BIOE QUARTERLY

FALL 2018

THROUGH THE LENS

A LETTER FROM THE DEPARTMENT CHAIR

Dear Fellow Bioengineers and Friends,

Time flies, and suddenly we find ourselves at the end of this year. It has been a very exciting quarter. UCSD Bioengineering's national ranking moved up again to #2 by the latest US News and Reports! We had a remarkable BE Day, where we get to see the strong energy among our undergraduate students, alumni and even some middle schoolers interested in bioengineering!

In this quarterly newsletter we are showcasing Professor Gert Cauwenberghs, a pioneer at the interface of brain and electronics. Along the same angle, we are featuring Dr. Chul Kim, who has been doing his post-doctoral training with Dr. Cauwenberghs and will soon start his own research group as a new Assistant Professor, as well as Cognionics, a startup company spun off from Dr. Cauwenberghs' laboratory. A cluster of stories like this sets a nice example on how a Bioengineering professor can make broad impacts related to research, education and entrepreneurship. We also introduce Professor Adah Almutairi, an affiliated faculty and a long-time supporter of our graduate education. The story on Bryan Yeh would give you a very different perspective from a student who successfully navigate through our undergraduate program.

Finally, I would like to congratulate and celebrate the graduating class! As you move on the next stage of your career, I hope that you find what you have learned in (and outside) the UCSD classrooms empower you in your new adventure. I recently had several opportunities to meet with some of our highly successfully alumni graduated back in the 80's-90's. I can see you develop along that trajectory many years down the road, and share your success with your alma mater!

Cheers,

Kun Zhang
Professor and Chair

INTRODUCTION

Dear Readers,

A lens is a curious piece of glassware. When arranged in a particular order, lenses not only empower us to observe minuscule details, but also permit us to look to the greater universe beyond what is known. The field of Bioengineering likewise exhibits both microscopic and telescopic properties. On the one hand, some engineers painstakingly peruse diminutive features of the human body—such as the orientation of collagen fiber in arteries and the neural circuit in our brain—to better understand the form and function of these biological components in a microscopic level. On the other hand, based on new-found knowledge acquired through research, engineers design novel medications and devices to combat diseases, impacting the world beyond the Bioengineering community.

Our fall issue *Through the Lens: Technology In Bioengineering* celebrates professors and students whose research not only contributed to the pool of scientific knowledge, but also promoted human welfare via technological innovations. For instance, Professor Almutairi, featured in the Research section, explored the photo-responsive and chemical-responsive properties of nanoparticles. From the fruit of this investigation, she developed nanoparticles carriers that selectively delivered remedial agents to specific regions of the human body. While her initial research was nanoscopic in scale, its application in the drug delivery process could revolutionize the pharmaceutical industry. This example thus demonstrates the microscopic aspect of academic research and its telescopic, far-reaching influence on human welfare.

The accomplishments highlighted in the following articles share a similar story—each started at a small atelier, with dreamers who wished to change the world. Just like lenses that magnify microscopic objects and bring entities afar to our naked eyes, these bioengineers observe minuscule structures of biological lifeforms and bring the dreams of curing illnesses to reality via technological applications. We at Bioengineering Quarterly invite you to probe into the intricate field of Bioengineering through the lens of technology.

Best,

Chak (Julian) Ho
Deputy Editor-in-Chief

THE BIOEQ TEAM

Editor-in-Chief.....Vania Pena, Linda Lei

Deputy Editor-in-Chief.....Chak (Julian) Ho

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Interviews.....Michelle Tong

Spotlight.....Neve Foresti

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If you are interested in joining our staff, please contact us at ucsd.bioe.news@gmail.com!

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The Bioengineering Quarterly (BioEQ) is a student run publication that covers the people, the research, and the events that occur within the UC San Diego Bioengineering Department. For Fall 2018, we decided to examine the role technology plays in bioengineering.

STUDENT ORGANIZATIONS

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Biomedical Engineering Society

Our focus is to enrich the experience of undergraduate students interested in biomedical engineering through personal and professional development. We serve our members by offering opportunities to learn technical skills, network with industry professionals, and impact our surrounding San Diego community through outreach programs. We also offer a robust peer mentorship program, engaging our members year long with fun events and activities.

Facebook: UCSD BMES
Website: http://bmes.ucsd.edu/
Email: bmes.ucsandiego@gmail.com
Rep: Justin Burger

Bioengineering Graduate Society

Facebook: BEGS UCSD
Website: http://begs.ucsd.edu
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Rep: Clara Posner

This year for BEGS was busy with a variety of career building and industry exposure events, including seminars and panels in biopharmaceuticals, drug delivery, and patent law. These were respectively delivered by experts in their respective fields, including Dr. Julio Baez, a member of the Bioengineering Industrial Advisory Board, and Dr. Rhodes, the CEO of Drug Delivery Experts. The quarter eventually culminated with the annual Mock Qualifying Exams to prepare first and second year graduate students for their transition to candidacy. Throughout the quarter, we also held weekly bonding activities, including boardgame sessions, several hikes, and a now-annual Murder Mystery party.

