



Woodburn Wastewater Plant Manager, Curtis Stultz, explains to Senior Design students the different aspects of the plant and some of the innovative ecological engineering based methods to treat nitrates in the waste water using phytoremediation.

Oregon State UNIVERSITY **OSU** College of Engineering

Biological & Ecological Engineering

Oregon State UNIVERSITY **OSU** College of Agricultural Sciences

DONOR AND ALUMNI EVENTS

EcoE Collaborates with Local Vineyards

Every year the Senior Class of Ecological Engineering designs a project that simulates the experience of being a hired as a contractor by a specific client or group of clients. This capstone project, titled Senior Design, combines the skills the students have learned during their time at Oregon State University into one project that they work on for two terms (Fall and Winter).

Wine grapes are the largest cash crop in Oregon; wineries produce high strength wastewater during wine production season and decentralized wastewater treatment systems are being adopted to treat in situ and reuse the water for irrigation of the vineyards.

For this year's project students will address the technical issue of providing oxygen to a pretreatment system that is designed to reduce the Biological Oxygen Demand of the incoming process wastewater by >50% so that it can be effectively handled by conventional wastewater systems. The system they are designing should be suitable for a location where line-power electricity is available but may not have internet/cellular connectivity.

The students are designing a pre-aeration treatment system that balance cost, environmental sustainability, robustness, and feasibility. They will build their solution and it will be tested under real-world conditions as would be found in the Willamette Valley, Oregon in June-October. Students also have an added element this year with crowdfunding to build their designs through the OSU Foundation's CREATE platform.

The primary objective of the design sequence is to provide students with hands-on experience in solving the kind of complex open-ended design problems they are likely to encounter in ecological engineering practice, including physical, legal, economic, social and environmental constraints. The class also provides the students with experience in real-world applications of mathematics, science, engineering economics, ethics and other disciplines related to engineering analysis and design, and a clearer perspective on the value of research in addressing contemporary problems in engineering design.

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Engineering Expo

When: Friday, May 19, 2017; 11-4 pm

Where: Kelley Engineering Building, OSU, Corvallis

What: All of Engineers Senior Design displays. See what EcoE students are doing and ask them questions about their design projects.



Spring Banquet

When: Thursday, May 25, 2017; Appetizers at 5:30 pm, Dinner at 6 pm, followed by an awards ceremony.

Where: Memorial Union Horizon Room

What: Please join us for our end of the year award banquet for a chance to recognize the exceptional students in Biological & Ecological Engineering. Dinner is included.

Graduation BBQ

When: Friday, June 16, 2017; 12:30 – 2:00 pm.

Where: Outside Gilmore Hall

What: A potluck BBQ for graduating senior's families to tour Gilmore Hall and meet the department. All students, Alumni and donors are welcome.

Thank you

by Dr. John Bolte, Department Head

As Fall term comes to an end we wanted to take the time to thank you for your continued support and contributions to the Department of Biological & Ecological Engineering. Your contributions and support help our students develop the skills and tools necessary for being successful in their careers and in life.

The undergraduate program in Ecological Engineering continues to show growth. We are into our ninth year and we have over 100 undergraduate students enrolled in the program. Our graduate program also continues to do great things, with our faculty currently serving as major advisors to 25 graduate students.

We are very excited about the changes that have taken place within our department and I would welcome the opportunity to visit with you about the goals we hold for the future. Please stop by and say hello if you are ever on campus or visit our website.

Over the past year our students and faculty have worked in Ecuador, Ghana, Kenya, Chile, Canada, and all over the United States, continuing BEE's commitment



to meaningful Biological and Ecological research.

From everyone in Biological & Ecological Engineering, we wish you and your families a Happy Holidays and Wonderful New Year!

Sincerely,

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create.osufoundation.org/project/3476

WEBSITE

www.bee.oregonstate.com

Professor in the Spotlight



Dr. Hong Liu is an Associate Professor who joined Biological & Ecological Engineering in 2005 after receiving her PhD in Environmental Engineering from Hong Kong University and working as a PostDoc for two years at Penn State University.

