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14. ABSTRACT

The final technical report summarizes the results of the 2018, 2019, and 2020 US Frontiers of Engineering (US FOE) symposium. It includes an Appendix that summarizes the 2020 US FOE, which was held virtually, and links to the published proceedings volumes from the 2018 and 2019 US FOE symposia. The topics covered at the meetings were:
2020: Food for Thought: The AgRevolution Shaping What We (Will) Eat, Next-Generation Energy Systems Integration, Engineering Innovation in Women's Health,; Plastics: Pollution Challenges and Innovations
2019: Advanced Manufacturing in the Age of Digital Transformation, Engineering the Genome, Self-Driving Cars: Technology and Ethics, and Blockchain Technology
2018: Quantum Computers: Are We There Yet?, The Role of Engineering in the Face of Conflict and Disaster, Resilient and Reliable Infrastructure, and Theranostics

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plant genomics, bioinsecticide, food safety, agricultural robots, water-energy nexus, future grids, women's health, plastics pollution, advanced manufacturing, digital twin, genome editing, autonomous vehicles, self-driving cars, blockchain, quantum computing, peace engineering, resilience infrastructure, theranostics

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The National Academy of Engineering's (NAE) *US Frontiers of Engineering (US FOE)* symposia bring together a select group of 100 of the nation's early-career engineering leaders from industry, academe, and government labs to discuss pioneering technical work and leading-edge research in various engineering fields and industry sectors. The goal of the US FOE conference is to introduce these outstanding engineers to each other, and through this interaction facilitate collaboration in engineering, the transfer of new techniques and approaches across fields, and establishment of contacts among the next generation of engineering leaders. Ultimately, this strengthens and builds US innovative capacity.

Through Sponsor Award # HR0011-18-10002, the Defense Advanced Research Projects Agency (DARPA) supported the 2018, 2019, and 2020 US Frontiers of Engineering meetings. This document and Appendix 1 constitute the final report for the three-year grant.

The broad goals of the Frontiers of Engineering symposia are to sustain and build US innovative capacity by

- Providing an opportunity for emerging engineering leaders, typically within 12 years of their terminal degree (MS or PhD), from different disciplines and employment sectors (industry, academia, government labs) to learn *from their peers* about cutting-edge research and pioneering technical work;
- Introducing outstanding engineers likely to be future technology leaders and policymakers to each other at a relatively early point in their careers, thereby establishing a foundation for continued contacts;
- Facilitating interactions that may lead to identification of synergies, collaborative opportunities, and the transfer of ideas and approaches across fields.

The following summarizes how these goals were met.

2020 US Frontiers of Engineering

The 2020 US Frontiers of Engineering was originally scheduled for September 2020 but was postponed due to the COVID-19 pandemic. DARPA program staff gave permission to extend the award to accommodate the rescheduled meeting on February 25-26. Because it was not possible to hold an in-person meeting in February, the symposium was held virtually. Dr. Jennifer West (NAE), Fitzpatrick Family University Professor in the Department of Biomedical Engineering, Duke University, chaired the symposium organizing committee and the symposium. There were 97 attendees with 44 from academe, 40 from industry, and 13 from federal/other labs. Fifty-six percent of the attendees were women. The topics were Food for Thought: The AgRevolution Shaping What We (Will) Eat; Next-Generation Energy Systems Integration; Engineering Innovation in Women's Health; and Plastics: Pollution Challenges and Innovations. Due to the professional and personal demands on families during this time, speakers submitted abstracts instead of full papers, and a symposium proceedings volume was not published as in previous years. Therefore, a technical report in lieu of the published volume is attached as Appendix 1. Video presentations and abstracts are available at the 2020 US FOE webpage at www.naefrontiers.org.

Sponsors for this symposium were The Grainger Foundation, the Defense Advanced Research Projects Agency, Air Force Office of Scientific Research, Department of Defense ASDR&E-Laboratories Office, National Science Foundation, Microsoft Research, Amazon, Cummins, and individual donors.

Data from post-meeting survey

Virtual meeting structure: good or excellent – 93%
Quality of presentations: good or excellent – 95%
Ability to interact virtually during networking times: good or excellent – 84%
Range of topics: about right – 95%
Gained something useful to work/research from presentations//discussion in other disciplines: 91%//93%
Identified potential collaborative opportunities//applications of interdisciplinary approaches: 96%//84%

Usefulness to professional development: useful or very useful – 95%

What an outstanding event. The pre-recorded sessions were a fantastic way to learn, pause, and re-play very valuable educational content. Over, I was amazed by how "in person" the event felt, with so many occasions to "bump into people" repeatedly to the point that they became acquaintances or more.

The conference provided a fantastic opportunity for me to gather different engineering perspectives and to identify critical needs for advanced processes that enable breakthrough technologies. I was able to expand my scientific network with engineers from diverse backgrounds. I developed relationships that can lead to fruitful industrial and academic collaborations.

Through discussion with brilliant engineers with AI and machine learning backgrounds, I was able to identify new opportunities to use novel optimization algorithms for process optimization to minimize energy, maximize yield, etc. at my company. I have already scheduled meetings with some of the researchers I met at FOE to discuss opportunities for collaboration.

I had more useful conversations during this conference than I would have had at an in-person conference.

This is better than any other topical meeting I've attended for some time. I can always attend more specialized meetings, but a broad topic meeting like this opened my eyes to a much wider range of problems than those most people in my specific research area tend to tackle.

I plan to have one of the attendees from academia present a seminar to the R&D group with my company. Also, I plan to follow up with another academic on possible collaboration areas.

I've already reached out to multiple participants and have already had discussions about moving forward with research projects.

Improvements for future virtual meetings: Longer poster sessions, provide more information about the breakout sessions in advance.

2019 US Frontiers of Engineering

The 2019 US Frontiers of Engineering was hosted by Boeing in N. Charleston, South Carolina, September 25-27. Dr. Jennifer West (NAE), Fitzpatrick Family University Professor in the Department of Biomedical Engineering, Duke University, chaired the symposium organizing committee and the symposium. There were 107 young engineer participants with 46 from academe, 47 from industry, and 14 from government. Forty-nine percent of the attendees were women. The topics were Advanced Manufacturing in the Age of Digital Transformation, Engineering the Genome, Self-Driving Cars: Technology and Ethics, and Blockchain Technology. In addition to the plenary sessions with 15 talks followed by discussion, on the first afternoon, Meet and Connect breakout sessions provided an opportunity for attendees to share their research and technical work so they could get to know each other early in the meeting. On the second afternoon, Boeing arranged tours of its plant where the Boeing 787 Dreamliner is manufactured. This was followed by a reception overlooking Final Assembly and dinner with a view of the Boeing South Carolina (BSC) complex. Ms. Joan Robinson-Berry, then-vice president of engineering, modifications, and maintenance for Boeing Global Services, spoke about the breadth of research and engineering—"from freezer to flight"—at BSC. She issued a call to action for increased diversity in the engineering workforce, encouraging the attendees to be drivers of change and to bring people from outside their communities to the table. In addition to The Grainger Foundation and Boeing, sponsors for this symposium were the Defense Advanced Research Projects Agency, Air Force Office of Scientific Research, Department of Defense ASDR&E Laboratories Office, US National Science Foundation, Microsoft Research, Cummins Inc., and Amazon. A proceedings volume containing symposium papers was published online in February 2020, and presentation slides, papers, and get-acquainted slides were posted at the FOE website. In addition, 10 of the symposium papers were published in the Winter 2019 issue of NAE's quarterly publication, *The Bridge*.