International Society for Pharmaceutical Engineering

We at the International Society of Pharmaceutical Engineering (ISPE) strives to equip students with skills necessary to post-undergraduate careers and to bridge the gap between academia and industry. We offer programs that encourage students to step out of their comfort zones and to actively discover their career interest. For instance, our mentorship program pairs each participant with a professional from the biomedical industry, thereby exposing the former to the real working environment. Likewise, we partner with avant-garde firms such as Genentech to familiarize students with internship and career opportunities. All our endeavors serve as a monumental push that propels undergraduates to spread their wings and to soar toward a bright future awaiting them.

Facebook: ISPE
Email: ispe.ucsd@gmail.com
Website: http://ispeucsd.weebly.com
Rep: Alyssa Chiang, Connie Gean, Chak (Julian) Ho

SynBio

SynBio has solidified the 2018 team for the international iGEM synthetic biology competition. The interdisciplinary team is comprised of undergraduates tasked with wet lab, dry lab, design, and logistics - congratulations to: Michael Herron, Zhijian Li, Claire Luo, Anser Abbas, Yiqun Jiang, Ishan Goyal, Tran Tram, and Varun Govil!

Occasional socials and weekly journal club meetings were held to explore synthetic biology topics. Finally, former and current iGEM participants have been working to advise and mentor two prospective high school iGEM teams from Torrey Pines High School and Del Norte High School through conference calls.

Facebook: SynBio
Email: diybioucsd@gmail.com
Rep: Harrison Li

Engineering World Health

This year, Engineering World Health's four project teams have successfully submitted their finalized designs for the National Design Competition. The Oxygen Analyzer Team, led by Samika Shenoy, has created a battery powered oxygen analyzer for half the price of a traditional instrument to verify the effectiveness of zeolite oxygen concentrators in remote settings. The Solar Sterilization and Distillation Team, led by Jackie Olness, has designed an inexpensive parabolic mirror that can heat a modified pressure cooker to produce clean water and sterilize surgical instruments in clinics without access to reliable electricity. The Pneumonia-Relief Air Filtration Team, led by Ashley Freeman, created a brilliantly effective air filter that uses activated carbon manufacturable with standard household resources to clean dangerous particles from the air. Lastly, the Body-Powered Prosthetic Arm Team, led by Harleen Singh, designed a robust and 3D-printable arm that is inexpensive and easy to repair for refugees without access to other resources. These teams were able to present their work and EWH's first annual Project Exposition.

Facebook Group: https://www.facebook.com/groups/ewh.ucsd/
Email: ewh@ucsd.edu
Rep: Niranjanaa Jeeva

Undergraduate Bioinformatics Club (UBIC)

UBIC at UCSD represents our undergraduates who are studying in or interested in the diverse field of bioinformatics. Through a combination of events, programs, and projects our mission is to educate and contribute to the education and aspirations of every bioinformatics student at UC San Diego.

Facebook: https://www.facebook.com/ubic.ucsd/
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Rep: Arya Kaul

FEATURES

BIOENGINEERING DAY

By Aditi Vaidya | Features Writer

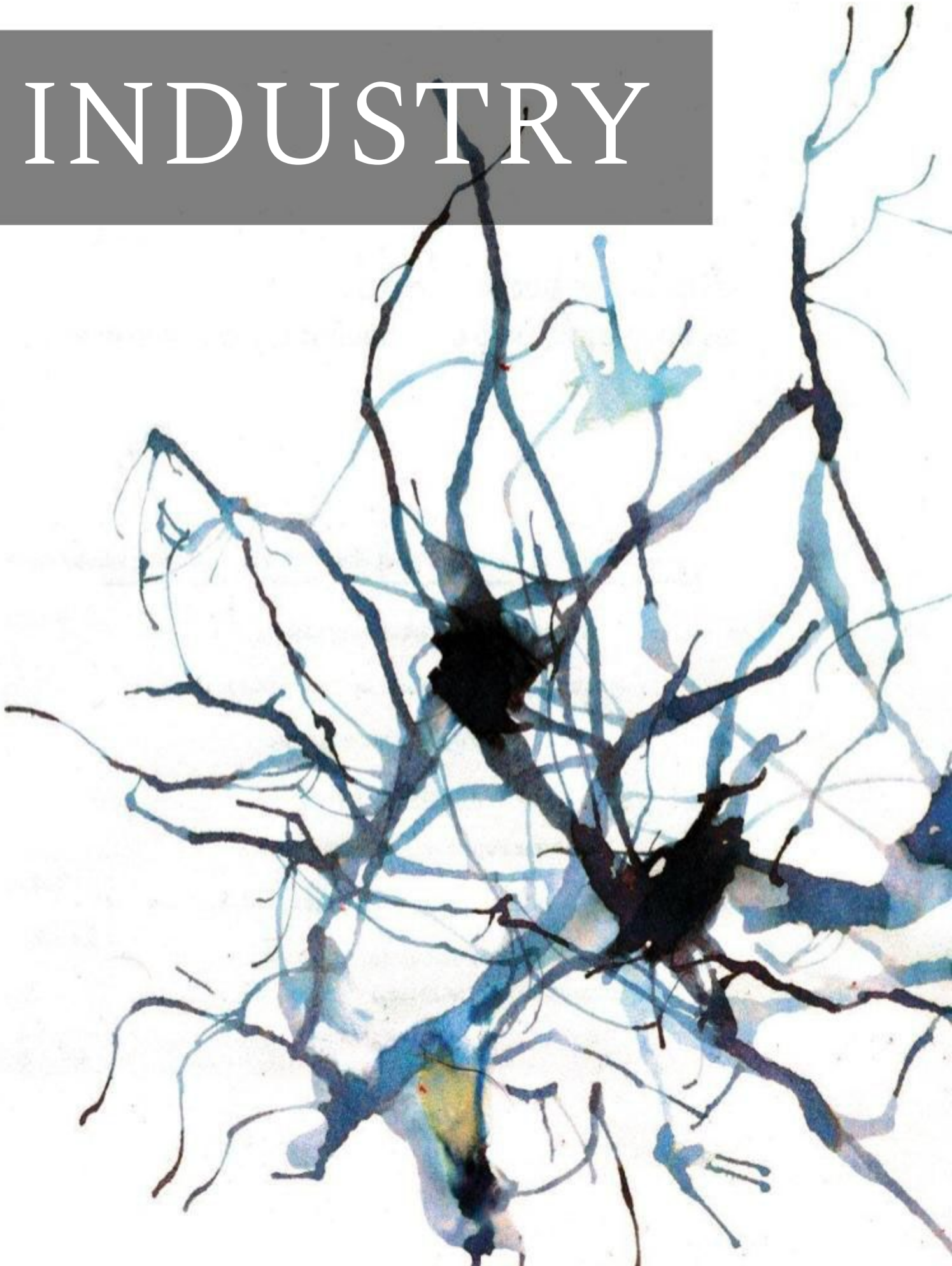
The culmination of a year's worth of discovery, innovation, and research occurred on April 27 at Bioengineering Day, the annual celebration of the field organized by the Biomedical Engineering Society. A day-long event at the Telemedicine Building that boasted speakers, industry demonstrations, and networking sessions, BE Day was the largest event of the year for students interested in the field to attend, learn from, and potentially network with leaders in academia and industry. Tasked with putting on such high-calibre event, the co-chairs of the event, Madinah Najib and Tong Jin, led a dedicated committee that worked all year to bring it together.

