA enriched by the device was validated high enough for further gene detection or analysis by qPCR with 2 miRNA biomarkers and 1 mRNA biomarker: mir21, let7 and GAPDH.

In conclusion, this microfluidic device reduces variation in operator bias, thereby should provide a robust tool for RNA applications.

PDMS-Based Flexible Microelectrode for Monitoring of Electrocardiography

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The flexible and implantable electrode is highly adaptive to the curves of body. The electrode should be adhered onto the body steadily under the motion, and be implanted stably in the tissue without any damages while maintaining conformal contact. Although most electrodes are fabricated with biocompatible materials, they should be shielded from tissues to prevent mechanical delamination from the device itself and side effect such as irritation, allergy, or inflammation. The fabricated electrode consists of polyimide (PI) and metal layer was fully encapsulated in polydimethylsiloxane (PDMS) which exhibits high bio-compatibility and flexibility. To evaluate device performance for electrocardiography (ECG) acquisition, the electrode was implanted under subcutaneous space of a rat. PDMS layer performed as a protection layer that resulted in no damages on metal-layer after implantation. We obtained stable ECG signals without distortions or attenuation of targeted signal over 4 weeks. The result indicated that the developed electrode had extremely small leakage current compare to direct contact electrode over the range of applied current from 0 to 10 mA. More than 99% of the applied current was prevented from leakage into the surrounding tissues with no inflammation or infection. Without PDMS layer, Au metal patterns were peeled off when implanted on the back of rats for a week due to friction stress between tissues and a metal-layer. A tightly fixated electrode enhanced level of conformal contact. Additionally, with enhanced electrical performance by bio-fluid, enhanced ECG signal qualities were successfully obtained. This suggested electrode may be utilized to monitor several biological signals without any risks.

Microfluidic Cell Culture Model of the Outer-Blood-Retinal-Barrier

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In this study, we build a microfluidic co-culture model of the outer-blood-retina-barrier in an attempt to elucidate age-related macular disease pathology. The two-layered microfluidic device is made up of an upper and lower channels. Human umbilical vein endothelial cells (HUVEC) embedded in fibrin gel formed vascular network in the lower channel, and the retinal pigment epithelial cells (RPE) was allowed to grow into monolayer in the upper channel. Using the model, our ongoing effort is to assess the barrier function of RPE and interactions of vasculature and RPE monolayer.

Wearable Enzymatic Alcohol Sensor

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Here, we describe a novel alcohol sensor technology that non-invasively detects alcohol that naturally diffuses through the skin, thus providing estimates of blood alcohol concentration (BAC).

Arrayed Label-Free Single-Cell Analysis by Electrorotation

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Single cells of different cell lines (HeLa, HEK 293 and M17) are arrayed in a microfluidic channel by the mean of dielectrophoresis (DEP) within micro cages made out of metal coated 3D electrodes. Alternating the applied signal between a trapping DEP and a electrorotation (ROT) signal, we can acquire ROT spectra of multiple arrayed cells in separate micro cages in flow at the same time. An individual connection of each electrode allows to let cells enter a specific micro cage or to be released and carried away by the flow individually.

Construction of In Vitro Hierarchical Vascular Networks using Tissue-Derived Microchannels of a Decellularized Liver Scaffold

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Brief Motivation, and Innovation

In vitro construction of hierarchical vascular networks is important in various aspects of medical fields including regenerative medicine, because vascular networks play critical roles in maintenance of physiological conditions. However, it is still a big challenge to construct hierarchical vascular networks in vitro with current techniques such as 3D bio-printing and sacrificial template methods due to complexity of vascular networks. Recent advances in decellularization techniques allowed us to fabricate tissue-derived microchannel networks, which have hierarchical structures continuing from large vessels to small vessels (1). The tissue-derived microchannel networks can provide a suitable environment for the construction of vascular networks in vitro. Here, we designed a tissue culture platform to construct hierarchical vascular networks using tissue-derived microchannel networks of a decellularized liver scaffold.

Brief Methods

A harvested rat liver was perfused with decellularization solutions such as trypsin and Triton X-100 through portal vein of the liver to remove cell components. After the decellularization, tissue-derived microchannel networks composed of extracellular matrix were fabricated in the decellularized liver. GFP-labeled human umbilical vein endothelial cells (GFP-HUVECs) were injected into the decellularized liver scaffold through portal vein, which resulted in the cells distributed throughout the tissue-derived microchannel networks. The recellularized liver scaffold was then placed in a perfusion culture chamber and connected to a peristaltic pump, to apply flow-derived mechanical stress to cells. Constructed vascular networks in the scaffold were observed by fluorescence microscopy.

Key Results

Decellularization techniques provided hierarchical microchannel networks composed of matrix proteins, which correspond to vascular networks in normal livers. After cell injection, GFP-HUVECs formed hierarchical vascular networks continuing from large vessels to microvessels using tissue-derived microchannel networks in perfusion culture, while microvessels were not observed in static culture. In addition, actin filaments of GFP-HUVECs were oriented along the central axis of vasculatures in perfusion culture, which suggested that cells recognized fluid shear stress (FSS) and subsequently formed microvessels. Moreover, fibronectin coating of microchannels enhanced the formation of microvessels in perfusion culture. Our results suggested that combination of flow-derived mechanical stress and fibronectin coating was important for the construction of hierarchical vascular networks in tissue-derived microchannel networks.

Conclusions

We developed a tissue culture model for the construction of in vitro hierarchical vascular networks using tissue-derived microchannel networks. This model is potentially useful for the future medical researches of drug screening and tissue engineering.

Patterning Macroporous Supraphysiological Fibrin by Photodegradable Hydrogel Particle Erosion

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The novel creation of supraphysiological fibrin scaffolds containing photodegradable particles that allow for temporal control of drug delivery or void formation. These scaffolds have tuneable mechanical properties never before achieved with fibrin and when combined with the temporal control over the microscale architecture of gel and/or release of chemical agents from the photodegradable microparticles creating an innovative new tool for tissue engineering.

Biomedical Liquid Marbles for Osteogenic Differentiation of Human Mesenchymal Stem Cells

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Liquid marble is a liquid droplet covered by micro- or nano-scaled particles and can be obtained by simply rolling a liquid droplet in hydrophobic powders [1]. Their facile preparation and bioinspired nature make liquid marble an attractive candidate as micro-bioreactors for biomedical applications, such as blood typing, drug screening and tumor tissue formation [2, 3]. However, the interaction between liquid marbles and human stem cells is not clear and rare reported. Here, we develop biomedical liquid marbles (BLM) prepared using fluorinated graphene (FG-BLM) and hydrophobic silicon dioxide (SiO_2 -BLM) for encapsulation of human bone marrow-derived mesenchymal stem cells (hBMSCs) and to investigate the cell fate in the biomedical liquid marbles (Fig. 1a). Normal cell culture media (DMEM) containing an appropriate density of hBMSCs was used to fabricate stem cell-laden liquid marble, with the cell behavior monitored for 21 days. The results show that the hBMSCs in both liquid marbles proliferate with time. Compared with those of SiO_2 -BLM, hBMSCs exhibit better cell proliferation and they form multicellular spheroids in FG-BLM. More interestingly, FG-BLM is found to speed up osteogenic differentiation and maturation including alkaline phosphate activity (ALP) production, calcium nodule deposition and osteogenesis-related proteins expression owing to the osteoinductive property of graphene (Fig. 1b). Therefore, this biomedical liquid marble system provides a facile and effective platform to investigate and expedite the osteogenesis of human stem cells in the confined environment as well as will broaden the regenerative medicine application of liquid marbles.

Highly Adherent Parylene-C Coatings with Nanostructuring for Enhanced Cell Adhesion and Growth

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Parylene-C is a frequently used polymeric thin-film coating in medical applications and is known for its excellent biocompatibility and flexible deposition process. However, its use in long-term implants is limited due to its poor adhesion to metals in liquid environments. In this work we present a strategy to anchor Parylene-C to medical grade titanium (Ti) by means of nanostructuring the Ti substrates surface prior to Parylene coating. We observe that, after aging in physiological salt solution for 3 days, Parylene coating lose their adhesion to bare titanium surfaces. However, the Parylene films deposited on nanostructured Ti surfaces retain full adhesion, even after aging them in the same solution for 10 days.

