2017-18 Annual Report

IOWA STATE UNIVERSITY

Department of Mechanical Engineering

The Department of Mechanical Engineering at Iowa State University continues for a second year as the nation's largest undergraduate ME program in the country. Our undergraduate enrollment for 2017-18 rose to 2,211, which is again an all-time high. We added four new faculty members, each with a unique focus. Research highlights include projects to increase energy efficiency in buildings, smart algorithms that can learn to visually identify stressed crops, tiny sensors to identify pathogens in food that can fit into food processing equipment and packaging, highly reliable batteries for pacemakers and other devices implanted in the body, and many more. Through their research, our faculty and students are working to improve everyone's lives, health and happiness. As a testament to the quality and dedication of our faculty, three of our junior faculty have been awarded very prestigious CAREER awards from the National Science Foundation.

Next year, 2019, will mark 150 years since the entry of our first class of students who studied "Mechanic Arts including mechanical engineering" at Iowa State. We continue to graduate highly qualified engineers who are much sought after by employers. I hope you enjoy reading about them.

Dr. Caroline Hayes
Lynn Gleason Professor of Interdisciplinary Engineering
Chair of Mechanical Engineering

"Give us an eager mind and we will give you back a disciplined and qualified mind."

~ Henry M. Black, ME Department Chair 1946-1972

Iowa State University Facts

- **Mission:** Create, share and apply knowledge to make Iowa and the world a better place.
- **Founded:** 1858
- **Enrollment (2017-18):** 36,321
- **Faculty and staff:** 6,000
- **Location:** Ames, Iowa (pop. 66,498)
- **Campus:** 1,900 acres
- **10 schools and colleges**
- **100 majors**
- **Alumni:** More than 248,000 living in 50 states and 150 countries
- **Ranked "Best college value in Iowa" by *Money Magazine***
- **$243.7 million directed to research in FY17**

By the Numbers

59
Faculty members

5
Patents awarded

214
Journal articles published

147
Conference publications

11
Professional society fellows

Largest
undergraduate enrollment in the nation

2,481
Total Students

Largest
undergraduate enrollment on campus

$12.7 million
department endowment

$4.5 million
in sponsored awards

$1 million
in expendable donations

IOWA STATE UNIVERSITY
Mechanical Engineering

3 2018 NSF CAREER awards

Learn more at
me.iastate.edu/nsf-career

Shan Hu
Assistant Professor

Reserach Areas
Nanomaterials for energy storage and energy harvesting

"Scalable Manufacturing of Hierarchical Nanostructures by Acoustically Modulated Emulsion Technique for Next Generation Renewable Energy Applications"

