
20
20 YEARS OF EXCELLENCE
Department of Biomedical Engineering
COLUMBIA | ENGINEERING
2000–2020
2020 BME
SENIOR DESIGN DAY
A VIRTUAL EXTRAVAGANZA!
COLUMBIA UNIVERSITY
MAY 7, 2020 | 10AM - 2PM

HOSTED BY

Aaron Kyle, Ph.D.
Columbia University

Arthur Autz
Columbia University

JUDGES

Robert Allen, Ph.D.
Einstein Medical School and Montefiore Hospital

Teresa Chen, Ph.D., J.D.
Columbia University

Krista Durney, Ph.D.
TARA, Inc.

Bryan Grulke, M.B.A.
Volcano Capital

Stephen Alexander Lee, M.S., M.Phil.
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Joan José Martínez, Ph.D.
Columbia Tech Ventures

Kacey Ronaldson-Bouchard, Ph.D.
Columbia University;
TARA Biosystems

Rami Said, P.T., D.P.T., M.Eng., O.C.S.
Columbia University
Physical Therapy Faculty Practice

Katherine Strong
Johnson & Johnson

Sabriya Stukes, Ph.D.
The City College of New York

AGENDA

10:00 a.m. **Project Pitches**

Design Teams (in presentation order)

- Gash Guardian
- Valera IUD
- Circuvent
- NeuroTrak
- ViveSense
- Solair
- ABW
- Get Pumped
- You-V Safe
- Clear Vision
- Mask On

12:00 p.m. **Break**

12:15 p.m. **Project Team Zoom Rooms**

12:45 p.m. **Judge Deliberations**

WELCOME

Department of Biomedical Engineering
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20 YEARS OF EXCELLENCE
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Aaron M. Kyle, Ph.D.
Columbia University

Arthur Autz
Columbia University

2020 BME Senior Design Day

Welcome to the 2020 BME Senior Design Day, held as a virtual event for the first time since its inception as part of the Columbia Engineering Senior Design Expo in 2014. This cornerstone event is an exhibition of the Senior students' design efforts. Given the current health crisis, we had to shift the end expectations of our projects, but we still have compelling needs, prospective solutions, and business plans that the BME Designers will present to our distinguished panel of judges in a pitch-style event.

We are excited to celebrate the hard work that our undergraduates have done as they complete their Biomedical Engineering studies at Columbia!

TEAM #1: GASH GUARDIAN

Sofia Barbosa, Brailey Faris, Kelsey Gray, Kevin Park, Anya Volter

58% of Americans experience or know someone who has experienced gun violence. Exsanguination for the average adult happens within four minutes of injury, leading to 56% of gun-related fatalities occurring before a victim reaches a hospital. This is largely attributable to untrained bystanders' inability to stop bleeding. There are effective solutions to treat gunshot wounds, but they rely on pre-existing expertise or physical abilities. In case of a shooting, civilians need an easy-to-use device to mitigate blood loss until emergency medical care arrives. We have created a user-friendly device that mitigates blood loss by creating an encapsulating seal around a wound. A silicon-plastic cup loaded with a coagulating material covers the wound and a seal is created around the wound, forming a space to restrict blood loss. The silicone attachment conforms to body curvature, making the device applicable to a variety of body locations. Initial testing demonstrates that the seal is successfully established within seconds and mitigates blood loss at physiological levels over seven minutes, which could be the difference between life and death for a gunshot wound victim awaiting medical care.

Advisor:

Clark Hung, Ph.D.
Professor of
Biomedical Engineering;
Chair of Undergraduate Studies

Team #2: Valera IUD

Hilme Athar, Darren Dong, Elisa Fang, Alex Kim, Lillian Wang

The intrauterine device (IUD) is the leading form of reversible contraception, with over 99% effectiveness and 168 million users worldwide. However, current IUD options have a one-size-fits-all shape and size that results in IUD expulsion from the uterus in up to 10% of users. IUD expulsion often goes unnoticed, leading to ineffective contraception and high risk of unplanned pregnancy. IUD users need a novel IUD design that remains in the uterus regardless of intrauterine forces and variations in uterine size and shape. Our solution, Valera IUD, solves the problem of IUD expulsion. Valera IUD is a blossom-shaped IUD which conforms to the uterus upon deployment and can decrease expulsion rates through a more adaptable fit. Initial prototype testing shows that our design is able to take on a wider range of conformations than current market IUDs and withstands uterine forces at levels comparable to existing IUDs, making the Valera IUD a promising approach to mitigate IUD expulsion.