Data from post-meeting survey
Meeting format: excellent or good – 97%
Quality of presentations: excellent or good – 98%
Opportunity to participate: excellent or good – 93%
Choice of topics: excellent or good – 98%
Gained something useful to work or research from presentations//discussion in other disciplines: yes or possibly – 96%//96%
Identified potential collaborative opportunities//applications of interdisciplinary approaches: yes or possibly – 87%//96%
Usefulness to professional development: very useful or useful – 96%

I have started a collaboration with one of the other participants on machine learning to power autonomous wearable devices, which has never before been demonstrated in the literature.

Great focus on meeting others. I was recently at the PECASE award ceremony, which is a great example of a tremendous opportunity lost. There was almost no opportunity for networking. NAE FOE is a great example of bringing together a number of the smartest individuals and giving them the opportunity to discuss big ideas and make a difference.

It was very easy to network because almost everyone was at the same point in his or her career, around the same age, and was enthusiastic about his or her work.

The most valuable aspect of the symposium was meeting fellow participant and gaining knowledge about current topics of engineering. It was great to understand what they were (e.g., blockchain, genome editing) for someone who did not have any prior knowledge. No other venue covers a variety of topics like these in detail.

Brilliant choice of speakers, topics, and participants!

I found it incredibly stimulating to be surrounded by such a diverse group of outstanding young engineers working on so many interesting topics and full of energy and ideas on how to make an impact in their field, their community, and on people around the world. It was really an energizing and very motivating experience that I hope to extend beyond the event. I also enjoyed very much that there was enough unstructured time left during the meals, breaks, and evenings to connect, socialize, and network with many people.

I loved how every evening there was a group of us who gathered in the bar at the hotel to continue conversations, and how John (NAE president) and Al (NAE executive officer) joined us every night as well. It shows real buy-in to the networking, not just from the participants but from the NAE leadership too.

Through the symposium, I am in contact with several engineers working in my field or related fields, and we are actively exploring collaborations.

I have several new ideas as a result of the sessions. I'd like to look into blockchain for spacecraft parts sourcing, and engineering the genome to build bacteria that can create a sustainable space environment.

2018 US Frontiers of Engineering
The 2018 US Frontiers of Engineering was hosted by MIT Lincoln Laboratory in Lexington, Massachusetts, September 5-7. Dr. Jennifer West (NAE), Fitzpatrick Family University Professor in the Department of Biomedical Engineering, Duke University, chaired the symposium organizing committee and the symposium. Adm. William Hayden, vice president of The Grainger Foundation, attended the meeting. There were 103 young engineer participants with 44 from academe, 44 from industry, and 15 from government. 44 percent of the attendees were women. The topics were Quantum Computers: Are We There Yet?, The Role of Engineering in the Face of Conflict and Disaster, Resilient and Reliable Infrastructure, and Theranostics. In addition to the plenary sessions with 14 talks followed by discussion, on the first afternoon, a poster session provided the opportunity for attendees to describe and answer questions about their research or technical work. On the second afternoon, MIT Lincoln Laboratory arranged tours of its Lincoln Flight and

Antenna Test Range Facility, the Lincoln Space Surveillance Complex, and three campus tours that included the Integrated Weather and Air Traffic Control Decision Support Facilities, Wide Area Persistent Surveillance, and Micro Electronics Laboratory. Dr. Grant Stokes, division head of Space Systems and Technology at MIT Lincoln Laboratory, gave the first evening's dinner speech, *Asteroids—Facts and Fiction.* He talked about the history of asteroid detection, the probability of Earth being hit by an asteroid, and the search for asteroids in a presentation that sprinkled interesting scientific data with humor. In addition to The Grainger Foundation and MIT Lincoln Laboratory, sponsors for this symposium were the Defense Advanced Research Projects Agency, Air Force Office of Scientific Research, Department of Defense ASDR&E Laboratories Office, US National Science Foundation, Microsoft Research, Cummins Inc., and Amazon. A proceedings volume containing symposium papers was published online in February 2019, and presentation slides, papers, and get-acquainted slides were posted at the FOE website. In addition, six of the symposium papers were published in the Winter 2018 issue of NAE's quarterly publication, *The Bridge*.

Data from post-meeting survey
Meeting format: good or excellent – 93%
Quality of presentations: good or excellent – 96%
Opportunity to participate: good or excellent – 96%
Choice of topics: good or excellent – 93%
Gained something useful to work or research from presentations//discussion in other disciplines: yes or possibly – 100%//98%
Identified potential collaborative opportunities//applications of interdisciplinary approaches: yes or possibly – 93%//93%
Usefulness to professional development: useful or very useful – 95%

Presentation quality was excellent. For concepts that are outside the normal area of expertise for most engineers, (e.g., Quantum Computing), the presenters did a great job explaining complete concepts in understandable language.

This was one of the most wonderful opportunities I have experienced academically. The chance to interact with other young and mid-career engineers from different disciplines was unique. The topics chosen for the speakers were interesting as they covered areas of national interest. The format of the plenary sessions was also terrific – I appreciated the general introduction followed by specific topics. The poster session was a great opportunity for us to better discuss science and engineering. All in all, this was an enlightening experience, scientifically and personally.

I will start a collaboration in the field of machine learning to help me find the best candidate to be used as a solid electrolyte in energy storage applications.

Having long breaks and social events helped to facilitate in-depth conversation about research. It is rare that I get to have time at a meeting to really get into the heart of the engineering that is conducted in my lab. Also, I have never been to an engineering meeting that was half women. Participating in this meeting was a truly transformative experience for me because it was so diverse and had, from what I can tell, at least half women. I found myself at a comfort level that I have never experienced before because there were more people there with similar experiences as mine. I found myself being more open about my work and my approach. I truly appreciate these interactions.

I don't often have the opportunity to interact with people in industry so it was extremely helpful to learn about their work and applications.

It was extremely useful to learn how engineers in disciplines rather disparate from my own think and approach problems. I was astounded by that diversity and am already taking this (for me) outside-of-the-box thinking and trying to apply it to my work.

The FOE program presents a unique opportunity to network with people both inside and outside my field. This allowed me to make connections that I fully expect to yield future collaborations. Also, I learned several things I believe will help me manage my career and set the trajectory for long-term success.