Additionally, we demonstrate that combining nanostructured surfaces with very thin Parylene coatings provides the additional benefit of accelerating cell proliferation. Nanostructured surfaces showed cell proliferation without the typically required oxygen plasma treatment. Combining plasma treatment and nanostructuring further improved proliferation performance over smooth Parylene surfaces.

PGI

Cell Printing in Complex Hydrogel Scaffolds

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Advancements in the microfabrication of soft materials have enabled the creation of increasingly sophisticated functional synthetic tissue structures for a myriad of tissue engineering applications. A challenge facing the field is mimicking the complex microarchitecture necessary to recapitulate proper morphology and function of many endogenous tissue constructs. This study describes the creation of polyethylene glycol diacrylate (PEGDA) hydrogel microenvironments (microgels) that maintain a high level of viability at single cell patterning scales and can be integrated into composite scaffolds with tunable modulus. PEGDA was stereolithographically patterned using a digital micromirror device to print single cell microgels at progressively decreasing length scales. The effect of feature size on cell viability was assessed and inert gas purging was introduced to preserve viability. A composite PEGDA scaffold created by this technique was mechanically tested and found to enable dynamic adjustability of the modulus. Together this approach advances the ability to microfabricate tissues that better mimic native constructs on cellular and subcellular length scales.

PGI

Preliminary Evaluation of a Novel, Biomaterial Delivery Vehicle for Cl-Amidine as a Potential Means to Reduce Implant-Associated Thrombosis and Fibrosis

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Thrombosis and fibrosis are often detrimental to medical device functions, such as implantable sensors, vascular grafts, and tissue-engineered constructs. The release of neutrophil extracellular traps (NETs) from neutrophils, sentinels of the innate immune response to biomaterials, is driven by peptidyl arginine deiminase 4 (PAD4) and may be intimately linked to these complications. In our preliminary work, we evaluated the ability of Cl-amidine, an irreversible inhibitor of PAD4, to attenuate NET release from implant-interacting neutrophils by local delivery from electrospun polydioxanone (PDO) (Patent pending).

Cryopreservation, Revival, and Lifespan Extension of Tissue Engineered Skeletal Muscle

Grant, Lauren¹, Raman, Ritu², Cvetkovic, Caroline¹, Ferrall-Fairbanks, Meghan³, Pagan-Diaz, Gelson¹, Hadley, Pierce¹, Platt, Manu³, Bashir, Rashid¹

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Here, we study the effects of cryopreservation on tissue engineered skeletal muscle and develop an optimized protocol for the fabrication, freezing, revival, and long-term culture of skeletal muscle without incurring loss of function or cell viability. Cryopreservation enables the efficient fabrication, storage, and shipment of these tissues, which in turn facilitates multidisciplinary collaboration between research groups, enabling advances in skeletal muscle regenerative medicine, organ-on-a-chip models of disease, drug testing, and soft robotics.

In Vivo Evaluation of Electrochemical Therapy for Localized Skin Regeneration through Acid/Base Creation

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Deep chemical peels are a common scar therapy that work by denaturing proteins in the dermis and causing collagen reorganization. While cost effective, the penetration depth of deep chemical peels can be difficult to control due to local tissue heterogeneity. Furthermore, deep chemical peels usually require phenol, which can be rapidly absorbed into the circulation and create risk of arrhythmia [2]. Electrochemical therapy (ECT) is a low-cost alternative that is capable of inducing localized skin regeneration via electrolysis generated by a voltage applied between two platinum electrodes. In this work, we study the efficacy of ECT as a localized, low-cost, and low-risk, method of scar therapy.

Cell Sheet Fabrication by Langevin Piezoelectric Transducer having Homogeneous Thickness Vibration Mode

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Cell sheet engineering is one of the most important technologies in regenerative medicine. A cell sheet fabrication technique relies on temperature-responsive polymer-coated cell culture dishes requiring low temperature culture, which affects cell activity. Thus, we developed a method to detach a cell sheet from the surface of widely used general culture dish by ultrasonic vibration. The proposed method provides cell sheets more intact than that by the conventionally used method.

The cell sheet detaching device was fabricated by combining a ubiquitous 35-mm cell culture dish, an ultrasonic Langevin transducer having a homogeneous longitudinal vibration mode at 19.68 kHz, and glycerol located between the dish and the Langevin transducer. 6.0 C₂C12 myoblasts were seeded on the cell culture dish and cultured for 72 hr to reach confluence, and then they are exposed to ultrasonic vibration from the bottom side of the dish in a 5% CO₂ humidified atmosphere incubator at 37B0C.

Consequently, 95.6% of trials successfully detached the cell sheet from the ubiquitous cell culture dish within 1 hr ($n = 45$). Note that the rest trials could detach cell sheets by pipetting after the exposure of ultrasonic. The detached cell sheet had a similar appearance to that detached by the conventional method. More excitingly, the cell sheet detached by our technique had higher metabolism than the conventional method. We believe our technique has a great potential to be used as a future standard for cell sheet fabrication.

PGI

Composite Hydrogels with Controlled Degradation in 3D Printed Scaffolds for Programmed Cell Delivery

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Controlled cell delivery has shown some promising outcomes compared with traditional cell delivery approaches over the past decades, and strategies focused on optimization or engineering of controlled cell delivery have been intensively studied. In this report, we demonstrate the fabrication of a 3D printed hydrogel scaffold infused with degradable PEGPLA/NB composite hydrogel core for controlled cell delivery with improved cell viability and facile tunability. The 3D printed poly(ethylene glycol) diacrylate (PEGDA) scaffold with specifically designed architectures can provide mechanical support while allowing bidirectional diffusion of small molecules, thus permitting structural integrity and long-term cell viability. Poly(lactic acid)-poly(ethylene glycol)-poly(lactic acid) (PLA-PEG-PLA), which is highly susceptible to hydrolysis, however, the acylation reactions it utilizes for chain growth have been reported as toxic to cells. Poly(ethylene glycol) norbornene (PEGNB), validated for its excellent cytocompatibility, was therefore mixed and infused together with PLA-PEG-PLA into the printed PEGDA scaffold. Cells encapsulated microfluidically into PEGNB microspheres and then polymerized within PEGPLA/NB composite hydrogel maintained excellent viability over a week. Controlled cell release was achieved via the manipulation of PEGPLA/NB composition. By increasing PEGNB proportion in the core, cell release was significantly slowed, while increasing PLA-PEG-PLA proportion eventually resulted in very robust cell release within a short time frame. Functionality of released cells was validated by their cell viability and proliferation potential. In summary, we have shown this droplet-microencapsulation technique coupled with composite degradable hydrogel and 3D printing could offer an alternative route for controlled cell delivery.

PGI

Effects of Apelins-12 and 13 on the Enlargement of In Vitro Microvessels Covered with Pericytes

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Brief Motivation, and Innovation

There are a lot of researches that construct vasculatures in vitro and try to understand the mechanism of caliber size regulation. However, most of the culture models were composed of vascular endothelial cells alone. Little is known about the size regulation mechanism in a model of endothelial cells covered with pericytes. Recently, apelin-13, endogenous peptide, was reported to enlarge cord structures formed by HUVECs. It also reported that HUVECs produced more apelin-12 under shear stress condition, so apelin-12 was expected to have the effect of vascular enlargement. However, it is unclear whether apelins-12 and 13 have such an effect on vascular structures with pericytes. In this study, we investigated the effect of apelins-12 and-13 on enlargement of microvessels covered with pericytes. This culture model is important to further investigate a new mechanism that vessel size is regulated by the interaction between endothelial cells and pericytes.