Dr. Liu's main research efforts are in bioenergy production and development of energy sustainable water and wastewater treatment systems. Her publications in these areas have over 12,000 citations, which led her to be named as a Highly Cited Researcher and listed in The World's Most Influential Scientific Minds in both 2014 and 2015 by Thomson Reuters. Hong's current research projects include:

- Developing microbial electrochemical systems for biohydrogen production from low-cost

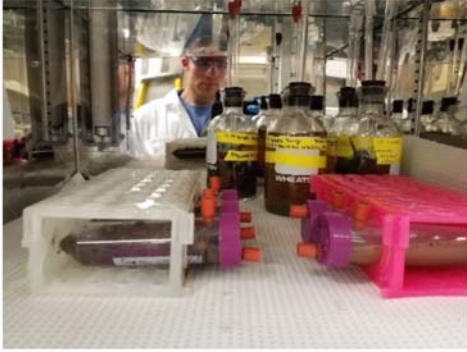
feedstocks, such as lignocellulose biomass and wastewater.

- Developing microbial fuel cell technology for electricity generation and wastewater treatment.
- Elucidating conduction mechanisms of anaerobic microbial community.

Hong says, "It has been a learning, exciting, and rewarding journey to work and teach at OSU. Being a professor at a leading research university is an ideal job for me because of my passion for both research and teaching. I chose OSU not only because of its great research and teaching environment, but also because Corvallis is such an open-minded and safe place for my family to live."

In her off-time, Dr. Liu enjoys time with her husband, her 6-year-old daughter, and 11 year-old-son. She loves cooking and watching movies in her spare time.

PROJECT IMPLEMENTATION



Travis Grohman works in the lab with the sequential batch reactors.



Column reactor set-up at the field site



Travis is investigating the flow problems in the outlet drainage line after the first flows of the season.

Woodchips Help Farmers Save \$

Travis Grohman, a Masters student in Water Resources Engineering, joined BEE in Fall 2015 with Dr. Frank Chaplen as his advisor. He is currently working on a research project developing design tools for increased efficiency of denitrifying permeable reactive barriers (PRBs) treating dairy runoff in Oregon funded directly by the Oregon Dairy Farmer's Association.

Why is this project important? "The purpose of this project is to make it easier for dairy farmers across Oregon to design and install effective woodchip bioreactors on their land. Woodchip bioreactors are simply trenches filled with woodchips that receive runoff from agricultural waste. The major function of these woodchip bioreactors is to remediate excess nitrate from agricultural runoff, although evidence also suggests that they may aid in reduction of harmful bacteria and viruses from agricultural runoff. Nitrate in agricultural runoff is a problem because of its stability in water and its tendency to fertilize harmful algae blooms in-stream. It is also harmful to humans if consumed in excess. The basic idea behind woodchip bioreactors is not a new one and has been used in groundwater and wastewater remediation of nitrate in one form or another for a long while.

"There are many technologies to consider with nitrate remediation of agricultural runoff (e.g. wetland construction, phytoremediation, buffer strips, etc.). We do not suggest that woodchip bioreactors are better or worse than these alternative technologies, but they fill an important niche in the repertoire of tools for nitrate reduction – they are cost effective, field-scale tool with no need for a change in current field management practices. They are also supported by enough evidence to prove their effectiveness. Woodchip bioreactors have been shown to last about 15 years with minimal maintenance. They may also be installed directly at the problem discharge area, making them perfect for treating agricultural subsurface drainage (or 'tile' drainage). They are also relatively easy to

install—requiring only a backhoe, inlet/outlet control structures, and woodchips.

"The major problem with designing and building woodchip bioreactors is estimating how they will perform. Because the bioreactors are populated naturally, with the efficiency dependent on local meteorological conditions (e.g. temperature and precipitation) as well as influent nitrate concentrations, it becomes difficult to estimate the nitrate reduction of a bioreactor that can be expected of a woodchip bioreactor. Our goal with this project is to make estimating the remediation potential of a woodchip bioreactor easier for dairy farmers across Oregon. The end goal of our is to provide Oregon dairy farmers with a simple computer tool which allows them to estimate the effectiveness of a woodchip bioreactor depending on their location, application rates, and area available for bioreactor installation."

Who else is working on it with you?