Adarsh Krishnamurthy
Assistant Professor

Reserach Interests
Computer-Aided Design (CAD) and Cardiovascular Biomechanics

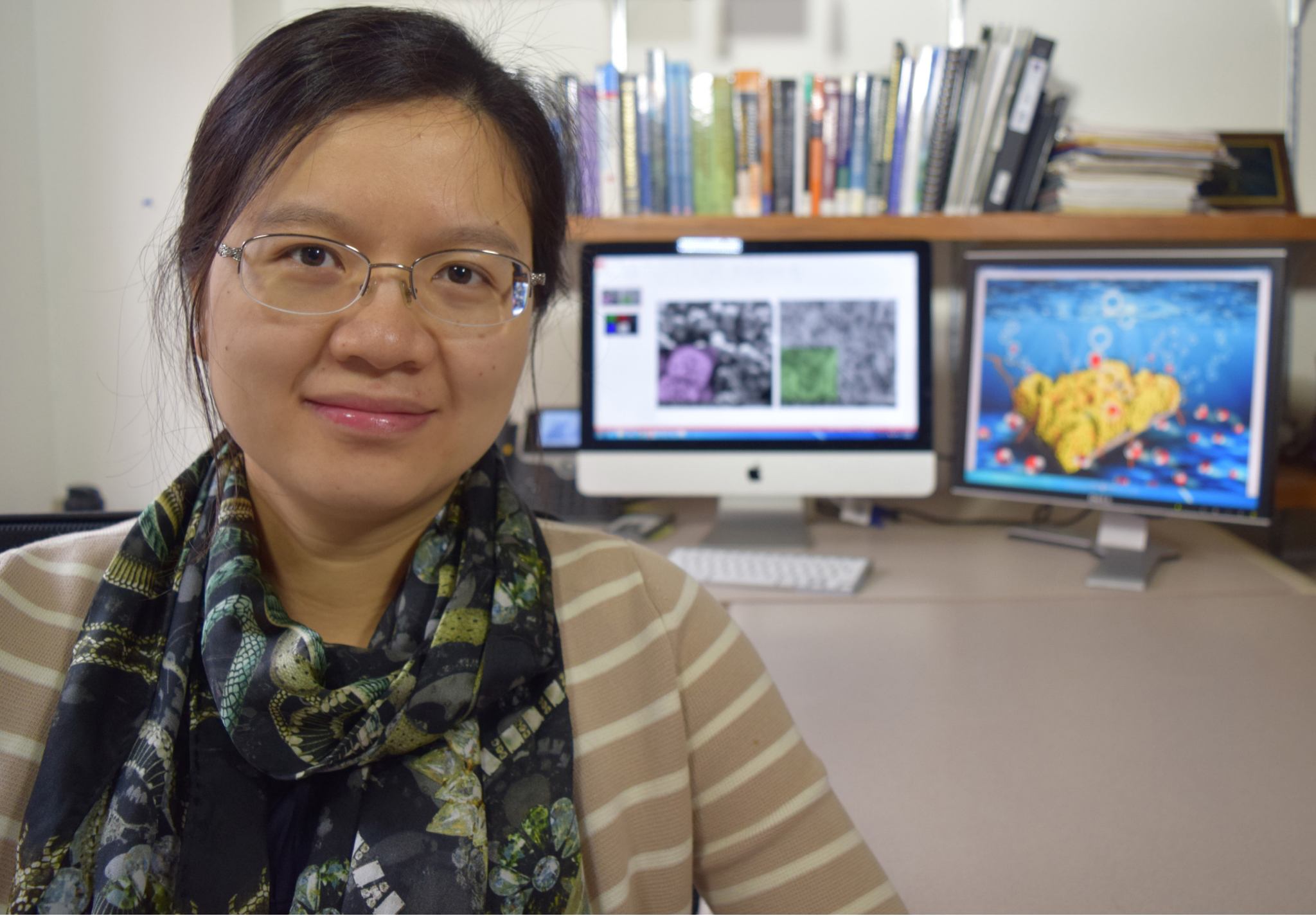
"GPU-Accelerated Framework for Integrated Modeling and Biomechanics Simulations of Cardiac Systems."

Juan Ren
Assistant Professor

Reserach Areas
Nanoscale probe-based broadband biomechanics characterization and cancer cell characterization

"Modeling and Control of Cellular Response to Dynamic Mechanical Manipulation Using a Dual-Input Platform."

GROUNDBREAKING RESEARCH. INSPIRING FUTURE ENGINEERING LEADERS.



Improving solar panels, batteries for wind energy storage

An ongoing research project by a mechanical engineering faculty member could lead to improved solar cells and better batteries for wind energy storage.

Shan Hu, an assistant professor of ME, is a recipient of the CAREER award from the National Science Foundation (NSF). The award will provide her with $500,000 over the next five years for her project entitled "Scalable Manufacturing of Hierarchical Nanostructures by Acoustically Modulated Emulsion Technique for Next Generation Renewable Energy Applications."

"I will investigate how the acoustic field can move and assemble droplets of an emulsion, a multi-phase fluid system consisting of two or more immiscible liquids. And apply this knowledge to develop a new nanomanufacturing strategy for the scalable assembly of nano-sized building blocks into functional hierarchical structures," said Hu. "The resulting hierarchical structures hold the promise of boosting the performance of solar cells, batteries, catalysts, and more."

Hu's research will mostly focus on the mechanical engineering principles of acoustics and fluid mechanics. Specifically, she'll look at the dynamics of emulsion droplets when they are subjected to acoustic radiation forces and drag forces in a standing acoustic field. The findings of her research can have various applications, some of which relate directly to Iowa.

"The knowledge gained from this research project will enable the scalable manufacturing of designer materials, which hold the promise of boosting the performance batteries, which is an important component for wind energy storage, and catalysts, which enable faster and more efficient production of biofuels, both of which are major industries here in Iowa," said Hu.

"I want to show that although mechanical engineering is one of the oldest branches of engineering, knowledge from a mechanical engineering degree is essential for solve emerging technical challenges in advanced materials and manufacturing, renewable energy, and more."

Hu's research will also aim to bring in students from underrepresented minority groups as well as students from community colleges to Iowa State to complete four-year degrees and potentially advanced degrees.