Brief Methods

A microfluidic device, which consists of two lateral medium-channels and a central gel-channel, was fabricated by softlithography. After 9:1 fibrin-collagen mixture was injected into the gel-channel, HUVECs and MSCs were seeded into separate medium-channels. Microvascular networks covered with pericytes were formed in 2 weeks of culture. Endothelial culture medium was supplemented with 50, 100 ng/mL apelin-12 or apelin-13. The size of constructed microvessels was analyzed by confocal microscopy.

Key Results

Microvessels enlarged their diameter from 19 B5m to 22 B5m when they were cultured in the media supplemented with 50, 100 ng/mL apelin-12. The addition of 50, 100 ng/mL apelin-13 also enlarged microvessel diameter from 18 B5m to 25 B5m. Because Tatemoto *et al.* reported that apelin-12 lowered blood pressure in rats via an NO-dependent mechanism, we hypothesized that apelins-12 and 13 induced NO production in HUVECs and released NO enlarged vessel diameter by relaxing pericytes. When we inhibited the production of NO by addition of L-NAME (eNOS inhibitor), enlargement induced by apelins-12 and 13 was suppressed.

Conclusions

Apelins-12 and 13 enlarged the vessel diameter of the microvessel covered with pericytes constructed in microfluidic devices. This enlargement was suppressed by inhibiting eNOS. These results suggest a novel mechanism of vascular size regulation that vessel diameter is enlarged by constant pericyte relaxation via NO production in HUVECs.

PGI

Maintenance of Implanted Mesenchymal Stem Cell Function using Injectable Monodisperse Hydrogel Particles Assembled into a Microporous Scaffold

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We developed an injectable microporous stem cell niche using microfluidically-generated monodisperse modular hydrogel particles. Delivered with MSCs, these particles are enzymatically assembled *in situ*, generating a highly-controlled interconnected microscale pore space, where cells can easily adhere, migrate and proliferate, leading to the enhanced survival of transplanted cells. Moreover, the properties of the particles, including stiffness, degradability and cell binding motif concentration, can be modulated independently. By modulating these properties, the microporous scaffold promotes the maintenance of stem cell properties.

Time-Varying Stiffness and Mass Measurement of Adherent Cancer Cells Around Mitosis

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Countless studies have associated mechanics to cellular functionality and physiology. Mechanical properties of cancer cells are useful biomarkers to evaluate their relative metastatic potential and cycle progression; hence, further explaining the basis of uncontrolled proliferation in cancer. We report a simultaneous real-time tracking of viscoelasticity (stiffness) and mass; revealing significant mechanical properties associated with a nanoscaled cellular membrane fluctuation.

Fabrication of an *in vitro* Pressure Platform to Study the Response of Primary Retinal Ganglion Cells to Physiological Abnormal Pressure

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Our proposed system utilizes a signal generator and pressure valve for generating hydrostatic and periodic pressure to mimic physiological relevant abnormal pressure. The primary retinal ganglion cells (RGCs) are cultured in poly(dimethylsiloxane)(PDMS) microfluidic device, allowing long-term monitoring and quantification of the morphological changes of primary RGCs over time. We show that the proposed platform can both generate static pressure and periodic pressure rhythm in microfluidic devices. The primary RGCs under high hydrostatic pressure show significant degenerations, characterized by total neurite length axon length and number of intersections. Our study demonstrated that the proposed platform simulate the relationship between elevated IOP and the degeneration of retinal ganglion cells, and inspires new ways to study the pathology of glaucoma

Micro-Electrical Impedance Spectroscopy and Identification of Patient-Derived, Dissociated Tumor Cells

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Fine needle aspirate sampling of tumors requires acquisition of sufficient cells to complete a diagnosis. Aspirates through such fine needles are typically composed of small cell clusters in suspension, making them readily amenable to microfluidic analysis. Here we show a microfluidic device with integrated electrodes capable of interrogating and identifying cellular components in a patient-derived sample of dissociated tumor cells using micro-electrical impedance spectroscopy (micro-EIS). We show that the micro-EIS system can distinguish dissociated tumor cells in a sample consisting of red blood cell (RBCs) and peripheral blood mononucleated cells (PBMCs). Our micro-EIS system can also distinguish dissociated tumor cells from normal cells and we show results for five major cancer types, specifically, lung, thyroid, breast, ovarian and kidney cancer. Moreover, our micro-EIS system, can make these distinctions in a label-free manner thereby opening the possibility of integration into standard clinical workflows at the point of care.

Magnetically Controlled Multi-Step Single Cell Assay in Ferrofluid Droplets

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Several challenges facing droplet manipulation hinder the application of microfluidic droplet systems to single cell studies, including high-throughput pump-free droplet manipulation and reagent addition. We have designed a novel microfluidic droplet platform that allows generation and positioning of monodisperse ferrofluid droplets, aqueous drops containing small magnetic nanoparticles, with a magnet. By controlling droplet location in the z-axis with respect to a reagent patterned surface, reagent transfer can be switched on or off rapidly by moving droplets into or out of contact with the reagent patterned surface regions.

Electrode-Electrolyte Interface Impedance Characterization of

Ultra-Miniaturized Microelectrode Arrays over Materials and

Geometries for Sub-Cellular and Cellular Sensing and Stimulation

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Electrochemical interfaces with low-impedance, high biocompatibility, and long-term stability are of paramount importance for electrode arrays widely used in a myriad of cellular sensing and stimulation applications, e.g., electroceuticals, brain interface, neuroprosthetics, drug discovery, chemical screening, and fundamental biology research. This is particularly relevant since ultra-miniaturized electrodes have become a necessity to achieve sub-cellular interfacing resolution. This paper reports a first comprehensive characterization and interfacial impedance spectroscopy of ultra-miniaturized electrodes over varying electrode sizes ($8C \mid 8 B5m^2$, $16C \mid 16 B5m^2$, and $32C \mid 32 B5m^2$) and a wide collection of electrode materials (gold Au, titanium nitride TiN, platinum Pt, and indium-tin-oxide ITO). Experimental results demonstrate that TiN electrodes offer the lowest electrochemical impedance. Equivalent electrochemical interfacial circuit models including interface capacitance, charge transfer resistance, and solution resistance are obtained for all the electrode designs based on the measured impedance spectroscopy results.

Non-Invasive Monitoring of Single-Cell Mechanics by Acoustic Scattering

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Doyle, Patrick, Manalis, Scott

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Single-cell mechanics are critical in understanding cytoskeletal dynamics¹ during cell growth and disease progression². However, monitoring mechanical changes of the same cell continuously remains difficult primarily due to the invasiveness of mechanical measurements. Here, we show a non-invasive method of quantifying cellular mechanical properties through acoustic fields that are scattered from a living cell. Our approach minimally (<15nm) deforms the cell with megahertz acoustic fields developed inside a fluid-filled vibrating cantilever. Through simulations, experiments with hydrogels of varying elastic modulus and chemically perturbed cells, we show that our acoustic readout signal, the size-normalized acoustic scattering (SNACS), measures cellular stiffness. By monitoring single mammalian cells for multiple cell cycles with a temporal resolution of <1 min, we find that cells maintain a constant SNACS throughout interphase but exhibit dynamic changes during mitosis. In early mitosis, mitotic cell swelling causes the reduction of SNACS. In late mitosis, SNACS briefly recovers before another rapid reduction during polar relaxation of the actin cortex. Our work proposes a new way of non-invasively probing subtle and transient mechanical dynamics that have previously been difficult to access.

Transwell Integrated Porous Sub-Micrometer PDMS Membranes as Alternative Cell Culture Platform

Tibbe, Martijn, le The, Hai, Eijkel, Jan, van den Berg, Albert, Leferink, Anne, Segerink, Loes

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In this research we integrated a porous sub micrometer PDMS membrane into a Transwell set-up. The cell culture ability of the PDMS membrane is compared with a traditional polycarbonate Transwell membrane. Results show comparable results regarding ZO-1 production when co-culturing endothelial cells and astrocytes.