Advisors:

Nandan Nerurkar, Ph.D.
Assistant Professor of
Biomedical Engineering

Kristin Myers, Ph.D.
Associate Professor of
Mechanical Engineering

DESIGN TEAMS

Team #3: Circuvent

Abhishek Chakraborty, Chandana Golla, Audrey Lee, Qiyue Peng, Mojde Yadollahikhales

The recommended treatment for a subset of mechanically ventilated COVID-19 patients is to place them on their belly. This practice is called prone positioning therapy; however, the manipulation of the endotracheal tubing (ETT) during repositioning presents the clinical challenges of (1) being dangerously kinked or dislodged, (2) being difficult to work with during emergency situations, and (3) increasing potential exposure of health workers to aerosolized infectious agents. Our solution can be directly connected to the mechanical ventilator and consists of a loop with ports throughout its circumference to facilitate connections to the ETT in a variety of patient positions. When a patient must be rapidly flipped, the patient remains intubated while the ventilator and vacuum hoses can be quickly re-positioned, and the patient rotated without requiring complete reconstruction of the entire apparatus. Our solution effectively protects patients and health care workers from dislodgement of the ETT and enables rapid medical intervention, while minimizing the risk of exposure to healthcare providers.

Advisor:

Katherine Reuther, Ph.D.
Senior Lecturer, Design Innovation and
Entrepreneurship, Dept of Biomedical
Engineering; Director, Master's Studies

TEAM #4: NEUROTRAK

Brandon Cuevas, Abhinav Kurada, Panagiotis Oikonomou, Juan Rodriguez

Epilepsy is a neurological disorder that affects over 65 million patients worldwide. Currently, the cycle of care for epilepsy is hamstrung by physician's over-reliance on inaccurate self-reported seizure data for monitoring patients outside-the-clinic. Over 85% of seizures go undetected in patient self-reporting. As a result, physicians often do not have sufficient data to confirm whether the medication they prescribed is effective in reducing seizures, leading to millions of patients experiencing a multi-year lag between initial diagnosis and optimal treatment. NeuroTrak aims to address this need by designing an outpatient solution to detect and differentiate focal onset with impaired awareness seizures (FIAs), the most common seizure subtype. Our wireless EEG system continuously gathers patient data, streams this biosignal to the patient's phone, and classifies this EEG data in real-time. Through our Residual Neural Network technology, Neurotrak will quantitatively inform clinical decisions through its 77% FIA detection and 85% seizure differentiation accuracy.

Advisor:

Katherine Reuther, Ph.D.
Senior Lecturer, Design Innovation and Entrepreneurship, Dept of Biomedical Engineering; Director, Master's Studies

DESIGN TEAMS

TEAM #5: VIVESENSE

Benji Greenfield, Dvora Leibowiz, Rosy Li, Peyton Peng, Jeremy Perna

A growing fraction of the global population faces infertility issues. Nearly half the cases of infertility are attributable to the male's reproductive system; treatments are often delayed due to the flawed assumption that the female partner is the infertile. Many men, including those who are recommended by physicians, do not seek reproductive healthcare because tests are costly, inaccessible, and socially awkward. Current at-home test kits are not accurate or readily interpretable by users. ViveSense presents a comprehensive, digital, at-home solution for aspiring fathers. A user collects a semen sample that he inserts into a cell-phone add-on optical system that captures video of the sample. Our image processing algorithms analyze the video and calculate key sperm health metrics. A cell-phone application outputs the results to the user and monitors health over time, providing an accurate, easily interpreted assessment of sperm health.