Publications

As noted above, a proceedings volume from the 2020 US Frontiers of Engineering Symposium was not published. Appendix 1 is the final technical report for that meeting. Each publication contains the papers presented at the symposium, contributors' bios, the program, and attendee list.

Frontiers of Engineering: Reports on Leading-Edge Engineering from the 2019 Symposium
Frontiers of Engineering: Reports on Leading-Edge Engineering from the 2018 Symposium

Direct questions to Janet Hunziker, jhunziker@nae.edu.

APPENDIX 1

2020 US Frontiers of Engineering

Final Technical Report

OVERVIEW

The 2020 US FOE, which is typically held in September but was postponed due to the COVID pandemic, was held virtually on February 25-26, 2021.

Goals of the Frontiers of Engineering Program

The practice of engineering is continually changing. Engineers must be able not only to thrive in an environment of rapid technological change and globalization but also to work on interdisciplinary teams. Today's research is being done at the intersections of engineering disciplines, and successful researchers and practitioners must be aware of developments and challenges in areas that may not be familiar to them.

At the annual 2½-day US Frontiers of Engineering Symposium, 100 of this country's best and brightest early-career engineers—from academia, industry, and government and a variety of engineering disciplines—learn from their peers about pioneering work in different areas of engineering. The number of participants is limited to 100 to maximize opportunities for interactions and exchanges among the attendees, who are chosen through a competitive nomination and selection process. The symposium is designed to foster contacts and learning among promising individuals who would not meet in the usual round of professional meetings. This networking may lead to collaborative work, facilitate the transfer of new techniques and approaches, and produce insights and applications that bolster US innovative capacity.

The four topics and the speakers for each year's meeting are selected by an organizing committee of engineers in the same early-career cohort as the participants. Speakers describe the challenges they face and communicate the excitement of their work to a technically sophisticated but nonspecialist audience. They provide a brief overview of their field of inquiry; define the frontiers of that field; describe experiments, prototypes, and design studies (completed or in progress) as well as new tools and methods, limitations and controversies; and assess the long-term significance of their work.

The 2020 Symposium

The topics for the 2020 US FOE were 1) Food for Thought: The AgRevolution Shaping What We (Will) Eat, 2) Next-Generation Energy Systems Integration, 3) Engineering Innovation in Women's Health, and 4) Plastics: Pollution Challenges and Innovations.

By 2050, the world population is expected to increase by a third, and at the same time, higher temperatures, severe weather events, and the rise of new challenges caused by climate change will affect agricultural output. Fortunately, novel technologies are being developed that are transforming what we eat, how we grow food, and what it means to be a farmer in the 21st century. The first speaker in the Food for Thought session described genome editing technologies and their application to engineer more resilient crops. This was followed by a talk on novel pest management strategies and new biologically based compounds for crop protection. The next speaker covered how the food safety of genetically modified crops and other biotechnology-derived products is ensured before reaching consumers. The session concluded with a presentation on the application of advanced robotics and automation technology that facilitate more efficient food production.

Our energy system is large and complex, includes more than electricity, and spans generation, distribution, and end use. Next-generation systems must be clean and adaptable to growing demand and new technologies. Challenges include integrating advances in optimization, computation, control, and AI to make power grids more efficient, robust, resilient, and sustainable; understanding how the energy-water nexus affects the design of future energy systems; and making energy more affordable and accessible for remote communities. Presentations in this session described the

operation of future grids using new tools in control theory and AI, major energy-water dependencies such as thermal power plant cooling and water desalination, and residential-scale energy systems for Native American communities.

Engineering is an integral part of healthcare innovation, yet, attention to women's health has traditionally lagged. Women's health encompasses reproduction, fertility, maternal health, normal and abnormal pregnancy, and the conditions associated with birthing injuries. It also includes sex and gender differences in many diseases and pathologies, such as cancer, cardiac disease, osteoporosis, mental health, auto immune disorders, substance abuse, and obesity. The first talk in the Engineering Innovation in Women's Health session described a low-cost, speculum-free camera device that empowers women in Africa to screen for cervical cancer. This was followed by a talk on research into the biomechanics of the reproductive tract that advances our understanding of the causes of preterm birth and birthing-related injuries. The next presentation covered tissue engineering of artificial ovaries, which gives hope to those wanting to grow their families. The session closed with a talk about NextGen Jane, a women's health start-up that uses data-driven resources so women can track their health using their menstrual blood.

The universal use of plastic has resulted in contamination in every corner of the globe; microplastic in particular is transported by air and water to remote locations of our planet. We see the toxic impacts on animals such as sea birds, turtles and whales, but we don't yet understand what this means for us as human or the implications for our global ecosystems. The session Plastics: Pollution Challenges and Innovations outlined the efforts engineers and scientists are making to mitigate these issues. Presentations covered the extent and impact of plastic contamination and the importance of citizen science and open data to hold polluters responsible; the necessity for environmental degradability as a design metric; and plastic "off-set" technology to fund the informal waste sector in India as a mechanism for addressing environmental and social justice issues related to plastic pollution.

Every attempt was made to re-create an experience for attendees that allowed for the personal interactions that are such an integral part of Frontiers of Engineering symposia. To that end, staff selected a virtual conference platform that allowed attendees to move around floor plans for a lobby, lecture hall, poster hall, and multipurpose room. Presentations were recorded in advance and available to attendees before the live event to allow more time for discussion, networking sessions, breakout groups, and happy hours. Many of the presentations are available for public viewing at the 2020 US FOE List of Sessions at www.naefrontiers.org.

The NAE is deeply grateful to the following for their support of the 2020 US Frontiers of Engineering symposium:

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We also thank the members of the Symposium Organizing Committee chaired by Dr. Jennifer West, Fitzpatrick Family University Professor of Biomedical Engineering at Duke University, for planning and organizing the event.

2020 US FRONTIERS OF ENGINEERING ORGANIZING COMMITTEE

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SESSION AND SPEAKER ABSTRACTS

Session I: Food for Thought: The AgRevolution Shaping What We (Will) Eat

Co-chairs: Lily S. Cheung, Georgia Institute of Technology, and Andrew J. Coughlin, Syngenta Corporation

By 2050, the world population is expected to increase by a third, and so will the demand on our agricultural systems. At the same time, higher temperatures, severe weather events, and the rise of new challenges caused by climate change will affect agricultural output. Ensuring food security along with making agriculture more sustainable are imperatives, as the sector is a significant contributor to greenhouse gas emissions. Fortunately, novel and exciting technologies are being developed that will transform what we eat, how we grow food, and what it means to be a farmer in the 21st Century. This session will offer a small sample of the many ways in which engineers are revolutionizing agriculture.