"Along with myself Dr. Chaplen, Troy Downing (OSU Department of Animal and Rangeland Sciences) as well as Dr. Jeff Morrell (OSU Department of Wood Sciences) are providing wonderful input on the project. I would also be remiss not to mention Seth Spencer, the Superintendent of the OSU experimental dairy farm, who has provided us with a great deal of assistance in our full-scale experimental bioreactors which are being built on the OSU Dairy farm."

How are you going to do this? "Our project studies woodchip bioreactors at three scales: laboratory, pilot, and full scale.

"At the laboratory scale, sequential batch reactors are used to obtain reaction rate laws under controlled conditions. Our laboratory scale reactors are being used to study the influence of such factors as temperature, inoculation source, nitrate influent concentration, residence time, and desiccation/inundation cycles.

"The pilot scale studies take the form of 4 inch plastic columns packed with woodchips."

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Senior Design continued

The term began with an introduction to the project and a weekend

field trip the Orenco Wastewater treatment facility, Reusstle-prayer Rock Vineyards and Misty Oaks Vineyards in Sutherlin, followed by a visit to the Woodburn Infiltration Galleries and OSU's Experimental Station in Hermiston. During their trip they learn about different ecological engineering processes and have the opportunity to learn from farmers and winemakers why this technology is not only important to crops but also the environment. The

students also feel the fieldtrip helps them get to know their cohorts a little more leading to stronger collaboration amongst team members as they pull from each other's individual strengths for their designs.

The Senior Design students finalized their designs at the end of Fall term and will begin building their pre-aeration treatment systems starting Winter term in January and present them at the Annual Engineering Expo at OSU's Kelley Engineering building on May 19. Like many professional engineers, the engineering students are raising funds so they can test their designs in the field and hopefully build a final system that has the possibility of being implemented throughout Oregon.

If you would like to make a tax-deductible donation to this year's designs, visit the CREATE page: create.osufoundation.org/project/3476



Ecological Engineering student, Stephanie Trujillo, works with her team on their pre-aeration treatment system design

BEE 101: First Year Students

This year the Ecological Engineering undergraduate program admitted 12 freshman and 10 transfer students. Every student in the program is required to take BEE 101 with Dr. Roger Ely, which is an introduction to engineering course with an Ecological Engineering focus. The students study engineering analysis and problem solving, professional ethics, the design process and teamwork. They test their knowledge of these topics at the end of the term with a final group irrigation project.

Irrigation projects around the world often require that water be raised to a higher elevation and in developing regions water lifting devices are often hand powered.

Their final project was to research, design, plan, construct, demonstrate and report on a hand-powered water lifting device with limited available resources, a typical issue many developing countries face.

The learning objectives of the project were to improve engineering teamwork and problems solving skills; to engage in practical creativity; and to practice writing a report, preparing plans, and documenting construction and testing. The teams compete at the end of the term to see which team can raise the most water the highest with the least amount of materials.

Dr. Ely added in a smaller challenge this year earlier in the term called the Marshmallow Spaghetti Tower challenge (made popular by Tom Wujec's TED Talk: Build a tower, build a team). Students were given 20 sticks of uncooked spaghetti, 1 yard of tape, 1 yard of string and 1 marshmallow. Using just these supplies, the teams attempted to build the tallest tower. The catch - the marshmallow has to be at the very top of the tower and the whole tower must stand with no

help for five seconds. Roger said the challenge really helped the students work together and come up with more efficient designs than previous years.

For the first time, all of the teams were able to successfully lift and move their water without their designs failing with the strongest design lifting close to 5 gallons of water 61 inches.

FIND MORE BEE 101 PHOTOS

www.facebook.com/BEEOSU



Open-Source Engineering

BEE Professor, Dr. John Selker, fired up the first 3D printer in January 2016 in the Openly Published Environmental Sensing (OPeNS) Lab with the idea of expanding the possibilities of scientific observation of our Earth, transforming the technology, methods, and culture by combining open-source development and cutting edge technology.

Dr. Selker says, "I was inspired by my nephew Adam Selker [to start the OPeNS Lab] who built his own 3-D printer, and went on to build a machine that measures stream bed permeability. At age 15, he was the youngest first-author of an American Geophysical Union scientific presentation that I know. If you want to know what the future will look like, ask a student. As we build this lab out, it is led by students from BEE, as well as computer and mechanical engineering."