Although it was put together by a student organization, the event had close ties to UCSD's Bioengineering Department as well: some of the undergraduate senior design projects were featured as poster presentations. Many professors in the department also attended the networking luncheon, which featured opportunities to have close conversations with faculty and leaders in industry.

Emerging technologies, which are driving forces of biomedical research and innovation, were a highlight of the event; they were expounded upon by the speakers, displayed in industry demonstrations, and discussed during the networking reception. Dr. Craig Goergen, an assistant professor at Purdue University, gave the 50th Anniversary Distinguished Lecture: "Cardiovascular Imaging, Modeling, and Device Development." He showcased his work, complete with moving image models, on advances relating to greater accuracy in cardiac and vascular imaging techniques, which would allow for earlier disease detection. Furthermore, the industry demonstrations session was an apt example of the application of disease research to the production of life-enhancing technologies, featuring presentations from the companies Thermo-Fischer, Cognionics, SeaSpine, and Synthetic Genomics. Due to the exposition-like nature of the session, attendees got the opportunity to closely interact with representatives from the companies in a similar fashion to the networking reception.

The Telemedicine Building was booming with registered attendees, ranging from students to professors to representatives from multiple companies, rendering a professional air to the event. This allowed for the research and innovation to be presented in an enhanced manner to the over 400 attendees that converged throughout the course of its 8 AM to 5 PM run. By the end of the day, it was apparent that the union of technology and biology forms the crux of bioengineering as a whole, a fact that Bioengineering Day vibrantly displayed.

INDUSTRY



Flex sensor: dry sensor used for transmitting EEG signals through hair

Cognionics

By Vania Pena | Interview Writer

Cognionics is a small but ambitious startup company originating right from UC San Diego and from UCSD Alumni, Mike Chi, who is currently the CEO. The company is an innovative leader in dry electrode, mobile EEG (electroencephalography), and multi-modal physiological monitoring systems. Speaking on behalf of Cognionics are its Customer Service Representative, Dominic Suares and its General Manager, Spencer Linton. Dominic handles a variety of tasks ranging from sales to documentation while Spencer helps allocate resources throughout the company, making sure the research and production teams can handle their workload.

"We're a company of young people," Dominic explained "I think our average age is probably less than 25... so we're just a young startup of UCSD Alumni and I think that [when it comes to hiring] we've always specifically looked for students." Dominic explained that this method appeared to give them an advantage: "In our case, it's worked very well." Although larger companies may be looking for more experienced employees, the culture that surrounds a wide-eyed, fresh graduate is what Cognionics has been able to benefit from for nearly a decade.

Industry

Embodying UCSD's motto to break things better, Cognionics brings to the table game-changing dry, mobile headsets and improved physiological sensors. Traditional versions of wet EEG systems would require the application of electrolytic gels in order to penetrate barriers like hair and skin. With advanced sensor developments, engineers at Cognionics were able to create a dry EEG headset that are able to surpass these problems through a combination of technologies, including active shielding, high input impedance, and noise cancellation. Among Cognionics' impressive array of headset technologies are the Quick-20 and Quick-30, dry and wireless headsets that deliver high quality signals, and the HD-72, high density and versatile headset with channels for reading other physiological components such as ECG*, EMG**, respiration, and GSR***.