Integrated 3-D Electrodes for Selective Cell Release in Hydrodynamic Traps

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As the field of personalized immunotherapy is growing, the possibility to retrieve cells after analysis for reinjection in the patient is a difficult issue that needs to be addressed. Currently single cell arrays based on hydrodynamic trapping suffer from the complexity to retrieve cells after analysis. Consequently we propose to use dielectrophoretic force as a driving force for selective single cell recovery. Integration of 3-dimensionnal standing electrodes in close vicinity of the fluidic traps could be achieved through a new fabrication method based on SU-8 photoresist.

Deep Learning at the Microscale for Improved Sperm Selection

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Infertility represents a biomedical grand challenge. Increasingly, couples are seeking medical assistance in achieving successful reproduction. In intracytoplasmic sperm injection, an individual sperm is selected and directly injected into an egg. Unfortunately, such a procedure lacks standardization between clinics, and remains highly subjective. Here, we showcase our recent efforts in pairing microscale assays with deep learning, to accelerate, standardize and enhance sperm selection by either (i) *classifying sperm* in existing WHO categories according to shape or (ii) *ranking sperm* according to DNA quality, as measured via our chemically-functionalized platform for single-cell assessment.

An Automatic Microfluidic System for Droplet-Based Single-Cell Analysis

Nan, Lang

The University of Hong Kong Shenzhen Institute of Research and Innovation (HKU-SIRI), Hong Kong, China

This system performs single-cell culture through an efficient collection of single droplets and will inspire new single-cell studies.

Membrane Porosity and Substrate Discontinuity Affect YAP Nuclear Localization

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Brief Motivation, and Innovation: The increasing use of porous membranes as scaffolds in organ- and lab-on-a-chip devices necessitates the investigation of the effects of these membranes on cellular growth and differentiation. Previously, we have shown disrupted membrane surfaces affect endothelial cell focal adhesion formation, ECM fibrillogenesis and migration similarly to soft substrates. Yes-associated protein (YAP) is a transcriptional coactivator involved in mechanotransduction that, when activated by subcellular localization to the nucleus, directs stem cell fate to an osteogenic lineage. YAP localization has been shown to be correlated with substrate stiffness in mesenchymal stem cells (MSCs). Here, we utilize ultrathin glass membranes with variable size micron and sub-micron pores to explore how substrate disruptions can influence human adipose-derived stem cells (ADSCs) through YAP localization, focal and fibrillar adhesion formation, and stress fiber formation.

Brief Methods: Non-porous and porous (0.5 B5m and 3.0 B5m pores), transparent, ultrathin SiO₂membranes were fabricated using standard MEMS processing techniques. ADSCs were stained with YAP antibody after 6 or 24 hours as well as with DAPI (nuclei), phalloidin (F-actin), and vinculin antibody (adhesion complexes).

Key Results: Immunofluorescent images exhibited quantifiable differences in the localization of YAP between ADSCs cultured on non-porous versus porous SiO₂membranes after 24 hours (Fig. 1A). Significant differences in the nuclear-to-cytoplasmic YAP ratio were observed on non-porous versus porous SiO₂membranes after 24 hours (Fig. 1B). Over time, the YAP ratio significantly increased on non-porous SiO₂membranes and slightly declined on porous SiO₂membranes (Fig. 1C). These results indicate that after 24 hours, more YAP localizes to the nucleus of ADSCs on non-porous than on porous SiO₂membranes. Analysis of the adhesion complex protein vinculin indicated no significant difference in the number or total area of focal adhesions (2-5 B5m) or fibrillar adhesions (>5 B5m) between ADSCs cultured on the different membranes. Despite this, more distinct F-actin fibers were observed to co-localize with the adhesions in ADSCs cultured on non-porous membranes with statistically larger cell spread area after 24 hours. On-going studies are investigating whether non-fouling PEG islands that mimic membrane pores have similar effects.

Conclusions: Our data suggests that subcellular disruptions in the surfaces of stiff substrates produce responses similar to continuous soft substrates, including decreased YAP nuclear localization and actin stress fiber formation. These responses may induce global changes within the cell that ultimately direct ADSC fate.

Droplet-Based Magnetic Ratcheting System of Sorting Productive Cells

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Single-cell sorting is rapidly leading to advances for a wide range of biomedical applications, especially for identifying the heterogeneity of cells in tissues or the differences in cell state¹. Common platforms for cell sorting include Fluorescence Activated Cell Sorting (FACS) or passive microfluidics approaches. However, sorting live cells based on growth rate, secreted products or biomass accumulation rate remain challenging. Here we introduce a versatile magnetic ratcheting technique for sorting cells based on the number encapsulated in large volume agarose microgels³. Encapsulation in an agarose gel enabled cells growth in ideal conditions and easy recovery after sorting. Here we demonstrate this platform using CHO cells, which are commonly used for production of therapeutic proteins. This system showed high efficiency of sorting actively dividing CHO cells and re-growth with high viability.

A Novel Microfluidic Device to Mature Stem Cell-Derived Human Liver Cells

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We describe the development of a novel microfluidic device that was utilized to determine the role of precisely controlled cell-cell interactions, co-culture with non-parenchymal cells (NPCs), and fluid flow on the functional maturation of induced pluripotent stem cell-derived human hepatocyte-like cells (iHeps) for constructing *in vitro* human liver models that have utility in drug development.

Engineering 3D Human Liver Microtissues using Droplet-Based Microfluidics

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We describe the development of a high-throughput microfluidic platform to fabricate 3-dimensional collagen microgels/microtissues containing primary human hepatocytes (main cell type of the human liver) and supportive fibroblasts. These microtissues maintained long-term and stable hepatocyte functions for 6 weeks *in vitro*, at levels higher than conventional self-assembled spheroids and macrogels. Lastly, the microtissues were shown to be useful for predicting clinically-relevant drug outcomes in the liver, towards mitigating the risk of drug-induced liver injury in humans.

PCR Detection using Paper-Based SERS Substrate for Enhanced Sensitivity and Reproducibility

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Recently, there is a growing demand for precision diagnostic or on-site diagnostic technologies in molecular diagnosis.¹ The PCR detection currently used in clinical practice has relied on fluorescence analysis. However, fluorescent dyes are vulnerable to photobleaching and has low detection limit. In this work, we developed a paper-based surface enhanced raman spectroscopy (SERS) substrate for PCR detection with enhanced sensitivity and reproducibility. The SERS substrate was prepared by vacuum filtration of silver nanowire (AgNW) solution onto a glass-fiber filter paper (GFFP) membrane.² The AgNWs stacked on the GFFP formed a high density of SERS-active hot spots at the points of nanowire intersections. In order to solve the problem of quantification and reproducibility of SERS, ROX, which does not have a chelating effect on dsDNA was introduced into PCR product as a reference dye together with dsDNA chelating agent, EVA green. As a result of raman signal analysis, raman signals of EVA green and ROX were similarly amplified in the negative control. On the other hand, in the PCR amplification product containing the target template, the raman signal of ROX remained unchanged while the raman signal of EVA green decreased with the target template concentration. These results indicate that as the PCR amplification product increases, EVA green is chelated by high molecular weight of dsDNA and cannot enter the hot spot, resulting in a decrease in the SERS effect, while ROX is not chelated with the dsDNA and the SERS signal is maintained in the hot spot. We could measure the signal of EVA green which was not chelated with dsDNA compared to the ROX signal, and we quantified the degree of PCR amplification through this. It was confirmed that a template amount of 0.005 ng was detected using our paper-based SERS substrate. The results were 1000 to 10000 times more sensitive than fluorescence detection using real-time PCR and electrophoresis.

Real-Time DNA Amplification by Recombinase Polymerase Amplification on Silicon Nanowire ISFETs

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École polytechnique fédérale de Lausanne, Lausanne, Vaud, Switzerland

We demonstrate detection of Recombinase Polymerase Amplification of puc19 using silicon nanowire Ion Sensitive Field Effect Transistors at room temperature.

On-Chip and Label-Free Detection of Conformation Changes in DNA Tweezer Nanostructures with Microwave Microfluidics

Stelson, Angela C.¹, Liu, Minghui², Little, Charles¹, Orloff, Nathan¹, Long, Christian¹, Nicholas, Stephanopoulos², Booth, James¹

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Here, we present an on-chip, label-free electronic technique that can detect conformational changes in a DNA nanomechanical b|tweezerb| structure through the use of microwave characterization of on-chip microfluidic devices.