"Engaging underrepresented minority groups is a good investment of time and effort," said Hu. "My research group will benefit from increased diversity, because I believe a diversified group brings new perspectives and nurtures creativity to solve research problems."

Hu is currently building the proposed nanomanufacturing platform with a team of both graduate and undergraduate students. In the next step, they will establish a multi-physics and multi-scale computational model of the setup to speed up the material design and manufacturing process.

Treating cardiovascular diseases with computational models

A research project by a mechanical engineering faculty member will use computational modeling to improve treatment processes for various cardiovascular diseases.

Adarsh Krishnamurthy, an assistant professor of mechanical engineering, is a recipient of the CAREER award from the National Science Foundation (NSF). The award will provide him with $500,000 over the next five years for his project entitled "GPU-Accelerated Framework for Integrated Modeling and Biomechanics Simulations of Cardiac Systems."

"The overarching goal of this research is to advance the state-of-the-art technology in translational medicine with the help of computational modeling and interactive analysis tools that will improve the basic understanding of the cardiac muscle and facilitate personalized treatment of cardiovascular diseases in patients," Krishnamurthy said.

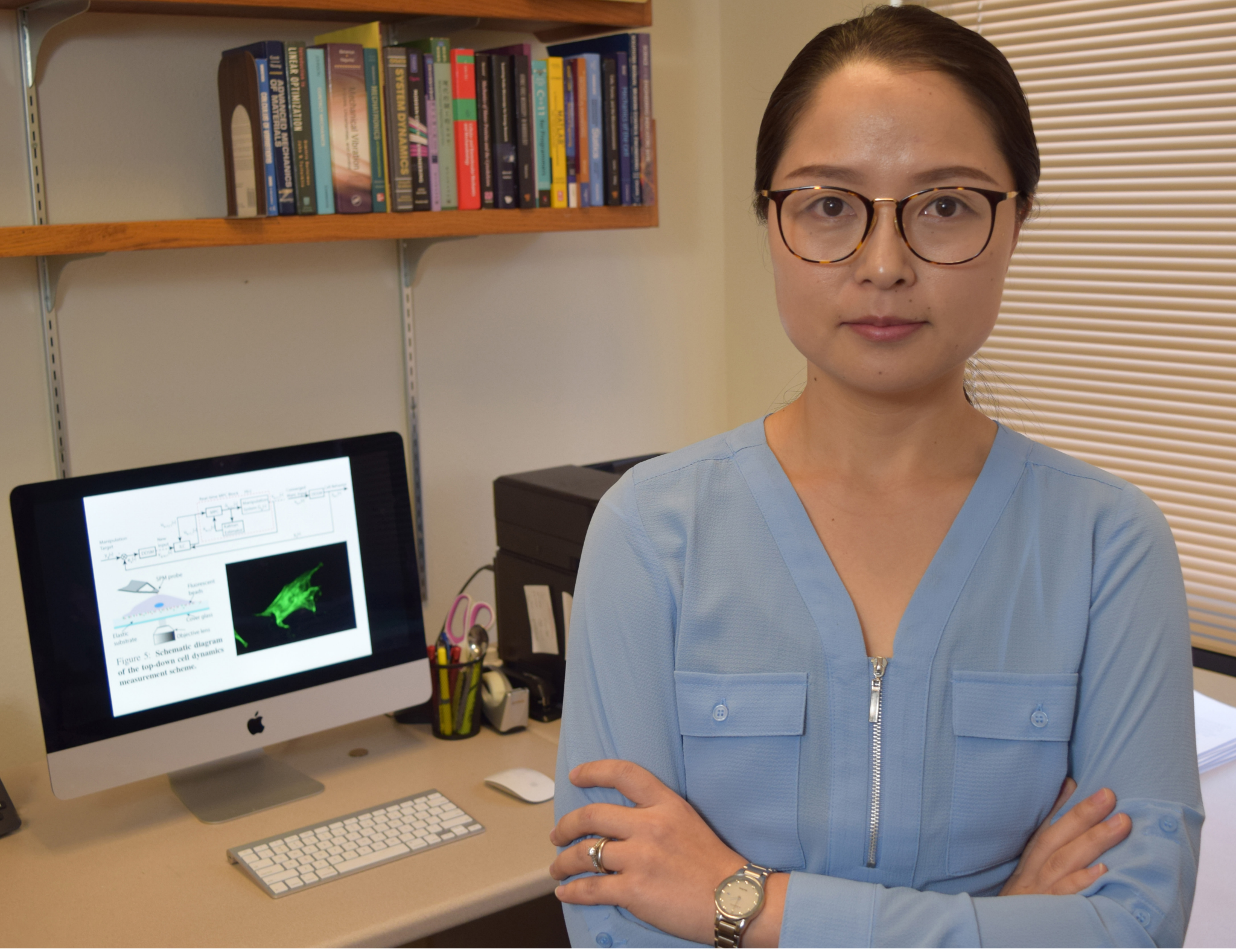
The research will focus on creating novel computational methods and tools to automate simulation and analysis of patient-specific cardiac systems resulting in optimized cardiac therapies and developing advanced multi-scale methods to model muscle contraction and growth that will help in advancing knowledge about disease and therapeutic mechanisms.