Speakers:

10,000 Years of Engineering Plant Genomes: The Essential Role of Genetic Variation in Crop Breeding
Aaron Hummel, Pairwise Plants

Peptides as a New Class of Bioinsecticide
Kyle Schneider, Vestaron Corp.

Safety Oversight for the Future of Food
Patrick Cournoyer, US FDA

Robots as Farmers: Automation in Precision Agriculture
Sierra Young, North Carolina State University

10,000 Years of Engineering Plant Genomes: The Essential Role of Genetic Variation in Crop Breeding
Aaron Hummel, Pairwise Plants

The remarkable history of agriculture is a story of increasing abundance and reliability of the food supply. Progress in crops has been driven by both opportunistic and systematic selection for more productive and more desirable traits (phenotypes). As in all living things, genetic variation in crops is the basis for phenotypic variation that can be observed and selected. Thus, genetic variation is essential to crop improvement. In this context genome editing is a modern expression of plant breeding, introducing targeted genetic variation that leads to phenotypes which can be observed and selected.

CRISPR systems provide immunity to viruses in prokaryotes and were first repurposed as genome editing tools in 2012. Since then a variety of CRISPR-based editing tools have been developed and used to remove, edit, and replace genes in a wide array of prokaryotic and eukaryotic organisms and cell types. Because of their efficiency and simple reprogramming, CRISPR editing tools offer a historically unprecedented level of precision and control for introducing variation at specific gene targets in crops. Effective application of genome editing to crop breeding programs represents a tremendous value for optimizing consumer traits in fresh foods and productivity in row crops by enabling restoration and creation of variation at key genes. It will be marked by significant breakthroughs in applied biological sciences.

Peptides as a New Class of Bioinsecticide
Kyle Schneider, Vestaron Corp.

Estimates suggest that more than 20% of all crops are lost to pest damage, causing farmers to spend more than $9 billion on pesticides in just the US alone. The majority of the insecticide market consists of synthetic agrochemicals that

are cheap, fast-acting, and highly efficacious. The use of synthetic insecticides, however, has come under increased scrutiny due to their negative environmental consequences, such as their long-term persistence in the environment and their inability to differentiate between beneficial and pest insects. Further, widespread overuse has resulted in insects that are becoming resistant to these pesticides, making it necessary for more chemical insecticides to be applied in order to be effective. As such, there is an urgent need for sustainable insecticides with novel modes of action to secure the world's food supply in the coming years.

Insecticidal peptides derived from animals or plants offer an interesting alternative to conventional chemicals. Compared to synthetics, peptides possess greater specificity for their target insects, no longterm environmental persistence, and are broken down into safe amino acids in the environment. Despite their promise, until recently no insecticidal peptide has been commercialized due to their high manufacturing costs, limited bioavailability to host insects, and lack of a clear regulatory pathway to market. Vestaron has solved each of these issues with the commercialization of its Spear™ peptide bioinsecticide. This peptide product is as effective against target pests as conventional chemicals, but without many of their negative environmental consequences, such as an improved fish and mammal safety profile, no residue along the food supply chain, and no adverse effect on honeybees. It is Vestaron's vision that the Spear™ peptide will be the first of many in a new class of safe and effective biopesticides for a sustainable future in agriculture.

Keeping the Food of the Future Safe
Patrick Cournoyer, US FDA

Genetic engineering makes it possible to reshape the food supply by dragging and dropping new genes into food-producing organisms. For over 30 years, developers of food ingredients and new plant varieties have used genetic engineering tools to bring a steadily increasing array of new foods to consumers' diets. These include biotech enzymes, optimized vegetable oils, synbio flavors, animal-free replacements for animal products, a newly edible grain, and pro-vitamin A fortified golden rice. The FDA works with developers to help them ensure that their new products will be safe to eat and legally compliant, applying established principles for the safety assessment of food ingredients. By monitoring advancements in science and by working with food innovators, the FDA helps ensure the safety of the future of food.

Robots as Farmers: Automation in Precision Agriculture
Sierra Young, North Carolina State University

The efficiency and productivity of production agriculture has drastically increased over the last 100 years due to mechanization; however, the acquisition of large agricultural machinery is costly, and there remain repetitive and labor-intensive tasks for which no automated solutions exist. Additionally, on-farm labor costs are increasing due to a growing workforce shortage. These economic pressures have ignited efforts towards developing smaller, portable, multi-task robotic systems for agriculture. These agricultural robots, or "agbots", promise to deliver smart, automated solutions for a variety of on-farm tasks, such as plant phenotyping, sorting, scouting, pruning, thinning, planting, spraying, weeding, and harvesting. Automated solutions are of particular importance to specialty crop industries, which currently rely on the availability of seasonal, manual labor for production.

A significant challenge to automating these tasks, however, is the dynamic, unstructured, and uncertain nature of agricultural environments, but ongoing advancements in artificial intelligence, navigation, and control are enabling systems to overcome these challenges. In light of these recent advancements, this talk will focus on cutting-edge agbot technologies from both industry and academia for automating specialized tasks in agriculture and will include case studies from a variety of cropping systems. The material covered in this talk will illustrate the potential for agbots to further improve efficiency and productivity of production agriculture, while identifying challenges that remain ahead before they become fully adopted and integrated on the farm.

Session II: Next-generation Energy Systems Integration

Co-chairs: Jennifer Kurtz, National Renewable Energy Laboratory, and Javad Lavaei, University of California, Berkeley

Energy impacts many aspects of our lives and has seen many transformations in recent history. The energy system, including electrical, fuels, and thermal sub-systems, has been essential to economic, industrial, and societal growth. The next-generation energy system must also be clean and adaptable to growing demand and new technologies. Our energy system is large and complex, includes more than electricity, and spans generation, distribution, and end use. Highly variable generation technologies in the energy system have increased in both number, location, and scale; along with decreasing costs. Many states and industries have aggressive targets for renewable generation and sustainability because these targets are needed to address climate change as well as business needs such as economics, sourcing, and resiliency. While these advancements and goals have many of us excited about the progress, our current energy system and operation are not able to flex and evolve enough to meet the goals without new vision and innovation. Some of these challenges with the current energy system are reliability, intermittency, variability, growth, emissions, and storage. Many of the renewable technologies support and/or address individual challenges, there is not one technology that meet all the requirements. Based on the studies by the Federal Energy Regulatory Commission, system operators resort to several heuristic methods to handle the complexity of the operation of the gird, which waste billions of dollars annually in the US. This session will discuss four main challenges for the next-generation integrated energy system:

- What solutions are needed in order to realize our greenhouse gas reduction goals? What policy and strategy are needed to enable, highly impactful integrated energy systems?
- How can technologies and operation strategies be integrated with highly variable generation without sacrificing grid reliability or resiliency?
- How can the new advances in optimization, computation, control, and artificial intelligence be used to make power grids more efficient, robust, resilient, and sustainable?
- How can energy be made affordable and accessible for remote communities?
- How does the energy-water dependency affect the design of future energy systems?