Droplet Microfluidics for RNA Fluorogenic Aptamer Screening

Guo, Wei, Tang, Matthew, Kinghorn, Andrew, Tanner, Julian, Shum, Anderson

The University of Hong Kong, Hong Kong, Hong Kong

In the presentation, we will illustrate a high-throughput RNA aptamer screening using the droplet microfluidic platform.

Conditional Separation Assay using Magnetic Particle-Labelled Probe for SNP Phasing

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Brief Motivation, and Innovation

When a person is heterozygous at more than one position, the placement or the phase of these mutations (*cis* for the same strand and *trans* for different strands) can result in variable phenotypes. For example, multiple SNPs have been correlated to high-altitude pulmonary edema (HAPE) and one of which is in the promoter region of the HSP70 gene family. When concurrent with another missense mutation, *trans* SNPs will result in one gene producing a reduced amount of the wild-type protein and another gene producing a normal amount of the mutated protein; on the other hand, *cis* SNPs will result in one gene rescuing the other mutated copy.

Despite the importance of SNP phasing, this information is often missed out in routine DNA sequencing technologies unless both parents are also sequenced, long-range PCR or DNA sequencing will be employed.

Thus, a nucleic acid self-assembly process is described to resolve the phase information of multiple SNPs. We have previously described an enzyme-based approach to phase two SNPs 100 nucleotides apart; however, diseases that require phasing usually have SNPs further apart. Herein, an enzyme-free method is presented to phase two SNPs 1378 nt apart from a 1.5-kb fragment of the HSP70 gene².

Brief Methods

The process involves two steps. First, two different fluorophore-labelled probes (one of which immobilized onto a magnetic bead (MB)) are added to test for the presence of the two SNPs. Then, a magnet is used to separate the MB and sort the position of SNPs based on the fluorescence signals in the retentate and supernatant.

Key Results

Using the optimized ratio of magnetic beads (MB) to the immobilized probe (3ug MB:1 pmol probe), salt concentration (0.5 M Na), and reaction conditions (37°C, 15 minutes per step), the levels of green and red fluorescence signals can be used to determine the allelic count and the phase of the two SNPs in all 10 possible haplotype combinations.

Conclusions

This can then serve as an alternative to long-range allele-specific PCR or sequencing in order to simultaneously test for the presence and phase of a specific pair of SNPs in the HSP70 gene.

References:

- b Conditional Displacement Hybridization Assay for Multiple SNP Phasing, b T.W. Fan, H. Lee Yu, et al. Analytical Chemistry, 89, 9961 (2017).
- b Genetic interaction of Hsp70 family genes polymorphisms with high-altitude pulmonary edema among Chinese railway constructors at altitudes exceeding 4000 meters b Y. Qi, W.Q. Niu, et al. Clinica Chimica Acta, 405, 17 (2009)

PGII

DNA-Stabilized Silver Nanoclusters (AgNCs) for Sensing DNA in Biological Media

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We report on the capabilities and limits of DNA-stabilized silver nanoclusters (DNA-AgNCs) as beacon-type sensors for single stranded, cell-free DNA.

PGII

Low Refractive Index Microfluidic Devices for High-Throughput Measurement of Chemotherapy Response

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When combined with advanced microscopy techniques such as quantitative phase microscopy (QPM), microfluidic devices can be used to quantify multiple features of cell behavior with applications in disease diagnosis and drug discovery. An important challenge facing the combination of these approaches is the difference in refractive index between channel structures made of conventional microfluidic device materials and aqueous cell culture media. This mismatch introduces artifacts near microfabricated structures. Here we address this challenge through the use of MY133-V2000 a

fluorinated polymer with refractive index nearly equal to that of water ($n = 1.33$). We demonstrate the fabrication and sealing of MY133-V2000 microfluidic devices with ordered arrays of cells for rapidly screening cancer therapies using QPM.

PGII

CMOS ASIC for Broadband Intravascular Ultrasonic Imaging

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We demonstrate a custom CMOS ASIC - optimized for a 40 MHz 100% fractional bandwidth transducer - offers significant improvements in imaging noise, instrumentation area, and bandwidth. The design has better than 400 ns recovery 15 dB of gain, harmonic distortion of better than -30 dB and an input referred noise of $1.9 \text{ nV/ Hz}^{1/2}$. The ASIC has been flip chipped thermosonically bonded to a PCB containing a 0.8 mm transducer for catheter implementation.

PGII

A Microfluidic Device Prototype to Isolate Circulating Cancer Cells

based on their Expression Levels of EpCAM Surface Marker

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We demonstrate a magnetic-microfluidic device to enrich and sort circulating tumor cells into sub-populations based upon epithelial expression levels in order to identify cells with high metastatic potential. The design was validated by the separation of MCF-7 cells spiked into whole blood based upon epithelial expression levels. The device is fabricated using rapid prototyping methods and the design is amenable with plastic injection molding for low cost high volume manufacturing.

PGII

Nanotopographical Regulation of Vascular Cells by Titanium Nanotubes for the Attenuation of Restenosis

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Coronary stenting is a procedure for opening blocked arteries. Post-procedure, the renarrowing of the artery through restenosis is a persisting complication that requires repeat revascularizations. Titanium nanotube patterned stents have been shown to decrease neointimal thickening. However, the optimal titanium nanotube size is not identified, and the mechanisms behind the effect are unknown. Since cell response to topographical cues is dependent on feature size and density, we fabricated titanium nanotube patterns with different diameters and assessed their effect on SMC response. Specifically, we examined SMC matrix protein production and inflammatory cytokine secretion, which are characteristics of restenosis. This study shows that 30 nm and 90 nm titanium nanotubes result in the greatest reduction SMC collagen I gene expression, and 90 nm titanium nanotubes reduce MCP-1 cytokine secretion. This study informs the design of titanium nanotubes as a promising stent surface for decreasing restenosis without cytotoxic drugs.

Controlled Synthesis of Ultra-Small Fluorescent Metal Nanoclusters in Droplet Microfluidic Reactor

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With unique optical and biological properties, fluorescent metal nanoclusters are of great potential for a variety of biomedical applications, such as bioimaging and biosensing. In order to promote the commercialization of these nanoclusters, their production have to be precisely controlled so as to achieve as uniform physical parameters and properties. Comparing with conventional bulk process, milli/microfluidic reactors can produce nanocrystals continuously and automatically with higher degree of control as well as efficiency. Nevertheless, most reported milli/micro-systems are still limited by their complex device geometry; moreover their mixing efficiency and control capability still need to be improved. For instance, fluids in continuous flow microreactors are dominated by laminar flow, requiring turbulence generated by complex channels to improve mixing efficiency. Meanwhile, some of the segmented flow microreactors can barely control the reagent ratio and mixing time, leading to polydispersity of the products. Herein, we designed and fabricated a droplet microfluidic reactor with high degree of control and mixing efficiency for the fluid reagents, which could maximize homogeneity of the chemical reaction environment, successfully achieving the preparation of ultra-small metal nanoclusters. Using silver nanoclusters (Ag NCs) as an example, we have demonstrated the feasibility of using this microreactor to automatically produce samples with controlled degree of reduction and highly uniform sizes. The as-prepared Ag NCs have an average diameter of ~1 nm, highly water-soluble and strong fluorescence brightness, suggesting their great value in photobiological researches.

Periadventitial Nitric Oxide Reduces Neointimal Hyperplasia in Arteriovenous Fistula: A Pilot Study

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In this pilot study, we have demonstrated that clinically significant AVF stenosis due to NIH can be reduced through the perivascular application of ECNO. Nanostructured ethylcellulose films functionalized with NO-releasing silica nanoparticles (ECNO) were synthesized and characterized. Yorkshire pigs underwent bilateral femoral AVF formation and half were treated with perivascular application of ECNO films prior to closure. After 30 days, pigs underwent radiographic, functional, and histologic analysis for NIH. Application of ECNO reduced NIH in 67% of pigs treated. The creation of a novel class of nanotechnology-enhanced prosthetics represents a potential paradigm shift to produce long-term prevention of NIH in not only the ESRD patient with AVF but all vascular lesions with NIH stenosis.