HD-72: Cognionic's high density, wireless, dry EEG headset

*ECG or EKG, Electrocardiography
**EMG, Electromyography
***GSR, Galvanic Skin Response

Furthermore, Cognionics widens the path to innovation with their development of the respiration sensor, replacing the traditional respiratory monitor belt which can be mildly intrusive to the wearer and needs to be cut to size. "We work a lot with sensor development, really the key to all of our devices is the sensors" Spencer commented. Cognionics boasts the development of the Drypad and Flex sensors that are able to efficiently (and comfortably) transmit an electrophysiological signal through dry skin and dry hair, respectively.

Drypad sensor: gel-less sensor used for transmitting through skin

Hydroflex Sensor (coming soon): sensor used for skin and hair

Dominic explained, "we look for people that want to learn basically, like at its core it's a personality fit." This emphasis of personality before skills is what separates a skilled individual from a skilled team member. At the end of the day, it's the way that people collaborate effectively with their colleagues, rather than how good at the work they are alone, that really makes them valuable employees. "Someone can have perfect skills and we just need them to be part of the team, part of the framework" Dominic added.

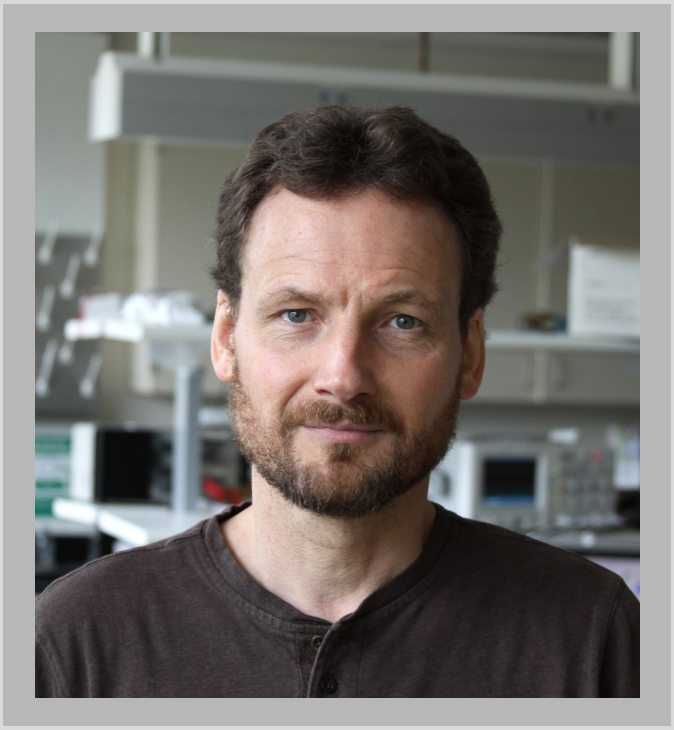
Furthermore, the successful engineers are those who show genuine interest in the company. Cognionics interviewers value a prospective employee's curiosity in the products and the bigger picture. When commenting tips to interviewees Spencer advises: "Come prepared, know a little bit about what Cognionics does. We try to be very open with all of our tech and we want people to almost come with questions already."

At the interview's end, Dominic emphasized that one quality of a successful Cognionics engineer is to be interested in multiple aspects of the job. "I think generally it's really helpful, we've seen engineers who come in who want to really understand everything about what we do, you know, who we sell to, what the driving motivations are for our products, and the engineers that come to this company who really look at how we fit into the marketplace and the bigger picture, those engineers end up doing very well in our company, and generally in most companies they'll do very well," Dominic explained. "From an engineering side," Spencer added, " it's very key to actually be very curious about what you're going to be doing or what you are doing."

Quick-30: a wireless, dry EEG headset developed by Cognionics

INTERVIEWS

Dr. Gert Cauwenberghs



Gert Cauwenberghs received his Master of Engineering in applied physics form the University of Brussels, Belgium, and went on to earn his M.S. and Ph.D. degrees in electrical engineering from California Institute of Technology, Pasadena. He has previously taught Electrical and Computer Engineering at Johns Hopkins University and Brain and Cognitive Science at Massachusetts Institute of Technology.

His current research covers two main areas: neuromorphic engineering and neural engineering with brain-computer interfaces. Neuromorphic engineering takes inspiration from neural biology, such as how the brain is organized structurally and functionally, to developing circuits and systems for neural computation. Neural engineering addresses interfacing silicon circuits with biology for recording and stimulating neural activity.

By Michelle Tong | Interview Writer

What sparked your interest in bioengineering?
"Within bioengineering, we are able to take inspiration from biology to building systems that are adaptive and resilient in interacting with their environment. While learning from biology, we are able to interface with the human body."

Why did you decide to come to UCSD?
"UCSD has an exemplary, unique collaborative environment that crosses between engineering and biology. In addition to leading the way in bioengineering the campus has great neuroscience, biology, and medical schools. Furthermore, in our backyard, we have great resources such as Qualcomm, Illumina, and other companies that are leading developments in information technology and biotechnology. I'm also an active part of the Institute

for Neural Computation here at UCSD, where scientists and engineering are working together to better understand how the brain works and how to better interface with the brain."