Speakers:

Enabling the Operation of Future Grids Using New Tools in Control Theory and AI
Johanna Mathieu, University of Michigan

Powerful Water and Thirsty Energy: A Systems Challenge
Noel Bakhtian, Lawrence Berkeley National Laboratory

Enabling Impactful Residential-scale Energy Systems for Native American Communities
Suzanne Singer, Native Renewables

Enabling the Operation of Future Grids Using New Tools in Control Theory and AI
Johanna Mathieu, University of Michigan

The shift towards a more sustainable energy future has led to a number of critical challenges in how to reliably and efficiently operate the electric power grid. In power grids, supply and demand must be balanced at all times; however, renewable energy resources such as wind and solar produce power when the wind blows and the sun shines, not necessarily when we need it, and there is very little storage. Further, some have proposed pathways to sustainable energy systems through electrification of resources that directly consume fossil fuels like cars, heating systems, and some industrial processes along with decarbonization of the electricity grid. However, electrification greatly increases the load on the grid, which in many parts of the country and world is already operating at its limit.

New tools in control theory, optimization theory, and artificial intelligence/machine learning are helping us better operate electric power grids undergoing these significant transformations. To accommodate more wind and solar,

researchers are developing approaches to exploit the flexibility of distributed energy resources (DERs) including small scale storage (batteries) and electric loads with flexible consumption patterns (electric vehicles, air conditioners, water heaters). Key challenges are to develop algorithms that are scalable enabling coordination of large numbers of DERs, low-cost to implement, low/no impact on electricity consumers, and reliable. Other research is focusing on ways to better utilize existing infrastructure/resources, which would allow the grid to safely operate even closer to its limits. Key challenges include dealing with uncertainty, nonconvexity, and insufficient sensing that limits situational awareness. This talk will describe a number of these challenges and the creative approaches being developed to address these challenges.

Powerful Water and Thirsty Energy: A Systems Challenge
Noël M. Bakhtian, Lawrence Livermore National Laboratory

A growing community, domestic and international, is being challenged by the interdependencies between energy and water. The "energy-water nexus," as it's typically labeled, can be broken down simply as "energy for water" and "water for energy." Energy is vital to the provision of water, being required for water extraction, transport, heating, treating, and desalination.[1] On the flip side, water is ubiquitous in energy production.[1] In fact, roughly 50% of the water used every day in the United States goes to the energy sector.[2]

The limiting factor is water, based on both quantity and quality. Although it seems we're surrounded by water, freshwater, which makes up more than two-thirds of all energy-required water,[2] is a constrained resource; accessible, reliable, and sustainable supplies of freshwater represent only about 0.0003% of the global water resource.

Not only that, but rapid economic and population growth are increasing global demand for both energy and water, further exacerbating water scarcity issues for the energy sector. By 2030, global energy demand is expected to have increased by 50%, while water demand will have increased by 40%.[3]
And then there's the compounding factor of climate change which has the potential to spur increased energy demand (think heating and cooling) while also impacting the energy-water system via increased water temperatures, sea level rise (which will contaminate freshwater supplies), and extreme events such as drought. [1,4]

This talk will dive into the major energy-water dependencies (e.g. thermal power plant cooling, water desalination), share major projects dedicated to the nexus around the world, and provide a framework for those seeking to address this global challenge.

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3) http://www.dni.gov/files/documents/GlobalTrends_2030.pdf
4) https://www.energy.gov/sites/prod/files/2013/07/f2/20130716-Energy%20Sector%20Vulnerabilities%20Report.pdf

Enabling Impactful Residential-scale Energy Systems for Native American Communities
Suzanne L. Singer, Native Renewables

Native American Tribes have historically developed fossil fuel and minerals resources on their lands to provide electricity to major cities in the U.S. In 2000, the Energy Information Administration reported that 75% of all Native American homes without electricity were on the Navajo reservation. Although tribes were exporting power, some tribal community benefits did not include energy access.

Today, there are an estimated 15,000 homes on the Navajo reservation without grid-tied electricity. Energy can be costly for some families, spending up to 50% of their income on energy. Approximately 40% of families haul water as they lack access to running water at their homes. Families have access to only 13 grocery stores within the 27,000 square miles that comprises the Navajo Nation.

These challenges provide the opportunity to develop impactful energy systems that integrate electricity, food, water, energy efficiency, transportation, and reduced greenhouse gas emissions. Local "on the ground", Native

American led organizations are leading efforts to build sustainable programs around community needs. Innovative programs, policies, investment, economic development, technology advances in climate, transportation, materials and manufacturing, internet access, and responsible data methodologies are needed to solve issues in an affordable and sustainable way.

This talk will discuss efforts, including Native Renewables work to develop integrated programs to address affordability, greenhouse gas emissions, education, and job creation through off-grid power solutions.

Session III: Engineering Innovation in Women's Health

Co-chairs: Kristin Myers, Columbia University, and Melissa Skala, Morgridge Institute for Research, University of Wisconsin, Madison

Engineering is an integral part of healthcare innovation, from advances in medical imaging technology to inventing new methods to sequence entire genomes. Engineers have long teamed with physicians and scientists to build an ecosystem of precision medicine from diagnosis to therapy to cure. Yet, attention to women's health has traditionally lagged, where the most basic characteristics of female anatomy and physiologic processes remain understudied and misunderstood. Women's health is a broad category encompassing reproduction, fertility, maternal health, normal and abnormal pregnancy, and the sequelae associated with birthing injuries. Women's health also includes sex and gender differences in many diseases and pathologies, such as: cancer, cardiac disease, osteoporosis, mental health, auto immune disorders, substance abuse, obesity, and others. This list is not exhaustive with new scientific frontiers developing based on the evolving discourse of medicine for all. Engineering innovations directed towards women's health ultimately improves the quality of life for everyone. In this session we feature female engineers, academics and an entrepreneur who focus on women's health including cervical cancer, infertility, preterm birth, birthing injury, and everyday reproductive health. The women featured in this session span engineering disciplines and numerous early career stages.