Mobile Piezoelectric Nanorobots for On-Demand Drug Delivery

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Here, we present a soft hybrid nanorobot that mimics an electric eel, that is able to generate electricity during its motion. Our nanorobots consist of a flexible piezoelectric tail composed of a polyvinylidene fluoride-based copolymer, linked to a polypyrrole nanowire which is decorated with nickel rings for magnetic actuation. Upon the application of rotating magnetic fields, the piezoelectric soft tail is

deformed, causing changes in its electric polarization. By tuning the magnetic field parameters, it is possible to either actuate the nanorobots towards targetted location or switch to the drug release mode for discharge of drugs.

PGII

MEMS-Actuated Carbon Fiber Microelectrode for Neural Recording

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Microwire and microelectrode arrays used for cortical neural recording typically consist of tens to hundreds of recording sites, but often only a fraction of these sites are in close enough proximity to firing neurons to record single-unit activity. Recent work has demonstrated precise, depth-controllable mechanisms for the insertion of single neural recording electrodes, but these methods are mostly only capable of inserting electrodes which elicit adverse biological response. We present an electrostatic-based actuator capable of inserting individual carbon fiber microelectrodes which elicit minimal to no adverse biological response. The device is shown to insert a carbon fiber recording electrode into an agar brain phantom and can record an artificial neural signal in saline. This technique provides a platform generalizable to many microwire-style recording electrodes.

PGII

Fibro-Neuronal Guidance on Common, 3D-Printed Textured Substrates

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Ability to direct neuronal growth not only carries great potential for treating neural conditions -e.g. bridging traumatically shattered connections - but would also be an exquisite tool for bionic applications that require physical interface between neurons and electronics. A testing platform is needed to better understand axonal guidance in the context of a specific *in-vivo* application. Versatility of 3D printing technology allows tailoring to researcher needs, both *in-vitro* and *in-vivo*. In this study we establish a fibro-neuronal co-culture inspired by our neural interface research, and demonstrate axon alignment on a texturized substrate fabricated with a common, versatile 3D-printing set-up.

PGII

Multi-Functional Nanostructured Biomaterials for Implantable, Biodegradable, Biocompatible Electronics

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Natural biosystems utilize multifunctional composites by bottom-up self-assemblies of nanomaterials for creating multiscale, hierarchical, and multiphasic structures. While conventional man-made synthetic composites increase one functionality by sacrificing the others, the biocomposites often synchronistically utilize their multi-functionalities. Here, extracted from biosystems, electrically conductive melanin nanoparticles and crystalline cellulose nanofibers are structured to translate their nanoscale versatilities into the synthetic biomedical devices by molecularly organized layer-by-layer assembly as well as thermodynamically driven self-assembly. By playing with matrix-filler interactions in the melanin composites, we could control the electrical conductivities, mechanical flexibilities, and

optical reflectivities. Furthermore, in the cellulose composites, mechanical, optical, and thermal properties could be adjusted by liquid crystalline behaviors of nanocelluloses. The bio-functionalities of these composites were further evaluated by mammalian cellular attachment and toxicity tests. With these unique combinations of multifunctional properties, these composites can be used as key functional materials in wide range of biomedical device applications such as implantable electrodes, sensors, and drug delivery carriers as well as emerging eco-friendly biodegradable electronics.

PGII

Modulating Electrical Behavior of Motor Neuronal Embryoid Bodies through Optogenetic Perturbation during Neurogenesis and Synaptogenesis

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Control and modulation of electrical activity of neural circuits is a grand challenge for biomedical, health, and engineering applications. Here, we used Channelrhodopsin-2 (ChR2) transfected mouse embryonic stem cell (mESC) derived motor neurons to explore short and long term programming of networks of these cells. When optically stimulated during neurogenesis as 3D embryoid bodies (EBs) in culture, a subsequent increase of neurite extensions and their electrical activity was measured using micro-electrode array (MEA) recordings. Not only we show short term deviations from steady state firing, we also achieved long term changes to the burst firing patterns in the network. In addition, the optical stimulation during synaptogenesis and network formation on the chip improved the network synchrony and coordinated firing of action potentials was increased. Our results demonstrated that a permanent change in the molecular pathways of the cells can result in altered structure and function of the resulting networks. Our approach can open up ways to program neural networks and systems, especially during development, towards a wide range of biomedical and engineering applications.

PGII

An Actuated Neural Probe Architecture for Reducing Gliosis-Induced Recording Degradation

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Glia encapsulation of chronically implanted neural probes inhibits recording and stimulation, and this signal loss is a significant factor limiting the clinical viability of most neural implant topologies for decades-long implantation. We demonstrate a mechanical proof of concept for silicon shank-style neural probes intended to minimize gliosis near the recording sites. Compliant whiskers on the edges of the probe fold inward to minimize tissue damage during insertion. Once implanted to the target depth and retracted slightly, these whiskers splay outward. The splayed tips, on which recording sites could be patterned, extend beyond the typical 50-100 micron radius of a glial scar. The whiskers are micron-scale to minimize or avoid glial scarring. Electrically inactive devices with whiskers of varying widths and curvature were designed and monolithically fabricated from a five-micron silicon-on-insulator (SOI) wafer, and their mechanical functionality was demonstrated in a 0.6% agar brain phantom. Deflection was plotted versus deflection speed, and those that were most compliant actuated successfully. This probe requires no preparation for use beyond what is typical for a shank-style silicon probe.

Durable Soft PEDOT/Graphene Oxide Composites on a Micro-Electrode for a Bioactive Neural Electrode

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We have introduced soft but durable conductive composites of poly(3,4-ethylenedioxythiophene) (PEDOT) / graphene oxide (GO) on gold microelectrodes through electrochemical methods for a bioactive neural electrode. It showed better electrochemical performances and biocompatibility than the PEDOT:PSS.

Creating a 3D Brain Angiogenesis Model with MSCs and Neural Cells Mimicking CNS Developmental Stages

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Brief Motivation, and Innovation

Blood-brain barrier (BBB) has selective permeability and prevents the central nervous system (CNS) drugs from passing vascular endothelial cells (ECs) to brain parenchyma. Since this BBB function is critical in drug delivery, it is essential to construct an *in vitro* BBB model for drug screening. In embryo brain, ECs acquire the BBB function immediately after angiogenesis occurred from perineural vascular plexus into brain parenchyma¹. Furthermore, on this angiogenesis stage, astrocytes which are considered as main component cells of BBB has not emerged yet. Neural progenitor cells (NPC) and neurons are started to produce, and they are involved in brain angiogenesis and BBB development². Therefore, we aimed to construct a 3D brain angiogenesis model mimicking the CNS developmental stages. The purpose of this study is to evaluate the effect of neural cells on brain angiogenesis in a 3D microfluidic device. The innovation in this study is to create the 3D brain vascular networks with neural cells.

Brief Methods

Human neural stem cells (NSCs) were cultured to prepare three types of neural cells mimicking CNS developmental stages such as NSC/NPC phase, neuron phase, and astrocyte phase. These neural cells, human brain microvascular endothelial cells (BMECs), and human mesenchymal stem cells (MSCs) were cultured in microfluidic devices which have two serial gel-channels sandwiched by two media-channels. Neural cells were mixed in fibrin gel and injected into one of the two gel-channels while BMECs and MSCs were cultured in a media-channel. Constructed capillary networks were observed by confocal microscopy.

Key Results

Firstly, we confirmed differentiation of NSCs and found that three types of neural cells were successfully prepared, which were nestin-positive NSC/NPC-phase cells, Tuj-1/MAP2-positive neuron-phase cells, and GFAP-positive astrocyte-phase cells. Next, these neural cells were cultured with BMECs in a microfluidic device. The results revealed that NSC/NPC-phase cells promoted capillary formation of BMECs compared with BMEC monoculture. By contrast, neuron-phase and astrocyte-phase cells inhibited capillary formation. Finally, three stages of neural cells were cultured with BMECs and MSCs. The result showed that brain capillary networks were constructed with neural cells regardless of developmental stages.