Advisor:

Qi Wang, Ph.D.
Associate Professor of Biomedical Engineering

Team #6: Solair

Lynn Bi, Bunmi Fariyike, Asad Saleem, Chris Shen, Karina Yeh

According to the World Health Organization, lower respiratory infections are the leading cause of death in low-income countries. Moreover, the co-morbidity of these diseases with the novel coronavirus has and will continue to devastate countries in all developmental phases. Studies estimate that 55% of these deaths could be prevented by providing consistent access to oxygen with breathing assist devices. However, current oxygen delivery methods are insufficient, requiring either cumbersome oxygen cylinders or expensive, high-maintenance, and electricity-dependent oxygen concentrators. Solair aims to provide a low-cost oxygen source with off-grid functionality and the necessary robustness for low-resource and/or emergency settings. We accomplish this by modifying the design of current concentrators to include pneumatic instead of electric valving components and by adding a solar-powered charging module. Computational simulations and in silico calculations demonstrate that Solair's novel pneumatic valve system and partially solar-powered paradigm show promise for generating oxygen of comparable quantity and purity to that of standard concentrators.

Advisor:

Kristin Myers, Ph.D.
Associate Professor of
Mechanical Engineering

Team #7: ABW

Michelle Borovskoy, Sam Jennings, Carlos Perez, Milcy Perez, Kylee Sullivan

IV infiltration and extravasation are complications that occur when fluid from a peripheral IV is not delivered into a blood vessel but instead leaks into the surrounding tissue. If undetected, severe tissue damage may occur. It is estimated that there are about 47.8 million cases in the U.S. each year. Diagnosis of such events is reliant on medical staff observation of the area surrounding the IV injection site. The lack of standardized, quantitative, continuous monitoring contributes to the diagnostic deficit, leaving IV patients susceptible to inadequate therapy or injury. Our proposed solution enhances medical staff's observational capability by detecting swelling, temperature, and discoloration at the IV site that are indicative of infiltration or extravasation. Our initial testing shows that our sensors have sufficient sensitivity for early detection of an infiltration event.

Advisor:

Christoph Juchem, Ph.D.
Associate Professor of
Biomedical Engineering

Team #8: Get Pumped

Michael Anne Bolene, David Carratu, Maria Geraghty, Hunter Hasley, Sarah-Jane Lynn, Kelsey Troth

Every day, up to 49% of women in America make a conscious decision to slip on a pair of painful high heels, which disrupt the natural mechanics of the body leading to long-term effects such as toe abnormalities, bunions, nerve damage, and arthritis. Although 71% of women report pain from their heels, they continue to wear these uncomfortable but fashionable accessories. Current solutions such as insoles, moleskin, or detachable heels only provide temporary relief from the inherent design flaws at the root of the problem. Get Pumped offers a revolutionary high heel carefully attuned to biomechanical stresses on the body, designed and tested with the goal of improving gait patterns and reducing damage through the use of mechanical dampeners in the heels, non-Newtonian soles, and a continuous linear incline build. We offer a biomechanically-sound alternative for health-conscious people without sacrificing the aesthetic appeal of high heel shoes.

Advisor:

Gerard Ateshian, Ph.D.
Andrew Walz Professor of
Mechanical Engineering &
Professor of Biomedical Engineering

DESIGN TEAMS

Team #9: You-V Safe

Nitya Hinduja, Jordynn Lurie, Mariel Ogurek, Lola Omokanwaye, William West

The current COVID-19 outbreak has mandated extended use of N95 masks. Medical personnel may touch their mask more than 25 times during extended use, introducing the possibility for contact transmission of pathogens between patients or during doffing of their masks. Current mask decontamination methods take too long and require healthcare workers to remove their mask. We present a decontamination hood for healthcare facilities that will allow for safe extended mask use by decontaminating N95 masks throughout the course of a day, reducing the risk of spreading pathogens and mask degradation. The resultant design superposes 222 nm UVC sources, allowing uniform spectral irradiance within a 10 cm region of interest for 30 second exposure periods. This wavelength and dosage have been proven to effectively decontaminate N95 masks and retain mask integrity while being safe for prolonged human exposure. Healthcare workers can clean their masks without removing them and with minimal disruption to their daily routine.