Speakers:

A Woman-centered Approach for Cervical Cancer Prevention
Mercy Asiedu, Massachusetts Institute of Technology

Growth and Remodeling of the Female Reproductive System
Kristin Miller, Tulane University

Functional and Tunable Biomimetics for Reproductive Tissue Engineering
Ariella Shikanov, University of Michigan

Menstruation as a Natural Biopsy—Building a Database to Fuel Early Diagnosis of Reproductive Disorders
Ridhi Tariyal, NextGen Jane

A Woman-centered Approach for Cervical Cancer Prevention
Mercy Asiedu, Massachusetts Institute of Technology

Addressing disparities in the global cancer burden is a key part of the post-2015 global development agenda. Cervical cancer is emblematic of that disparity, with almost 90% of cases and cancer-related deaths occurring in low and middle-income countries (LMICs). Many LMICs lack the health care infrastructure required for cytology-based screening and referral colposcopic diagnosis, which have dramatically reduced the disease burden in wealthier countries. The World Health Organization (WHO) recommends adoption of alternative protocols that employ low-cost and simple-to-use screening technologies and treat all women who are positive based on these tests. One strategy – highly sensitive human papillomavirus (HPV) testing – has been shown to reduce the incidence and mortality from cervical cancer when coupled directly with outpatient treatment for women with HPV-positive results. More recent guidelines have moved back from this "screen & treat" approach, given concerns about overtreatment. The American Society of Clinical Oncology (ASCO) recently released guidelines recommending that HPV be used as a screening test, followed by triage with Visual Inspection with Acetic Acid (VIA) to confirm the presence of lesions. While this may decrease overtreatment, VIA remains a poor triage test because of low sensitivity and specificity and low quality of interpretation. There is a need for a triage test that is low-cost, easy-to-use and will provide reliable results at the point-of-care.

This presentation will discuss our multipronged, approach to addressing these barriers to cervical cancer screening and management. The first component is a patient-centered device that reimagines the pelvic exam, for self-cervix imaging without the need of the speculum and which can be used in combination with self-HPV screening to triage women who need diagnostic colposcopy. The Callascope has been tested in Durham, NC and in Accra, Ghana and achieves cervix visualization of 83% for provider-based imaging without the speculum, and 95% for self-based imaging while enabling 2x patient comfort. The second component includes a Pocket Colposcope, a low-cost high-quality, portable colposcope, that packages all the features of a $15,000 standard of care colposcope into a hand-held device. The Pocket colposcope enables multi contrast, and imaging at multiple magnifications and has been validated in clinical investigations on > 1000 patients in hospitals across the globe and an international image concordance study found to the Pocket Colposcope to be comparable to a standard colposcope when compared to the gold standard, pathology. The third component is a machine learning algorithm for automated, and accurate decision-making that overcome limitations of no-uniform provider experience or lack of access to a provider who can interpret the images. The algorithms apply feature-extraction and machine learning methods to leverage multiple sources of contrast. Preliminary results achieve sensitivity, specificity, and accuracy of 81.3%, 78.6%, and 80.0%, respectively, when used to distinguish cervical intraepithelial neoplasia (CIN+) relative to normal and benign tissues. These results are superior to three expert providers (77% sensitivity, 51% specificity, and 63% accuracy) with experience ranging from 15-40 years. When the Pocket colposcope and machine-learning algorithms can be followed immediately with treatment using a portable thermocoagulator, which has been recently approved by the WHO for cervical cancer ablation. In summary, a three-visit model (screening, diagnosis and treatment) can be consolidated to a single visit. The majority of women (98 out of 100) can complete the screening process at home with self-HPV and self-imaging. A small subset would then attend a health facility, ideally near her home to receive confirmatory diagnosis with the Pocket Colposcope followed by treatment. These results demonstrate the potential for this multi-pronged solution to put women at the center of the solution in resource-limited settings. This model could pave the way for women-centered approaches for other sexual and reproductive health challenges.

Growth and Remodeling of the Female Reproductive System
Kristin Miller, Tulane University

The female reproductive system is dynamic and adapts to changes in response to biomechanical (intrabdominal pressure) and biochemical signals (hormones and inflammation) during menstruation, pregnancy, postpartum healing, aging, and certain disease states [1]. The function of female reproductive tissues is dictated by the composition and organization of fibrous structures and cell types within the tissue. In response to altered biomechanical or biochemical signals, cells within these tissues produce, remove, or reorganize fibrous components to maintain a preferred biomechanical state. Imbalances in this process, however, can lead to abnormal tissue function and disease due to either excessive deposition leading to fibrosis, which causes decreased tissue elasticity, or excessive removal (degeneration) leading to decreased tissue mass and insufficient tissue structural stability. Degeneration of the biological tissues in female reproductive system contributes to conditions such as pelvic floor disorders (i.e. urinary and fecal incontinence and pelvic organ prolapse), and preterm birth [2,3]. Reproductive health conditions impact the health and quality of life in women worldwide. The underlying causes of tissue degeneration in the female reproductive system, however, are not well understood and likely multifactorial in nature [1]. Biomechanical and biochemical processes, as well as the interplay between these processes, may contribute to the progression of disease states.

Towards this end, mounting evidence shows that computational models are valuable tools to describe and predict these processes [4-6]. Growth and remodeling computational models, which consider changes in tissue geometry or mass in response to altered biomechanical loads, can describe and predict preclinical and clinical progression of cardiovascular disease and bone regeneration [7]. Reproductive and cardiovascular tissues are composed of the same baseline fibrous components, albeit in different ratios and organizations. Therefore, we submit that applying growth and remodeling models to the female reproductive system is a special opportunity to better understand reproductive system dynamics and improve clinical healthcare of women's reproductive health pathologies. In particular, there is a critical need to better understand the underlying processes and interactions of tissue adaptation induced by steroid hormones and mechanical loads in the female reproductive system. Challenges remain to develop appropriate experimental and theoretical frameworks given the extremely large deformations experienced by the reproductive system and the high interactions with adjacent tissues that are difficult to recapitulate in existing

technologies. Further, the reproductive system is drastically understudied – so many pieces of critical data to inform such models are missing. Therefore, it is necessary to modify or develop experimental tools, collect extensive data on tissue structure and function, and to develop new mathematical frameworks. In this talk, I will summarize the current progress, emerging technologies, and challenges of general biomechanics and growth and remodeling in the female reproductive system.

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[2] Liu, X., Zhao, Y., Pawlyk, B., Damaser, M., & Li, T. (2006). Failure of elastic fiber homeostasis leads to pelvic floor disorders. The American journal of pathology, 168(2), 519-528.
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[4] Fernandez, M., House, M., Jambawalikar, S., Zork, N., Vink, J., Wapner, R., & Myers, K. (2016). Investigating the mechanical function of the cervix during pregnancy using finite element models derived from high-resolution 3D MRI. Computer methods in biomechanics and biomedical engineering, 19(4), 404-417.
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[6] Conway, C. K., Qureshi, H. J., Morris, V. L., Danso, E. K., Desrosiers, L., Knoepp, L. R., ... & Miller, K. S. (2019). Biaxial biomechanical properties of the nonpregnant murine cervix and uterus. Journal of biomechanics, 94, 39-48.
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Functional and Tunable Biomimetics for Reproductive Tissue Engineering

Ariella Shikanov, University of Michigan

Ovarian follicles are multicellular aggregates in the ovary responsible for a woman's fertility and ovarian endocrine function. Currently, young women and prepubertal girls diagnosed with cancer and facing cytotoxic treatments have limited options to preserve their fertility, resulting in depletion of the non-renewable ovarian reserve and premature ovarian insufficiency (POI). POI results in sterility, along with consequences of lost ovarian endocrine function: premature osteopenia, muscle wasting, and cardiovascular diseases. The unique challenges associated with fertility preservation in females are primarily due to limited and non-renewable ovarian reserve. Technologies for the cryopreservation of eggs or embryos available for adult patients are not suitable for prepubertal patients or adult patients with hormone- and time-sensitive cancers. Additionally, none of the clinically available fertility preservation options can restore the lost ovarian endocrine function and none are suitable for children and young adults.