What was one challenge you faced in your research and how did you overcome it?
"The greatest challenge that faces the field of neuroengineering is how to approach modeling of brain activity and disease without a fundamental understanding of how the brain operates, let alone the functioning of the underlying fabrics. A solution to this problem is a long undertaking involving many disciplines that will require systematic approaches that are the hallmark of of bioengineering. One other major

challenge, from an instrumentation perspective, is recording signals from the brain without intruding on the mobility and comfort of the user. How can we record from the brain while the subject is freely moving around? We developed noncontact EEG recording that does not need ohmic gel contact and instead operates through capacitive coupling to the skin to acquire signals from the brain. This idea around non-contact sensing grew from academic exploration in the lab to industry-grade development at a spin-off company, Cognionics Inc. In this case, the challenge of developing non-contact interfaces turned into a business opportunity."

What applications are you most excited for from your research?

"I'm looking forward to applications in unintrusive, 24/7 monitoring, of brain activity for neurological monitoring. In the long term, we'd like to close the loop and implement neurofeedback, or feedback activity back to the brain for remediating problems. An example of our current efforts is an EEG hearing aid which records signals from the brain inside the ear. This would allow us to record signals from the brain in addition to sending signals to the brain in the form of sound. This presents a unique opportunity to close the loop by presenting sounds as a way to modulate brain activity for purposes such as relaxation, meditation or remediating disorders such as tinnitus. Despite our major challenge that we don't really know how the brain works, empirically we can develop control strategies in which we can modulate or adapt stimuli, such as auditory signals in ear-EEG, to modulate neural responses."

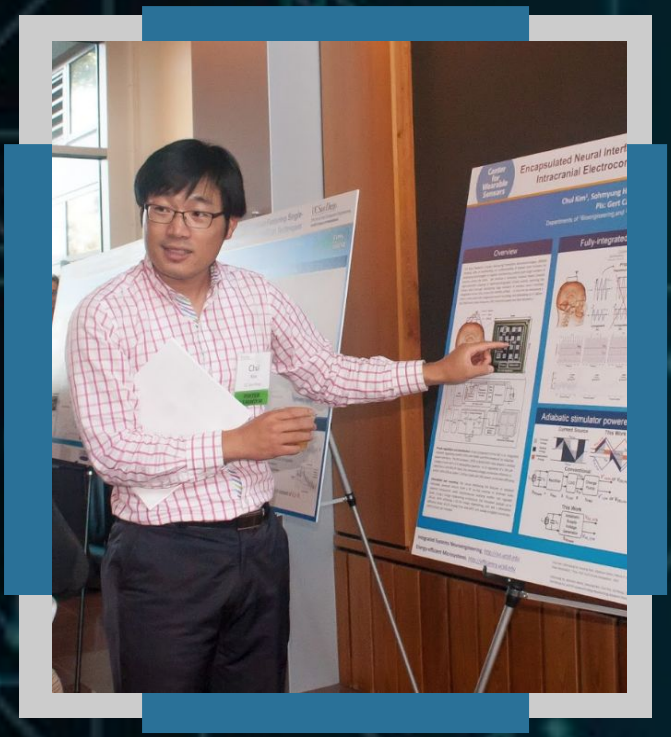
How do you think the bioengineering field is growing and where do you see it heading in the future?

"Our vision for the future of bioengineering is less of an invasive approach than surgery and devices implanted in patients bodies. Rather, we envision 24/7 monitoring and modulating activity of the body in ways to intervene only when necessary. Wherever feasible, we prefer to intervene in an minimally intrusive, and ideally non-invasive fashion because our body has great built-in defense mechanisms with exquisite immune machinery to solve its own problems. Bioengineering should help the process rather than replace that process.

We envision 24/7 monitoring of vital signals indicative of cardiovascular and brain activity to detect problems early before they escalate so that we can intervene before hospital visits for medical emergencies occur. We can stream that information to a caretaker who can remotely intervene if necessary. This is fundamentally different from the traditional centralized approach where sick patients and caregivers flock hospitals under acute medical conditions, and instead preventive and continuous healthcare is brought to and centered around humans in a much less obtrusive fashion."

Chul Kim: Postdoctoral fellow at UC San Diego

By Michelle Tong | Interview Writer



Chul Kim has completed his postdoctoral research at Gert Cauwenberghs lab at UC San Diego. He will soon be a assistant professor at the University of Waterloo, Canada. He has a Electrical Engineering B.S. from Kyungpook National University, South Korea and a Electrical Engineering M.S. from Korea Advanced Institute of Science and Technology (KAIST), South Korea. His research revolves around designing biopotential circuits to target next generation brain interfaces.

Bioengineering is such an interdisciplinary field, do you have any tips for navigating it?

"I have a background in EE, industrial experience in the semiconductor field, and I've completed my PhD here. Throughout my work, I've worked with neurologists, biologists, bioengineers, and neuroscientists. Everyone has their own jargon and backgrounds so it was challenging to communicate sometimes. By communicating with them, I realized their hardware needs for high input dynamic range and low energy sensors. While understanding different fields can be very challenging, it opens the door to new, valuable research opportunities and techniques. In my opinion, everyone should have one strong specialty. With that specialty we should communicate with many other areas so that we can improve other areas. By communicating with neuroscientists, I was able to discuss new problems and design a new system for them."