Krishnamurthy said that computational models, developed from patient-specific clinical data, can help refine the diagnosis. His proposed research project will focus on developing predictive computational models that can be used to explain the different mechanisms of heart failure.

"One of the main challenges in developing patient-specific models are the lack of tools to systematically generate the patient-specific geometry and tune the parameters of the model to match baseline cardiac characteristics of the patient," said Krishnamurthy. "As part of this research we will build computational tools that facilitate the generation of patient-specific cardiac models from clinical data – such as CT or MR images and pressure measurements – with minimal user intervention that can replicate the baseline characteristics of the patient and can ultimately be used to personalize heart failure intervention therapies."

Krishnamurthy's research also aims to bridge GPU-accelerated modeling and simulations with biomedical engineering. Through subject-specific modeling and the resulting data, bioengineers and other medical professionals will be able to better understand complex heart diseases in humans as well as in different species.

While this research has applications that extend nationally and even internationally, it can also have a direct impact in Iowa where heart disease has been the state's leading cause of death since 1920, according to data from the Iowa Department of Public Health. Through this research Krishnamurthy said he would like to better pinpoint the regional differences that lead to higher rates of heart disease in Iowa.



Examining the mechanical behavior of cells

A research project by a mechanical engineering faculty member will study the dynamic mechanical behavior of live cells which might someday be used to help treat cancer.

Juan Ren, an assistant professor of mechanical engineering, is a recipient of the CAREER award from the National Science Foundation (NSF). The award will provide her with $500,000 over the next five years for her project entitled "Modeling and Control of Cellular Response to Dynamic Mechanical Manipulation Using a Dual-Input Platform."

"The aim of this research is to develop a hardware as well as a control algorithm to study the dynamics of cell mechanical response, or what we call mechanotransduction," said Ren. "The first step we need to do is invent a platform which can excite or disturb the cells using forces on both the top of the cells as well as the bottom where they grow. With this platform, which we call the dual-direction platform, we can observe if we excite the live cells from different directions, and how the structure of the cytoskeleton, which is the internal skeleton of the cells, will change in order to affect the cell's mechanical response."