Patients at risk and prepubertal girls can undergo ovarian tissue cryopreservation prior to beginning of cytotoxic treatments. This ovarian tissue typically contains thousands of early-stage primordial and primary follicles, which carry the potential to restore fertility, yet have been challenging to mature *in vitro* or *in vivo*. We, and others, have demonstrated that three-dimensional biomimetic constructs promote tissue regeneration and restore biological function. We aim to create artificial constructs that support healthy follicle growth and development outside the body and after transplantation by combining approaches from engineering, materials, chemistry and life sciences. For example, to obtain fertilizable oocytes from small follicles cultured *in vitro* we created a culture system for multiple follicles that recapitulates well-choreographed synchronized signaling events, involving soluble cytokines and transcription factor activation necessary for follicle maturation. Resulting mature oocytes can be stored for future fertilization and used for assisted reproduction. For restoration of lost endocrine function in patients with POI we designed an immunoisolating capsule able to support the physiological function of the implanted allogeneic ovarian tissue and protect the allograft from immune rejection. We demonstrated that non-vascularized ovarian tissue encapsulated in a hydrogel-based capsule responds to endogenous stimuli and secretes ovarian hormones that reach systemic circulation by diffusion to restore cyclic ovarian function in ovariectomized mice. Results from our research will provide insights into follicle development and help bridge the gap to support the use of cryopreserved ovarian tissue for fertility and ovarian endocrine function restoration.

Menstruation as a Natural Biopsy—Building a Database to Fuel Early Diagnosis of Reproductive Disorders

Ridhi Tariyal, NextGen Jane

NexGen Jane There exist myriad conditions which can impact female-born reproductive health. These range from heritable and environmental conditions such as cancer and non-communicable disorders like endometriosis, to communicable diseases such as STIs and pelvic inflammatory disease (PID). The range of problems associated with diagnosing these diseases vary as broadly as the conditions themselves, many of which are asymptomatic (chlamydia) or nascent and difficult to diagnose (ovarian cancer, endometriosis). These impediments handicap our ability to treat reproductive conditions early and effectively. A tampon provides singular access to the female reproductive system: a 'natural biopsy', and the only non-invasive biopsy available. This unprecedented, and continual, access to reproductive tissues gives NextGen Jane an opportunity to look for molecular signatures of disease by interrogating the cells of the endometrium, cervix, ovaries, fallopian tubes and other cell types, including immune cells and bacteria found in the reproductive tract. By examining these cells from our consumers, we are able to study diseases that exclusively affect femaleborn people at unprecedented scale and speed. The NextGen Jane system enables radical improvements in medical management in the following ways: 1. A tampon used during menstruation provides us with singular access to tissues from the upper reproductive tract - a non-invasive, natural reproductive biopsy of endometrial, ovarian, and fallopian tube cells. 2. A tampon used during non-menstruation functions as a large vaginal swab of the lower reproductive tract, and can provide us with regular snapshots of the vaginal microbiome, as well as access to vaginal and cervical cells. 3. A system which no longer depends on a doctor's visit encourages clinical engagement without the clinic. NGJ's sample collection system allows for remote collection anywhere, and is mailed back to a lab, eliminating the cumbersome demands of cold chain, and the burdensome logistics of planning and making an in-office clinic visit. This enables NGJ to initiate multiple biological engagements with the consumer over many years. 4. Molecular signals isolated from cells naturally shed by the reproductive system provide unprecedented insight into reproductive disorders.

Session IV: Plastics: Pollution Challenges and Innovations

Co-chairs: Anela Choy, Scripps Institution of Oceanography at UC San Diego, and Jenna Jambeck, University of Georgia

More than 8 billion metric tons of plastic has been produced since only 1950, and while plastic has become an essential component of our society and we can't imagine our lives without it, it's universal use has resulted in contamination in every corner of the globe: from the deepest depths of our oceans to remote mountain tops. While the material and waste from widespread global use is produced by humans, plastic, and especially microplastic is transported by air and water to remote locations of our planet. While we have seen ecotoxic impacts, especially to animals such as sea birds, turtles and whales, we don't yet know what this means for us, as humans, nor do we understand the full implications to our global ecosystems. We do however, know enough to try to mitigate this issue – and engineers and scientists are working on various interventions spanning the entire value chain.

Speakers:

Plastics and Transforming Ecosystems Science into Accountability
Jeremy Conkle, Texas A&M University, Corpus Christi

Challenges in Plastics Circularity: The Necessity for Environmental Degradability as a Design Metric
Desiree Plata, Massachusetts Institute of Technology

Empowering Businesses to Restore Nature's Balance
Svanika Balasubramian, rePurpose

Plastics and Transforming Ecosystems Science into Accountability
Jeremy Conkle, Texas A&M University

Plastics are essential in our society because they improve safety, reduce costs and often provide environmental benefits. Because of this, plastic production is growing by >12 million tons annually across the globe. Production in North America grew an average of 0.75 million tons between 2000 and 2016 (48 to 60 million tons) but jumped 4.4 million tons in 2017. This is the start of an upward trend on the continent, with many new pellet plants planned in the U.S. Texas with its ports and nearby oil and gas extraction is leading this growth, where the city of Corpus Christi anticipates opening the two largest polyethylene terephthalate plants in the world before 2024. Coastal Texas is already home to numerous plants that ship their product globally. This current production and its transportation have resulted in the ubiquitous presence of pellets in several bays as well as the entire Texas Seashore. Contamination is particularly high in the Matagorda/Lavaca Bay system, which is home to a manufacturer that produces polyethylene, polypropylene, and polyvinyl chloride. A small local citizen group in that community successfully sued the manufacturer under the Clean Water Act, resulting in a $50 million settlement after they were found guilty. The manufacturer also agreed to re-engineer their stormwater and wastewater systems so that they achieve zero pellet discharge in the future. This promising outcome was only possible due to several years of daily sampling by a small citizen group. They collected >2,000 samples documenting pellets and plastic powder and are still sampling almost daily to ensure the manufacturer does not violate the settlement. The positive outcome, in this case, was possible because plastic pellets are visible with the naked eye, unlike traditional organic and inorganic pollutants. This makes citizen sample collection and documentation cheaper and potentially more legally sound. Therefore, the scientific community must work with citizen groups and lawyers to ensure that the data is collected and documented properly, but also that the "experimental design" will provide data that address key aspects of the case. While each case is unique some of these key questions might be source tracking, material identification, and aging. Researchers already have some of the tools to address these questions, but others must be developed. As more plastics plants begin production globally, the research community must learn from the recent case in Texas and establish tools and approaches to document the presence, identify sources of the discharges and spills and explain their harm to ecosystems.