What was on challenge you faced in your research and how did you overcome it?

"The neuroengineering team created some implantable system for neural systems but they were big and power hungry. My major contribution to the system is implementing ultra low power, energy efficient miniaturized implants. Other research teams used off chip components, or discrete components that are not built on the chip, such as capacitors, resistors, and inductors. My research integrated everything into one chip so that it is more compact and the chip becomes an implantable system.

What applications are you most excited for from your research?"

"I made an implantable chip that detects brain waves, performs electrical stimulation, receives power wirelessly, and sends information wirelessly. A neural brain-machine interface with the designed chip has many clinical applications such as seizure detection and prevention. Moreover, this designed chip enables ultra low power sensing technique for Internet-of-Things."


SPOTLIGHT

STUDENT SPOTLIGHT: BRYAN YEH

By Neve Foresti | Spotlight Writer

Bryan Yeh is known in the bioengineering community for his dedicated leadership in the Biomedical Engineering Society as well as Tau Beta Pi (Engineering Honor Society). He is graduating this spring from UCSD from the Bioengineering: Bioinformatics program.

1. How did you become interested in bioinformatics?

As a freshman, I entered UCSD as a biotech major. During high school, I really enjoyed learning about engineering technology. Specifically, I was a member of my school's FIRST robotics team, and through that, I did a lot with computer science and software. I really enjoyed that experience because when I worked on robotics, I felt like I was a hacker.

When I applied for colleges, I thought computer science was a lot of fun, but I knew that bioengineering was the best way for me to make an impact. I got to UCSD, and I had a lot of friends who were computer science majors. Then I started thinking: maybe I should switch. I saw that our bioengineering department offers bioinformatics, which is basically my two passions combined: biology and computer science.

I started exploring bioinformatics with my upper division friends. I asked everyone about the program and careers, and I ultimately decided that bioinformatics was the program for me. I could do what I want with health, but also still do what I especially enjoy: coding. It took me a while to decide, but in the end I switched my sophomore year.

2. What has been your experience with getting industry positions with such a new and specific major like bioinformatics?

When I worked at Amazon, most of my coworkers were computer science graduates. I don't know if that's because they prefer computer science majors or if most of the people applying are computer science majors. I don't think there are that many people who can apply anyways because most universities do not yet have undergraduate bioinformatics programs.

I also want to mention that I haven't had difficulty getting computer science or bioinformatics positions even though I'm in the bioengineering department. A lot of people thinking about switching to Bioengineering: Bioinformatics ask if industry prefers computer science majors. However, hiring is a two-step process: getting the interview and completing the interview. During the process of getting the interview, it is possible that they could ask, "you're not a computer science major; why should we choose you?" But I think it's possible to supplement that doubt in many different ways, like project teams, lab experience, or being a CS tutor. Once you get the interview, your major does not matter. At least for entry level positions, it's just a matter of: can you do the job? You learn enough in the bioinformatics program that you can learn anything you want related to computer science.

3. What do you see yourself doing after graduation?

I'm still trying to figure that out myself, but would like to continue my dream of making a big health impact with computer science. I will work in industry for a few years, and maybe after I figure out exactly which field I want to work in, I will go back for my masters degree. Right now I know I really want to do machine learning. I'm just not sure if I want to do that in industry or academia.

Now I've gotten really interested in machine learning and neural networking. I've taken a couple machine learning (ML) courses, and I think that now I want to take some sort of ML-approach to biology. One of the reasons why I really like CS is that there are many tools that they've gotten really good at making. It would be really great to leverage all this computational power and apply it to biology problems. I would like to get involved with either that or designing new machine learning techniques inspired from biological phenomena like the brain.

4. What were some of the most valuable things you learned during your internships at Amazon and Illumina?

First, I got to know what life is like after graduation. What you do in school is not really what you do for the rest of your life, so it's really key to do these internships and ask: will I enjoy doing this from 9-5 every day? After my internship, I decided that I can.

Working at a large company, like Genentech and Amazon, has many benefits. You get to work with a lot of data and enormous systems, and there's better mentorship because there are a lot of people whom you can ask for help. You also get to learn how to work on a large-scale project. However, sometimes you might feel like you're a small cog in a big machine. I was working on a very particular project for a specific team. It made me ask myself if I want to have a job where I can make more of an impact.

When I worked at Illumina, which is a smaller company than Amazon, I felt like I made a bigger impact because I examined variance detection in cancer cells. If there are more mutations on the outside proteins, the immune system won't recognize that cancer cell, meaning that new drugs won't be as effective.