Conclusions

This study demonstrated co-culture models of BMECs, MSCs, and three types of NSC-derived neural cells mimicking CNS developmental stages. These models are useful for evaluating the effect of neural cells on brain angiogenesis. In particular, BBB development of BMECs with neural cells can be further investigated.

Engineering Microporous Annealed Particle (MAP) Hydrogels as a Novel Immunotherapy Platform for Melanoma

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In this study we are introducing a novel platform for cancer immunotherapy, using microfluidically fabricated microporous hydrogels loaded with immunostimulatory adjuvants, that can be directly injected in a tumor mass to create a microenvironment that fosters recruitment of the cells of the host's adaptive immune system and provides them with sustained stimulating signals in order to overcome the immunosuppressive tumor environment.

3D Microcancers in Microwell Array for Drug Testing

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We have developed a rapid and high throughput 3D microcancer platform that minimizes selective pressure and maintains the microenvironment in a silicon microchip with microwell array and at the same time provides opportunities for high throughput drug testing with easy real time characterization.

Individualizing Multi-Drug Therapy for Pediatric Acute Lymphoblastic Leukemia using CURATE.AI, an Artificial Intelligence Platform

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Acute Lymphoblastic Leukemia (ALL), the most common neoplasm of children, is a malignancy of lymphoid progenitor cells in the bone marrow. In this study, ALL patients were administered a combination of 6-mercaptopurine (6MP), vincristine, methotrexate (MTX), and dexamethasone (DEX) during the continuation phase of chemotherapy with dosages adjusted according to neutrophil count (ANC) and platelet levels. Clinical standard dosing follows titration protocols that fail to capture the dynamic nature of drug synergy, which can vary dramatically both between patients and within one patient's treatment duration. To address this challenge, we developed a powerful artificial intelligence technology platform termed CURATE.AI, which constructs patient-specific profiles or maps used to identify optimized drug dosages to better manage desired clinical outputs, such as ANC and platelet levels. CURATE.AI identified continually evolving optimized four- and two-drug dosage ratios throughout the duration of care demonstrating greater stability of patient response measures within the desired bounds, and representing steps toward the design of enhanced chemotherapy regimens, potentially reducing treatment induced pathologies and improving overall survival rates. Furthermore, with advances in nanomedicine towards combinatorial medicine such as co-delivery of multiple therapies for cancer treatment, there exists the potential to interface artificial intelligence like CURATE.AI with nanomedicine to achieve patient-specific optimization in combinatorial nanotherapy.

Micro/Nano Particle Based-Oxygen Sensing Film for Continuous and Non-Invasive Measurement of Oxygen Partial Pressure Around Cells

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Measurement of oxygen partial pressure around the cells is very important for analyzing cellular functions especially relating hypoxia. However, techniques for directly monitoring the oxygen concentration around the cells have not been in wide use and optimized. Therefore, we prepared micro/nano sized polystyrene (PS) particles incorporated with phosphorescent substance, palladium(II) octaethylporphyrin (PdOEP), and fabricated an oxygen sensing film in which the particles were mixed with polydimethylsiloxane (PDMS). This film showed higher sensitivity and accuracy, and it has possible to continuously and non-invasively measure the oxygen partial pressure and oxygen consumption rate of the cells *in vitro* by culturing the cells directly on the film.

Novel Electrospun Nanofiber-Assisted Dish for Long-Term Humanized Neuromuscular Junction (NMJ)

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Proper development, maturation, organization, and maintenance of NMJs are crucial for the functionality of the neuromuscular system. To date, there have been few NMJ studies on the development of patterned axons as well as muscles *in vitro*, and long-term maintenance of the NMJ system. The lack of such *in vitro* model system limits the application and understanding of the eventual tissue engineering problem, as well as drug screening and clinical researches. For the first time, electrospun PLA nanofibers were used as a novel *in vitro* culture system to guide axons towards muscle groups and provide a long-term support for NMJ in this study.

Conductiometric Sensing of Immunoglobulin G: A Metallo-Immunoassay for Detection of Physiological IGG Concentrations

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We propose to sense immunoglobulin G (IgG), one of the most plentiful antibodies in human serum, by coupling a free-solution metallo-immunoassay with oxidation of captured silver nanoparticles (AgNPs). The immune system relies on antibodies to recognize and guide the destruction of harmful agents in the body, thus protecting the body from infection. Changes in serum IgG levels indicate altered immune status, which can occur in conditions ranging from cancer and liver disease, to inflammation and immunodeficiency. Unfortunately, bulk IgG testing remains uncommon due to the high cost and analysis time the traditional immunoassay demands. Creating a more accessible sensor could greatly improve monitoring of immune disorders and enable personalized treatment for immune-deficient patients. To do so, we will first magnetically separate complexes with IgG bound to both magnetic beads and silver nanoparticles in solution (Figure 1a). We will then oxidize the AgNPs bound to IgG, which will result in a shift in solution electrical conductivity that can be directly correlated to bulk IgG concentration. Preliminary results have confirmed a shift in bulk conductivity in response to varying AgNP concentrations (Figure 1b-c). Future studies will focus on the construction of the metallo-immunoassay with measurements in bulk solution, as well as the design of a microfluidic chip to detect conductivity shifts in small volume samples. By applying the principles of an immunoassay without the need for optical detection, surface modifications, or extensive washing steps, we hope to develop a sensing mechanism amenable for the point of care due to minimal user involvement, small sample size, and low power requirements.

Structured Hydrogel Particles with Nanofabricated Interfaces via Controlled Oxygen Inhibition

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Hydrogels have been engineered for a variety of biomedical applications including biosensing, drug delivery, cell delivery, and tissue engineering. The fabrication of hydrogels into nanoscale and microscale particles has been a subject of intense activity and promises to extend their range of applicability. Here, we demonstrate the ability to tune, with extraordinary precision, the interfacial properties of PEGDA particles generated in a droplet microfluidic device exploiting oxygen-inhibited photopolymerization. We demonstrate the broad utility of these engineered microgels by creating spherical particles with complex but predictable radial crosslinking density gradients. Immunoassays were conducted to examine the network properties of these particles, revealing a high degree of structural tunability, which, in turn, dictates macromolecule encapsulation and release profiles, as well as the presence of radial crosslinking gradients that impact the availability of functional groups.

Effects of Exposure to 5.8 GHz Electromagnetic Field on Micronucleus Formation, DNA Strand Breaks, and Heat Shock Protein Expressions in Cells Derived from Human Eye

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In the near future, electrification will be introduced to heavy-duty vehicles and passenger cars. However, wireless power transfer (WPT) requires high energy levels, and the suitability of various types of WPT systems must be assessed. This paper describes a method for solving technical and safety issues associated with this technology. We exposed human corneal epithelial (HCE-T) cells derived from the human eye to 5.8-GHz electromagnetic fields for 24 h. We observed no statistically significant increase in micronucleus (MN) frequency in cells exposed to a 5.8-GHz field at 1 mW/cm² (the general public level in ICNIRP) relative to sham-exposed or incubator controls. Similarly, DNA strand breaks, and expression of heat shock protein (Hsp) Hsp27, Hsp70, and Hsp90N1 exhibited no statistically significant effects as a result of exposure. These results indicate that exposure to 5.8-GHz electromagnetic fields at 1 mW/cm² for 24 h has little or no effect on micronucleus formation, DNA strand breaks, and Hsp expression in human eye cells.