Advisor:

Barclay Morrison III, Ph.D.
Professor of
Biomedical Engineering

TEAM #10: CLEAR VISION

Steven Bessler, Jonathan Kapilian, Michael Kirschner, Moshe Willner, Lekha Yesantharao

During laparoscopic surgery, the laparoscope's lens can be obstructed by debris, blood, interstitial fluid, or condensation. The surgeon must remove the scope from the body and clean the lens approximately twelve times per hour of surgery. This prolongs procedure time and costs the health-care system approximately $255.3M annually. Many solutions fail to clear obstructions, or have limitations such as manual intervention, reduced dexterity, increased bulkiness, or sutured components. Therefore, there is a need for a way to maintain a clear visual field during laparoscopic surgery with minimal disturbance to the surgeon's concentration. Clear Vision is a novel solution to this problem. The small cap rests on the lens of the laparoscope and detects obstructions using an infrared sensor. This initiates bursts of pressurized saline and CO_2 to clear the obstruction. Initial prototyping and testing demonstrated effective detection and efficient cleaning without interruption to the surgical procedure.

Advisor:

Nandan Nerurkar, Ph.D.
Assistant Professor of
Biomedical Engineering

DESIGN TEAMS

TEAM #11: MASK ON

Grace Kim, Yujin Kim, Christina Li, Helen Xu, Hangwei Zhuang

N95 respirators are crucial in protecting health care workers (HCWs) from potential COVID-19 transmission. The personal protective equipment shortage has forced HCWs to decontaminate and reuse respirators. However, mask fit degrades quickly with 20% failing fit tests after five decontamination cycles, exposing HCWs to 30% more ambient aerosols than properly fitted masks. Infected HCWs put themselves, colleagues, and patients at risk. Currently, no solutions improve respirator fit to extend its use. Therefore, a solution adaptable in-hospital that prevents air leakage when HCWs wear respirators is needed. We propose an elastic harness that fits over and around a respirator, with straps holding the mask flush against the face. An air-filled flap folds under the nose bridge for improved seal and comfort. A fluorescent tracer test will quantify our solution's impact and the total inward leakage (TIL) of the modified mask will be quantified using an OSHA-approved aerosol test.

Advisor:

Clark Hung, Ph.D.
Professor of
Biomedical Engineering;
Chair of Undergraduate Studies

MEET OUR JUDGES

Robert Allen, Ph.D.
Einstein Medical School
and Montefiore Hospital

Robert Allen is an Assistant Research Professor in the Department of Obstetrics & Gynecology and Women's Health at Einstein Medical School and Montefiore Hospital. He performs research and helps train obstetric providers in mechanically difficulty births using birthing simulators. This training has already helped reduce incidence of neonatal birth injuries. For 30 years, Dr. Allen directed senior design programs in mechanical and biomedical engineering. He has authored or co-authored over 60 journal publications in design and mechanics, over a dozen book chapters, and has generated more than $3 M in external support for research and teaching. He is principal inventor on three issued patents. A retired professional engineer, he is a co-founder of Birth Injury Prevention, LLC, a company dedicated to improving maternal-child health.

Teresa Chen, Ph.D., J.D.
Columbia University

Teresa Chen joined the Office of the General Counsel (OGC) in February 2014 as an Associate General Counsel. As a member of the OGC's patent and licensing group, she manages patent prosecution in the life sciences area. Ms. Chen comes to Columbia with specialized experience in patent law, previously working as a patent agent and as an associate at the law firm of Winston & Strawn from 2006 to 2014. Prior to joining Winston, Ms. Chen was an assistant professor at Albert Einstein College of Medicine.

Ms. Chen received a Ph.D. in Genetics and Development from Columbia University and a J.D. from Fordham Law School. She is admitted to practice law in New York State and before the U.S. Patent and Trademark Office.

Krista Durney, Ph.D.
TARA, Inc.

Krista Durney, Ph.D. is the Project Manager at TARA, Inc. Dr. Durney was trained in the laboratories of Gerard Ateshian, Ph.D. and Clark Hung, Ph.D. at Columbia University, where her graduate research focused on musculoskeletal biomechanics and tissue engineering. Krista was trained in financial markets and business valuation at Goldman Sachs where she covered the pharmaceutical and biotechnology sectors as an equity research fellow.

During her graduate studies, Krista's entrepreneurial spirit has led to her involvement in bringing two technologies out of the university through funding from Columbia's Biomedical Technology Accelerator and Cisco's Global Problem Solver Challenge. She obtained both her Bachelor and Master of Engineering degrees from The Cooper Union in NYC (Inter-Disciplinary and Mechanical Engineering), and her Ph.D. from Columbia University (Biomedical Engineering).