5. What is a particularly memorable experience from your time as a bioengineering student?

This fall quarter, I took BENG 193 (Clinical Bioengineering), and this was an amazing experience because I had the opportunity to watch a lot of surgeries. I was really worried when I was applying because at the time, I did not understand how bioinformatics could relate to the surgery room. However, now I believe that soon bioinformatics and computer science will have a really big impact in the medical industry. Less and less will we have doctors, and more and more will we have robots and algorithms. Eventually, this change will occur in the surgery room as well. The future is there, so it's good for me to get this experience from BENG 193. This experience showed me what types of problems surgeons have and allowed me to think about how I can solve those problems with bioinformatics and computer science.

amazon illumina®

RESEARCH HIGHLIGHTS

Research Highlight: Dr. Almutairi

By Michael Hu | Research Highlight Writer

Bio: *Professor Adah Almutairi attended Occidental College for her bachelor's degree before completing her PhD at UC Riverside, both with a focus on chemistry. She then moved to UC Berkeley for her post-doctoral work, before joining the Skaggs School of Pharmacy at UC San Diego in 2008. Presently, she also holds appointments in departments of Nanoengineering and Radiology, and is the current director of the Center of Excellence in Nanomedicine.*

The variety of available pharmaceuticals has expanded greatly during the last several decades, and has been aided more recently by developments in machine learning[3] and a resurgence of natural products[6]. However, the costs of development and approval remain high, averaging over $800 million per drug[4]. Moreover, many drugs experience issues of localization or clearance, and nearly all are restricted to specific concentration ranges for optimal pharmaceutical effectiveness[5]. In such cases, traditional methods such as intravenous injections and oral deliveries are non-viable, and the controlled delivery of the drug itself becomes a fundamental challenge.

To address this issue, the Almutairi Lab has developed an array of biocompatible nanoparticle carriers capable of selectively delivering therapeutics under controlled conditions. For instance, in 2012, researchers under Professor Almutairi synthesized a polymeric nanoparticle capable of releasing cargo when exposed to hydrogen peroxide (H_2O_2), a compound produced at low levels within the body, often in regions of inflammation. Chemically, the polymer contains a set of boronic ester groups, which oxidize in response to H_2O_2 and prompt degradation of the overall structure[2] (Figure 1).

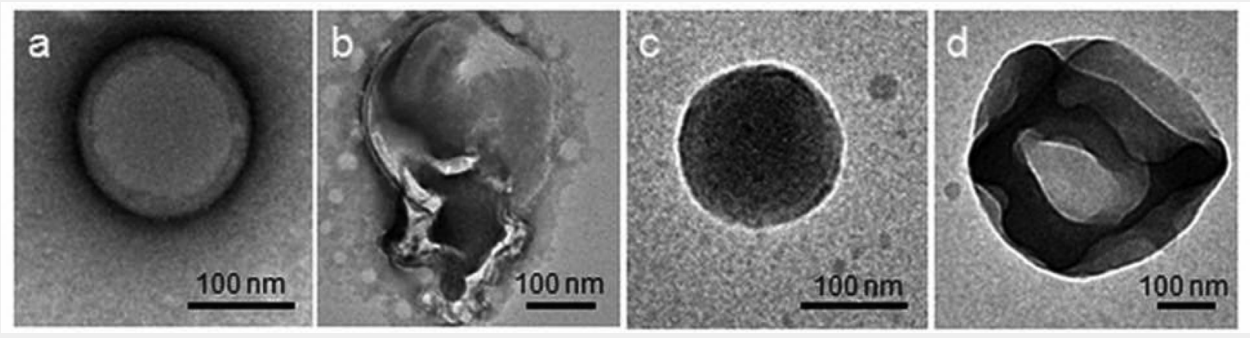


Figure 1: Nanoparticle carriers experience stability in PBS (A and C) but degrade when exposed to H_2O_2 (B and D).

Nanoparticles were confirmed to be biocompatible, stable in water, and responsive to biological concentrations of H_2O_2 as low as 50 uM. In addition, the byproducts produced following degradation were non-toxic[2]. In general, H_2O_2 is produced at high levels within the body in regions experiencing inflammation, which occurs in afflictions such as arthritis and chronic obstructive pulmonary disease. As such, these nanoparticles may serve as a potential method for delivering anti-inflammatory drugs.

In addition to delivery vehicles that exhibit selective release under specific biological conditions, the Almutairi Lab has also formulated vehicles capable of responding to external stimuli. Historically, many attempts have been made to engineer therapeutic carriers that are able to release cargo in response to light, with most efforts focusing on the use of UV-responsive or IR-responsive polymers. Notably however, UV-responsive polymers are applicationally limited by the low penetration depth of UV wavelengths[7]. In contrast, IR wavelengths tend to have higher penetration, but far fewer materials are IR-responsive to begin with[7]. To address such issues, the Almutairi Lab has designed several novel systems that grant IR-responsiveness to materials that are ordinarily IR-insensitive. One of these systems consists of polymer nanoparticle carriers that are completely non-photoreactive. However, by using near-IR light waves to heat the water encapsulated in the nanoparticle, a phase-transition is induced in the polymer, allowing for the contents to diffuse through its surface[8] (Figure 2). A similar system has been also designed using polymers that swell and release contents when exposed to visible light[1], and successful release of anti-inflammatory drugs was achieved with *in vivo* mouse models[1].