Acoustic Biosensing using Functionalized Microbubbles

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Functionalized microbubbles are investigated as a new platform for acoustic biosensing. In medical ultrasound, microbubbles of ultrasound contrast agents are injected to enhance contrast between blood and tissue. Microbubbles are not only good ultrasound scatterers: when placed in an ultrasound field, they act as non-linear resonators and we propose to exploit this for biosensing. Through finite element simulations, analytical modelling and acoustic characterization experiments we conclude that bioanalyte-binding events taking place on the surface of a microbubble generate measurable shifts in resonant frequency, detectable from near-field and far-field acoustic scattering. This sensing strategy overcomes the classic biosensing paradigm through a technology in which functionalisation of a fixed surface is not required, enabling acoustic *in-vivo* biosensing.

Conformal Stretch Sensors for Human Motion Sensing and Control

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Current strain sensors exhibit a trade-off between dynamic range and strain sensitivity; these sensors therefore are not suitable for applications that require both large strain and excellent signal resolution, such as gesture control for virtual and augmented reality or feedback for prosthetics. Shape-memory polymer (SMPs) coupled with thin films on stretchable elastomeric support substrates have recently emerged as fabrication platforms that improve strain sensor characteristics. By leveraging a commodity shrink-wrap film and novel lift-off process, we are able to achieve soft skin-mountable strain sensors with larger dynamic ranges (over 350%), high gauge factor with linear responses to strain (from 0-150%), smaller footprint size, and less hysteresis compared to other piezoresistive sensors [1]. We demonstrate that these sensors can resolve down to 5B0 resolution of the proximal interphalangeal (PIP) joint, which would enable gesture control for gaming and other motion sensing and control applications. In summary, the sensors demonstrate large dynamic ranges with linear response for simplistic correlations, low hysteresis for reliable data acquisition, and high strain sensitivity for improved signal resolution with a smaller footprint. These sensor qualities are attractive for applications that require tunable yet unobtrusive motion sensing and control.

A continuous Conductivity-Based Surface Analyzer and Multi-Analyte Biosensor for Biological Fluids

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See abstract

Development of a Multilayered Drug-Delivery Sheet that Allows Minimally Invasive Delivery to the Eye

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In this study, we aimed to develop a DDS sheet that can be injected and remained at the desired location for long-term drug release. The device is comprised of microfabricated layers made of photopolymerized tri(ethyleneglycol)dimethacrylate (TEGDM) and poly(ethyleneglycol)dimethacrylate (PEGDM). By adjusting the ratio of PEGDM and TEGDM, we can control the release of drug from the sheet and self-deployment of the sheets. We evaluated the drug release characteristics, self-deployment of the sheets and injection of sheets on to the sclera of the rabbit eye. As a result, this sheet enabled long-term locally drug release and could be delivered less-invasively on to the eye by using a syringe. This DDS sheet has great promise to less-invasive and efficacious treatment.

Magnetically Controlled Alginate Micromanipulators with Aligned Magnetic Nanorods

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Magnetic manipulation of micro- and millimeter scale robot-like particles has the potential to enable local, tissue specific delivery of therapeutics. Here we present alginate capsules loaded with magnetically aligned nanorods, and demonstrated the ability to move these capsules up inclined surfaces and across tissue surfaces via rotating magnetic fields. Additionally, we demonstrate the ability to load these capsules with small molecules, demonstrating payload release as the capsule is guided along a surface.

Liquid-Metal Microfluidic Portable Energy Transducer (LIMMPET)

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LIMMPET (LIquid Metal Microfluidic Portable Energy Transducer) is a dynamical electrostatic charge amplifier in a liquid-metal microfluidic architecture which represents a new approach to harvesting spurious electrostatic charge through pressure-driven flow of microfluidic metal droplets in a multiphase system. This sort of novel harvesting technique can allow for battery-free small device operation and be an enabling technology for wearable and implantable medical devices. Our theoretical analysis suggests that the energy harvesting technology we propose may offer an unparalleled conversion efficiency of over 95% - a tenfold increase compared to current standards - in an intrinsically scalable and flexible architecture. The small size and intrinsic scalability enable parallelization of the basic concept to yield a small footprint device that could be integrated into micro and nanotechnology for biological and medical applications. Specifically, in our system, LIMMPETb's parallel microfluidic channels carry an alternating pattern of insulating (oil) and conducting (mercury) liquids. A random, or intentionally seeded, initial charge imbalance between conducting drops is amplified by electrostatic induction as the droplets flow and capacitively interact within the serpentine channel. The charge is collected by the output terminals, which can be connected to a load, for immediate use, or a capacitor for storage. Results from our first prototype device show that we can consistently generate voltage across the connected 10 nF load capacitor. However the maximum potential difference produced was 6 V over two minutes, and the voltage growth rate varied from 25 mV/sec to 67 mV/sec. This corresponds to a maximum power output of 4 nW, not yet close to the theoretical maximum of 12 B5W for the device geometry. Because of this, we are currently testing an improved device that optimizes channel geometry and spacing and is expected to yield the predicted results in terms of power generation. If successful, such a small-footprint device could be integrated into the heel of a shoe and powered by human locomotion, enabling use in commercial and medical applications such as continuous glucose monitoring or as a wearable sweat sensor.

Improved Shunt Survival with MEMS-Enabled Ventricular Catheter in Treatment of Intraventricular Hemorrhage

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Brain hemorrhage is one of the most common and lethal forms of stroke affecting more than 2 million patients annually worldwide. In 45% of these cases, bleeding occurs inside the ventricles of the brain (intraventricular hemorrhage, IVH). IVH can lead to an even deadlier condition (50-80% mortality) known as post-hemorrhagic hydrocephalus (PHH, 40% of IVH) when blood clot forms and obstructs the circulation of cerebrospinal fluid (CSF)^{1,2}. For these patients, immediate neurosurgical interventional devices are typically required to remove excess blood and relieve elevated intracranial pressure (ICP). External ventricular drainage (EVD), ventricular reservoir devices, or implanted shunt systems are used to treat IVH and PHH; however, these drainage devices quickly becomes occluded with blood clots. Maintaining the functionality of implanted drainage devices is an important challenge in treatment of IVH and to prevent subsequent PHH. Here we demonstrate improved shunt survival by using smart self-clearing ventricular catheter with integrated magnetic microactuators that can combat blood-clot related obstruction ³.

Development of an Implantable Cell Culture Device for Retinal Diseases

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In this study, we aimed to develop a periocular implant device for long-term drug delivery for treating retinal diseases. We encapsulated genetically engineered cells that can secrete BDNF inside the periocular implant device. Utilizing the cells, long-term drug delivery is expected. We fabricated reservoir for cell culture. Then, we evaluated two types of 3D culture of ARPE cells: (1) the cells embedded in collagen gel, (2) the cells were cultured on polystyrene sheet. However, the cells could not survive for a long time in collagen gel. While, it is expected that cells can differentiate on PS sheets and form a monolayer structure, maintaining their in vivo physiological functions.

A Facile Microfluidic Approach to Create Microencapsulations for Cell Confinement

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It is important to achieve complete screening and analysis of hundreds of thousands of cells at high throughput. We present novel microcapsules made of poly(lactic-co-glycolic) acid (PLGA) to encapsulate the cells and provide single cell views. The cells thus encapsulated in microconfinements were not masked by the intrinsic heterogeneity of the cell population. The cell microencapsulations provided 3D cell containment chambers. The hollow microcapsules were fabricated using a simple polydimethylsiloxane (PDMS) microfluidic device. The PDMS device had Y-shaped channels through which cells were focused between flowing PLGA solution. The microcapsule cores contained cells with PLGA acting as an encapsulating membrane. The shapes of the microcapsules were controlled by altering the flow rates of the cell suspension and PLGA. Using this design to encapsulate cells fulfilled several often-conflicting criteria, such as permeability, stability, and biocompatibility. The suitability of this novel microenvironment formulation for live cell encapsulation was evaluated using human glioblastoma multiforme (hGBM) cells. To demonstrate an efficient encapsulation of 1-2 cells, we varied the flow rate of cells and PLGA solutions and observed a significant effect of flow rate on encapsulation. The cell viability was also evaluated post-encapsulation. The hollow PLGA microcapsules can be used for encapsulation of many cells and potentially developed into a point-of-care cell profiling device for diseases.

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