Bryan Grulke, M.B.A.
Volcano Capital

Bryan Grulke is a Partner at Volcano Capital, an early stage health care venture capital firm based in New York City. Volcano Capital focuses on the medical device sector and has made 15+ investments to date. Prior to joining Volcano Capital, Mr. Grulke worked as a strategy consultant at Bain & Company and in the corporate strategy group at Philips International. Mr. Grulke graduated from Harvard Business School and Duke University, summa cum laude with a B.S. degree in Economics.

Stephen Alexander Lee,
M.S., M.Phil.
Columbia University

Stephen Lee is a Ph.D. student in the Ultrasound Elastography and Imaging Laboratory at Columbia University. His work specifically focuses on the intersection between neurobiology and engineering and their applications to new, non-invasive therapeutics. His research has been presented at several international conferences, led to several patents, and has won the 2019 Institute of Electrical and Electronics Engineers (IEEE) IUS student paper award. In addition to academic research, Stephen also holds affiliation with the MANAI institute of science and technology in Japan where he leads a research program and workshop with international high school and middle schoolers.

Joan José Martínez, Ph.D.
Columbia Tech Ventures

Joan José Martínez is a technology licensing officer at Columbia Technology Ventures, Columbia University's tech transfer office that manages patenting and licensing of university inventions. In his four years at CTV, Joan has managed over 200 inventions and negotiated over 50 license agreements with industry partners. Before technology transfer, Joan completed his doctorate in bioengineering at University of Utah, with a focus on neural interfaces.

Kacey Ronaldson-Bouchard, Ph.D.
Columbia University;
TARA Biosystems

Dr. Kacey Ronaldson-Bouchard is an Associate Research Scientist at Columbia University focusing on biomedical engineering and "patient-in-a-dish" disease models. She is also the co-founder of TARA Biosystems, which offers physiologically relevant human "heart-on-a-chip" tissue models for cardiac risk assessment and drug discovery applications.

Rami Said, P.T., D.P.T., M.Eng., O.C.S.
Columbia University
Physical Therapy
Faculty Practice

Dr. Rami Said is the Director of the Columbia University Physical Therapy Faculty Practice in Tarrytown and an Instructor of Rehabilitation and Regenerative Medicine at Columbia University Irving Medical Center. As a Board-Certified Orthopedic Clinical Specialist, he specializes in delivering individualized physical therapy treatment to patients of all ages with a wide range of musculoskeletal, sports, and spine injuries in order to maximize function, improve quality of life, and restore the participation of recreational, functional, or professional activities. As an Instructor of Rehabilitation and Regenerative Medicine for the Doctoral Program in Physical Therapy, he participates in the instruction of Gross Anatomy, Kinesiology, Biomechanics, Orthopedics, and Sports Rehabilitation. His areas of interests include creating a movement-based injury risk profile for athletes of different sports, the utilization of technology to assess biomechanical forces and stress applied to the body during therapeutic exercise, and the delivery of physical therapy education. Dr. Said received his Bachelor & Master of Engineering degrees from The Cooper Union for the Advancement of Science & Art, with a focus in Biomechanics and received his Doctoral Degree in Physical Therapy from Columbia University.

JUDGES

Katherine Strong
Johnson & Johnson

Upon graduating from Columbia University, Katherine accepted a position at Johnson & Johnson's Design Studio in New York City. The J&J Design Studio creates end-user solutions across all the company's business groups: Consumer, Pharma, Medical Devices, and Corporate Communications. Katherine is a part of the Insights and Experience Strategy team. In her role as a strategist/analyst, Katherine uses synthesis, visualization, and storytelling to help design and communicate strategies that enable the organization to deliver people-centered solutions.

Sabriya Stukes, Ph.D.
The City College of New York

Sabriya Stukes is the Associate Director of the Master's in Translational Medicine (MTM) program at The City College of New York, a brand new type of graduate degree that educates and trains scientists and engineers in the hands-on process of medical technology innovation, design and commercialization. A microbiologist, educator and science communicator, her expertise is in working with individuals to identify unmet community needs, design sustainable clinical solutions, think critically about the world around them and craft compelling scientific narratives. She also has worked for over a decade in fostering equitable and inclusive environments in the STEM disciplines and thinks deeply about how we can build sustainable solutions that work for all and not just some.


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