The OPeNS lab has a few objectives:

- Develop new approaches to precision farming under a changing climate. Specifically, how to have sensor-systems of low enough cost and high enough accuracy to be used across most agricultural settings and for research in environmental science;
- Advance the field of environmental sensing for agricultural and environmental sciences through development of novel adaptation of 3-D printing and solid-state sensors of water, atmosphere, and soil status;
- Create global engagement through the world's first curated system of peer-reviewed, DOI indexed, open-source publication of designs and validation studies of evolving scientific instrumentation for environmental observation;
- Provide user, student and researcher access to the power of hands-on experimentation and experimental design through access to a wide range of machines;

- Foster student and faculty excitement, creativity and innovation by translating ideas into functional systems;

- Promote collaborative learning between farmers, extension agents, faculty and students around the world.

"The world has quietly changed," says Dr. Selker. "We can now transition things from our imagination to reality with a few clicks and a 3-D printer. Also, we can measure our environment at precisions never before possible at costs of pennies by leveraging the technology in our phones, cars, and home-sensing systems. Combine this all with ultra-low-power cell phone chips and data-logging micro controllers has transformed our ability to see our world. How can we translate this potential into action? Can we use these tools to improve agriculture? To monitor climate change? To understand our precious earth?"

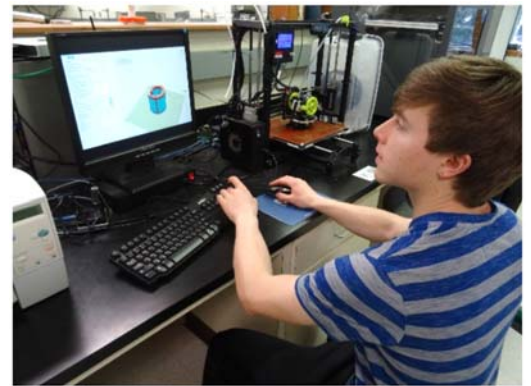
Selker is hoping to do all of this and more with the USDA funded lab that is focused on developing environmental sensing projects and research.

Running the lab for Dr. Selker is Dr. Chet Udell, who was recruited from University of Oregon where he taught Music Engineering after earning his PhD in Music Composition with cognate in Electrical Engineering from University of Florida, as well as two student technicians, Manuel Lopez (Sophomore, Electrical Engineering) and Mitch Nelke (Sophomore, Mechanical Engineering).

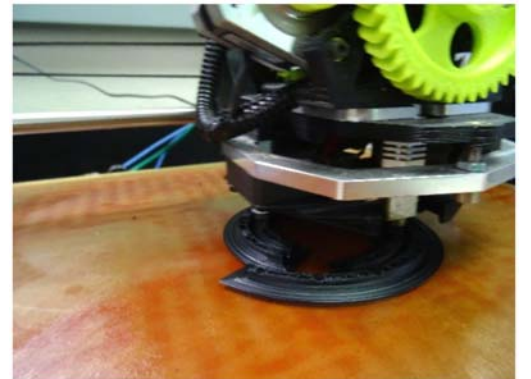
Dr. Udell has been working hard getting the lab set up by ordering supplies and machines, organized and producing items since he began in September. He says, "Our ethos at the OPeNS Lab isn't DIY (do-it-yourself), but DIT (do-it-together). Everything we help design is open-access and freely available on websites like GitHub and Thingiverse."

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3D DESIGNS COME TO LIFE



Water Resources Engineering Graduate Student Andrew Miller works on a design for his research project that will be printed on one of the 3D printers in the OPeNS Lab.



An OPeNS lab printer prints a piece for a prototype on one of the 3D printers that was designed by one of the Graduate Students advised in BEE.



OPeNS Lab Technician, Manuel Lopez, makes adjustments to the laser cutter which will translate into a cut design. The possibilities are endless as the laser can cut through almost any material someone would like to work with.