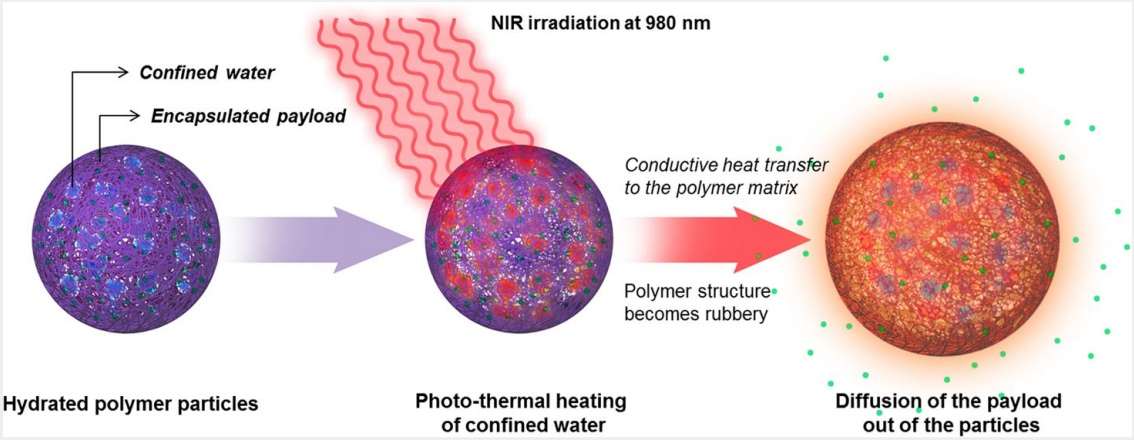


Figure 2: IR-induced release in non-photoresponsive polymer carriers via heating of encapsulated water.

In another variant, Professor Almutairi's research group generates an IR-responsive carrier by filling a a UV-responsive polymer with upconverting nanoparticles (UNCPs). UNCPs are materials with unique photoresponsive properties that allow them to absorb IR wavelengths, but emit UV wavelengths in response. By encapsulating them within a UV-responsive carrier, IR wavelengths can be used to induce UV-emission from the UNCPs, resulting in degradation of the UV-responsive carrier[7] (Figure 3).

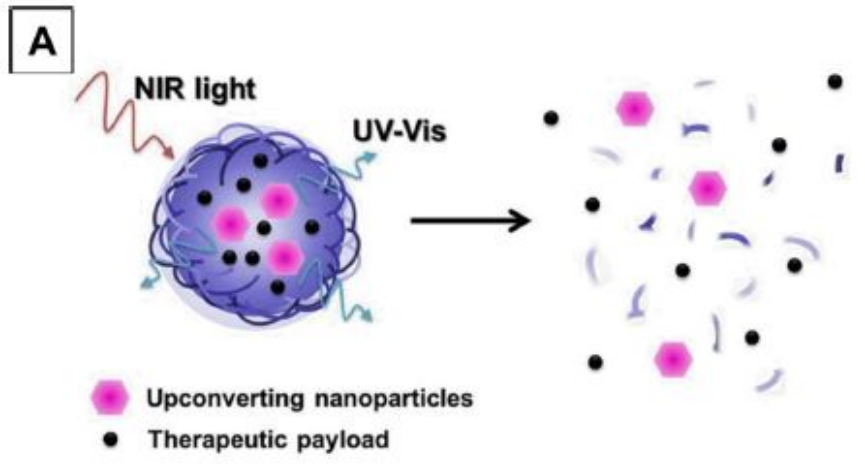


Figure 3: IR-induced release in UV-responsive polymers using UNCPs. IR light is absorbed by UNCPs, which release UV-wavelengths in response. UV wavelengths are subsequently absorbed by the surrounding polymer, causing degradation.

In summary, the Almutairi Lab has designed a variety of novel nanoparticles capable of degrading in response to various stimuli, ranging from hydrogen peroxide to IR wavelengths. While clinical viability of these systems has not yet been confirmed, the proof-of-concept work achieved by Professor Almutairi demonstrates successful translation of fundamental materials-engineering to a biological application.

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ACKNOWLEDGEMENTS

A LETTER FROM THE EDITOR-IN-CHIEF

Dear Readers,

It is our immense pleasure to present to you our fall and final installment of the 2018 year. As the last days of the month trickle by, it is a time of reflection and recognition of not only the fruit of our labors, but also the things that were instrumental in our triumphs.

In light of our successful publication, I would like to personally acknowledge and thank our enthusiastic department heads and officials, for their continued and avid support of our organization, our hard-working staff, for their patience and flexibility as we continue to build and expand our ambitious establishment, and to you, our keen readers, whose interest alone helps fuel the success of our growing newsletter.

Advancing forward, I have only the warmest of wishes for you all in this coming new year and the expectation that we can again capture your interest through our pages. Thank you for joining us as we peer *Through the Lens* of our shared passion, and we hope to see you here again soon!

Best Regards,

Vania Peña
BioEQ Editor-in-Chief

STAFF NOTE

All of us at the BioEQ would like to thank:

The Bioengineering Department for their overwhelming support of this project, Dr. Geert Schmid Schoenbein, Dr. John Watson, Dr. Kun Zhang, and Omar Vasquez for their ideas and suggestions. The Biomedical Engineering Society (BMES), The International Society of Pharmaceutical Engineers (ISPE), Undergraduate Bioinformatics Club (UBIC), SynBio, Bioengineering Graduate Society (BEGS), Engineering World Health (EWH) for their help in publicizing and sponsoring the BioEQ, and The Jacobs School of Engineering.

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