Challenges in Plastic Circularity: The Necessity for Environmental Degradability as a Design Metric
Desirée Plata, Massachusetts Institute of Technology

The high visibility of marine plastic pollution, coupled with growth in broad concerns for the environment, has made modern society question its long-accepted materials management practices. The status quo of our materials management systems constructs a linear economy (i.e., make-take-dispose), whereas a circular economy (i.e., one that relies on substantial material recovery rather than disposal) is favored to reduce the burden of waste. However, there are major challenges to implementing materials circularity. Even with circular management systems in place, there will always be some fractional loss to the environment. Since plastics production continues to rise exponentially and *the next 15 years of plastic production will outweigh all previous fabrication*, strategies are needed to ensure these fractional losses are ultimately degradable. This talk will first review the current materials management strategies and challenges to a circular economy, highlight why our goods should be implicitly degradable, discuss what it means to be "biodegradable" versus environmentally labile, and finally lay out research to accelerate discovery to inform a new future of implicitly degradable and/or reusable plastics.

Empowering Businesses to Restore Nature's Balance
Svanika Balasubramian, rePurpose

I am a co-founder of rePurpose, a global movement of conscious consumers and businesses going Plastic Neutral**.** As the world's first Plastic Credit Platform, we make climate action delightfully simple for companies of all sizes by removing and recycling as much ocean-bound plastic waste as they produce while embedding sustainability into their product experience to reach and retain purposeful consumers.

1) Plastic Neutral Products: With us, consumer brands get to take climate action that is good for their business and our planet in 3 easy steps:
1. We calculate their plastic use in 2 minutes with packaging/sales stats
2. We compensate for their footprint by eliminating as much plastic waste from nature as they use through our global network of vetted recycling projects
3. We help them run unique marketing campaigns on plastic neutrality that instantly differentiate from competitors and demonstrate authentic societal responsibility, overnight
2) EverydayNeutral: We add a tick-box at the Point of Checkout for any e-commerce retailer where customers can add a few pennies and erase the unique plastic footprint of their purchase that day. By enabling people to balance out the bad by doing an equal amount of good, you build goodwill with new customers and retain loyal ones - all at no cost to the business.
3) Plastic Neutral Consumers: Individuals anywhere in the world can subscribe to go Plastic Neutral by taking our 3-minute plastic footprint calculator and paying $2-4/month to a project of your choice to compensate for your consumption and join our global community.

National Academy of Engineering
2020 US Frontiers of Engineering
Virtual
February 24-26, 2021

Program
All Times are Eastern Time.

Wednesday, February 24

6:00 – 7:00pm Help Desk / EPB Onboarding *Lobby*

7:00 – 8:30 pm Virtual Welcome Reception*Multipurpose Room*

7:10pm Remarks – Jennifer West, Symposium Chair *Multipurpose Room*

Thursday, February 25

10:00 – 11:00am Help Desk / EPB Onboarding *Lobby*

11:00 am Welcome – John Anderson, President, National Academy of Engineering *Lecture Hall*
Opening Remarks – Jennifer West, Duke University, Symposium Chair

11:10 **FOOD FOR THOUGHT: The AgRevolution Shaping What We (Will) Eat**
Co-chairs: Lily Cheung, Georgia Institute of Technology, and Andrew Coughlin, Syngenta Corp.

10,000 Years of Engineering Plant Genomes: The Essential Role of Genetic Variation in Crop Breeding
Aaron Hummel, Pairwise Plants

Peptides as a New Class of Bioinsecticide
Kyle Schneider, Vestaron Corp.

Safety Oversight for the Future of Food
Patrick Cournoyer, US FDA

Robots as Farmers: Automation in Precision Agriculture
Sierra Young, North Carolina State University

12:15 Meet and Connect: Open Room Networking *Multipurpose Room*

1:00 Break

1:15 Poster Session 1 *Poster Hall*

1:45 Poster Session 2

2:15 **NEXT-GENERATION ENERGY SYSTEMS INTEGRATION** *Lecture Hall*
Co-chairs: Jennifer Kurtz, National Renewable Energy Laboratory, and Javad Lavaei, University of California, Berkeley

Enabling the Operation of Future Grids Using New Tools in Control Theory and AI
Johanna Mathieu, University of Michigan

Powerful Water and Thirsty Energy: A Systems Challenge
Noel Bakhtian, Lawrence Berkeley National Laboratory

Enabling Impactful Residential-scale Energy Systems for Native American Communities
Suzanne Singer, Native Renewables

3:15 Break

3:30 Breakout Session 1: *Next Grand Challenges for Engineering* *Multipurpose Room*

4:30-5:30 "Happy Hour" (Optional Networking) *Multipurpose Room*

Friday, February 26

11:00 am Announcements *Lecture Hall*

11:05 **ENGINEERING INNOVATION IN WOMEN'S HEALTH** *Lecture Hall*
Co-chairs: Kristin Myers, Columbia University, and Melissa Skala, Morgidge Institute and University of Wisconsin-Madison

A Woman-centered Approach for Cervical Cancer Prevention
Mercy Asiedu, Massachusetts Institute of Technology

Growth and Remodeling of the Female Reproductive System
Kristin Miller, Tulane University

Functional and Tunable Biomimetics for Reproductive Tissue Engineering
Ariella Shikanov, University of Michigan

Menstruation as a Natural Biopsy—Building a Database to Fuel Early Diagnosis of Reproductive Disorders
Ridhi Tariyal, NextGen Jane

12:05 Meet and Connect: Open Room Networking *Multipurpose Room*

12:30 Breakout Session 2: *Disciplinary Focus Groups* *Multipurpose Room*

1:30 Break

1:40 **PLASTICS: POLLUTION CHALLENGES AND INNOVATIONS** *Lecture Hall*
Co-chairs: Anela Choy, Scripps Institution of Oceanography, and Jenna Jambeck, University of Georgia

Plastics and Transforming Ecosystems Science into Accountability
Jeremy Conkle, Texas A&M University, Corpus Christi

	Challenges in Plastics Circularity: The Necessity for Environmental Degradability as a Design Metric Desiree Plata, Massachusetts Institute of Technology	
	Empowering Businesses to Restore Nature's Balance Svanika Balasubramian, rePurpose	
2:40	Break	
2:50	Breakout Session 3: *Session Topic Discussions and Topics Suggested by Attendees*	*Multipurpose Room*
3:50	Concluding Remarks	
4:00-5:00	"Happy Hour" (Optional Networking)	*Multipurpose Room*

2020 US Frontiers of Engineering
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