Woodchips continued

"Subsurface drainage discharge from the OSU dairy farm is collected and amended with nitrate for use as an influent media into the columns. The influent media is pumped into the bottom of the column and effluent flows out the top at a steady rate. Temperature is logged using a data logger and influent/effluent is collected periodically for testing. The major purpose of these column reactors is to provide data midway between the controlled laboratory experiments and the full scale experiments over which we have very little control. The column studies also allow us to calculate physical properties of the woodchips we are using for the experiment (e.g. drainable porosity and hydraulic conductivity). Currently, the most interesting question we are exploring with these columns is determining the best method for scaling our laboratory-derived reaction rates to

the slightly chaotic, diurnal temperatures experienced in the field.

"The full scale experiments consist of two woodchip bioreactors. The bioreactors are both located along the main discharge line of the existing tile drainage system at the OSU Dairy farm. The two bioreactors have differing geometries so that we may better calibrate our hydraulic model of flow through the bioreactor. This is important when considering that the configuration of land each dairy farmer is willing to use for his/her bioreactor can differ dramatically. Inlet and outlet control structures control the flow through the reactor, with excess flow diverted to a bypass line, avoiding overflow and/or undesirable hydraulic residence times within the bioreactor. Pressure transducers are to be used for monitoring the water level at points along the bioreactor, and samples from influent, effluent, and sampling wells within the bioreactor are to be periodically tested for nitrate levels. The

full scale bioreactors are currently still under construction due to ongoing repairs needed on the subsurface drainage line, but we plan to have them running by mid-January.

"This project is funded directly by the Oregon Dairy Farmers Association. Our initial grant was for \$20,000 with a second year grant proposal awaiting approval. It brings a great deal of satisfaction to be funded by a group representing the stakeholders of our project; it lets us know that this project is something that they are interested in and in the end we hope to offer as much assistance to our stakeholders as possible. Our goal is that the efforts we exert on this project makes it easier and more cost-effect for dairy farmers across Oregon to consider woodchip bioreactors as a possible nitrate reduction option, as well as design an effective bioreactor should they choose to include this technology in their nutrient management plan."

OPENS continued



"All of our designs, code, and methods can be downloaded, reproduced, and modified by anyone," he continues. "In so doing, we're empowering a global community to make, use, and improve

devices that help us gain new insights into the world around us - and that is really cool."

Selker continues, "Our vision is to cut the price of measurements per dollar by 100, and bring techniques that open five entirely new measurement opportunities each year."

Examples of current projects include a new way to sample the constituents of rainwater for \$5 in place of the current \$500 system; a 100-sample water quality device for \$300 in place of the current 24-sample device that costs \$5,000 (and ours does this while protecting the samples from any losses, which the current technology does not achieve); a soil-profiling device that reports gas and water status of the surface every 6" to 6 feet depth; a rain gauge that for \$10 reports not only the rain, but also measures the evaporation; and the list goes on.

Udell says, "We are seeking to collaborate not only with researchers within Oregon State, but also with academic extension, our regional agricultural and environmental

communities, and academic researchers throughout the world."

The OPEnS lab is located on the second floor of the Gilmore Annex and if you want to get involved, follow them online, propose project ideas and/or sign up for lab innovation updates through their website at www.open-sensing.org.

Pictured: The "Rube Goldberg" box was designed to demonstrate at conferences some of the technology that can be built in the OPEnS lab. The box takes in water from another box (not pictured) through tubing and deposits it in a bottle in the bottom of the box. Inside the bottle there is a sensor that tells an Arduino that the bottle is full and turns two pumps on. These pumps move the water to another container. When the other container is full a solenoid valve opens to let the water flow out of the box through some tubing and into the other box.

OPENS LAB WEBSITE

www.open-sensing.org

Ecological Engineering Student Society

The Ecological Engineering Student Society (EESS) of OSU was founded in 2009 by students in EcoE. They are a group of motivated students who view the club as a place to acquire hands-on experience with system design and construction, data collection, professional communication and research. The club allows students to be involved with a wide range of ecological engineering applications that aren't necessarily available in the classroom.

Faculty Advisor: Dr. Chad Higgins

President: Jack Blackham

Vice President: Lars Larson

Secretary: Kayla Nolette

Treasurer: Neal Poovaviranon

Project Coordinator: Lucas Evans

Mission Statement

"An interdisciplinary assembly of students focused on facilitating student engagement in campus and community opportunities, promoting professional growth and development, and to stimulate student reasoning towards the design of diverse, adaptable, and resilient engineering solutions."

Current Projects

EESS is focused on the completion of two existing projects that include a large aquaponics system and a rainwater catchment system. Both of which are located in the EESS Weniger Hall greenhouses. The aquaponics system cycles dissolves nutrients between a large fish tank and plants to grow edible produce and fish simultaneously. The rainwater catchment captures runoff from the greenhouse roofs and stores it in a pressurized tank to water greenhouse plants. Nearing completion, some necessary modification and fine-tuning remain for it to be fully operational. These projects will offer future EESS members the opportunity for testing and monitoring. Eventually the club has plans to install an arduino to monitor water quality of the larger, multi-tiered aquaponics system and as a water level control of the rain catchment system. This presents an opportunity for

basic computer programming and electrical engineering skills within the scope of ecological engineering.

Looking to the Future

As the club moves forward, they are constantly looking for new projects to take on. Some of the potential options include design and construction of an improved drainage system at Starker Arts Garden for Education (SAGE) or the adoption of a stream and bioswale on the OSU campus. Many members have also expressed interest in learning and incorporating geotechnical skills into future projects. In similar fashion to the professional world, all projects taken on by the EESS offer future opportunities to monitor, improve, or alter as future members see fit. Projects can be proposed by any club member and must pass through the EESS Project Fee Board committee, which acts as an oversight into the feasibility, relevance to ecological engineering, project cost, sustainability and educational value of the proposal.

How you can help

The EESS is constantly looking to grow and improve. Please contact the club President, Jack Blackham (blackhaj@oregonstate.edu); Event Coordinator, Willow Walker (walkewil@oregonstate.edu); or Project Coordinator, Lucas Evans (evansluc@oregonstate.edu), if you wish to propose a project, present research or professional work, or believe that your job location would make for an informative and practical field trip. Finally, thank you for all your work and involvement within the realm of ecological engineering and beyond to make this world a better place.

How you can help

Find EESS online: sites.google.com/a/onid.oregonstate.edu/eess/about and on Facebook: www.facebook.com/groups/EcologicalEngineeringStudentSociety/

EESS IN THE COMMUNITY



Down the River Clean Up

EESS Student joined the Clackamas River Basin Council to help with clean-up on the Clackamas River, a tributary of the Willamette entering near Oregon City.



Greenhouse

EESS member, Ecological Engineering Student Sam Rabe, works on the aquaculture set-up in their greenhouse in Weniger Hall.



EESS Plant Sale

EESS club members at the Fall Plant Sale to help raise money to fund club projects.

EESS OPERATES PARTIALLY THANKS TO OUR GENEROUS DONORS

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www.campaignforosu.com/bee-scholarship

WEBSITE

www.bee.oregonstate.com

Ron Miner Scholarship Recipient



The Ron Miner Memorial Scholarship honors the memory of J. Ronald Miner, an Agricultural Engineering professor at OSU from 1972-2003. Dr. Miner was an internationally recognized expert on livestock waste management, water quality and odor control. At the same

time, he served as an endlessly supportive coach and mentor to his graduate students and is remembered for his charm, enthusiasm for life and love for teaching.

Carl Talsma is a Water Resources Engineering M.S. candidate in BEE and the recipient of the Ron Miner Memorial Fellowship. Carl is working under advisor Dr. Stephen Good.

Carl graduated with his B.S. in Environmental Engineering from Cornell in 2015. Carl has worked for the Whitefish Lake Institute, a non-profit organization, where he helped in providing comprehensive water quality data collection and analysis. He has also interned at the Pu'u Wa'awa'a Hawai'i State Forest Reserve where he conducted a study of herbivory and disease on out-planted endangered plant species.

Carl, along with advisor Dr. Stephen Good, Biological & Ecological Engineering, is working on determining discrepancies between remote sensing evaporation models and the error within those models. Carl is also working on the partitioning of evaporation and transpiration using stable isotopes. Carl is hoping to gain a deeper understanding of hydrologic processes and environmental modeling and apply those skills to a professional career.

Thank you to Betty Miner and the family of Dr. Ron Miner for their continued support of the Biological & Ecological Engineering program via their generous donations which give us the opportunity to fund a phenomenal students like Carl.

To donate to one of BEE's scholarship funds, visit www.campaignforosu/beescholarship.

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