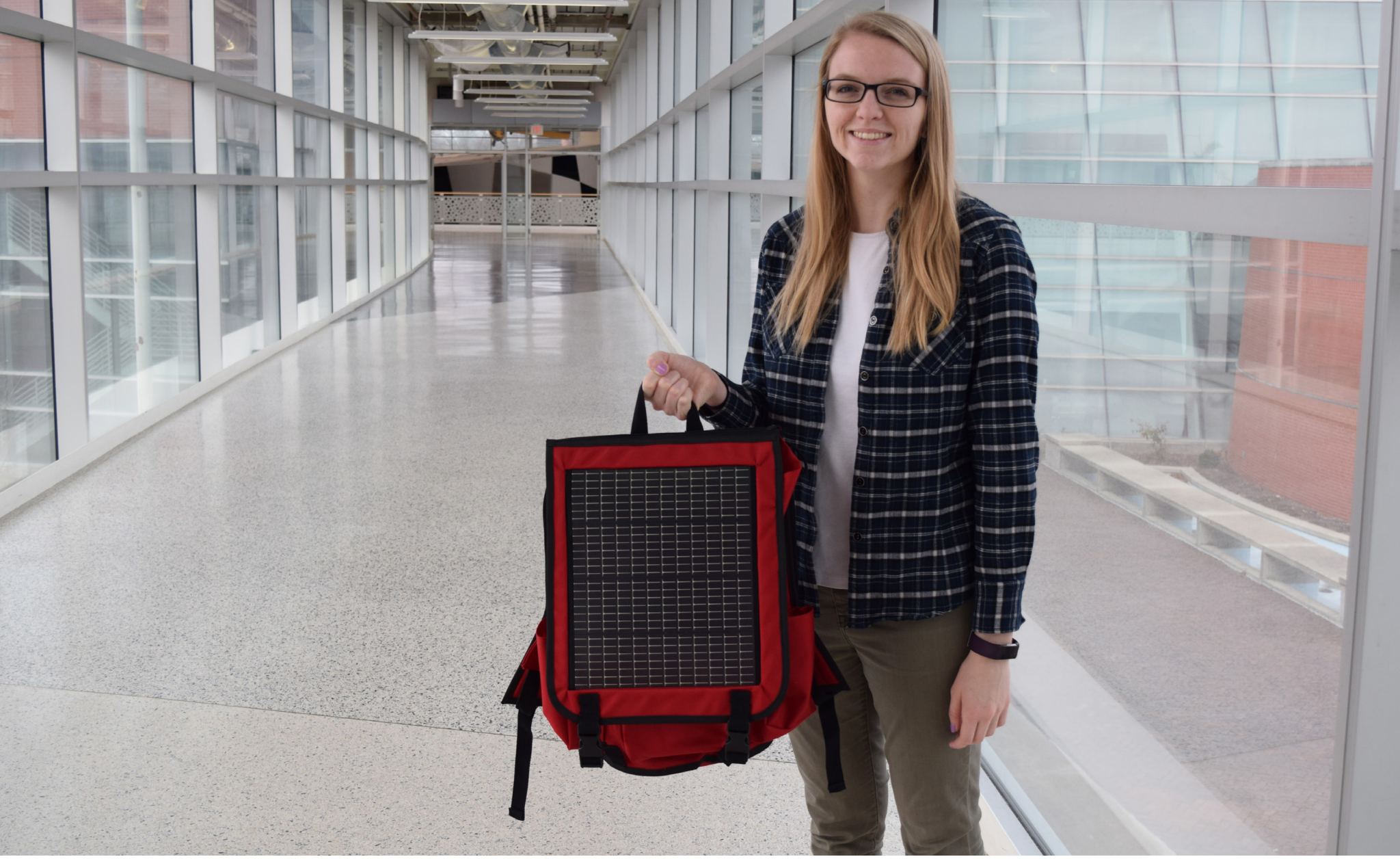
Once Ren and her research team study this, the next step will be to use control approaches to manipulate the mechanical properties of cells to make them behave in a way mechanically that is good for tissue generation or other biomedical applications.

"This is an interesting topic and no one has looked at it extensively from the mechanical and controls point of view," said Ren. "I'm junior faculty here and this was the first time I submitted an NSF CAREER proposal so I was pretty excited when I heard I won it."

The primary application area for his project is for biomedical uses. From the medical point of view, Ren and her research team can use the outcome of this research to improve a medicine's effectiveness. For example, they can study the most effective and efficient ways for cells to absorb the active components of a drug or protein.

Another direct product of this is that because they are studying the mechanical reorganization of the cytoskeleton and its dynamics, they can use the data and the model they build for biosynthesis approaches to build materials or structures which can synthesize the behavior or simulate the behavior of true cells or even at the tissue level.

More effective cancer treatment would be one potential outcome of this research. In general cancer cells are softer than normal cells, and because they are soft they are more flexible to migrate to affect other healthy tissues. Once Ren and her research team can control the growth of the cell or tissue they can target and eliminate the bad cells or tissues, adding that the research can also have applications outside of the biomedical field.



ME student designs award-winning solar-powered backpack

A dying cell phone or laptop battery can be a source of anxiety for an already busy college student, but a project by a mechanical engineering senior aims to alleviate that.

Courtney Beringer, a senior in ME with a minor in energy systems, has spent the past three years working with Eulanda Sanders, Donna R. Danielson Professor in Textiles and Clothing and Chair of the Department of Apparel, Events, and Hospitality Management (AESHM), developing and prototyping a solar panel-equipped backpack.

The idea for the backpack came about because of Beringer's participation in Iowa State's Honors Program. Sanders was interested in overseeing an interdisciplinary project that would bring engineering students together to design a wearable product incorporating solar panels. Beringer jumped at the opportunity since it allowed her to combine her two passions: engineering and environmental sustainability. She started on the project in January of 2016 and worked with Sam Vande Loo, a fellow undergraduate in ME.

"I conducted a focus group interview to collect qualitative data and then made an online survey that received over 700 usable responses with qualitative and quantitative data," said Beringer. "From this data, we decided to design a solar powered book bag that uses solar energy to create electrical energy that can charge various devices."

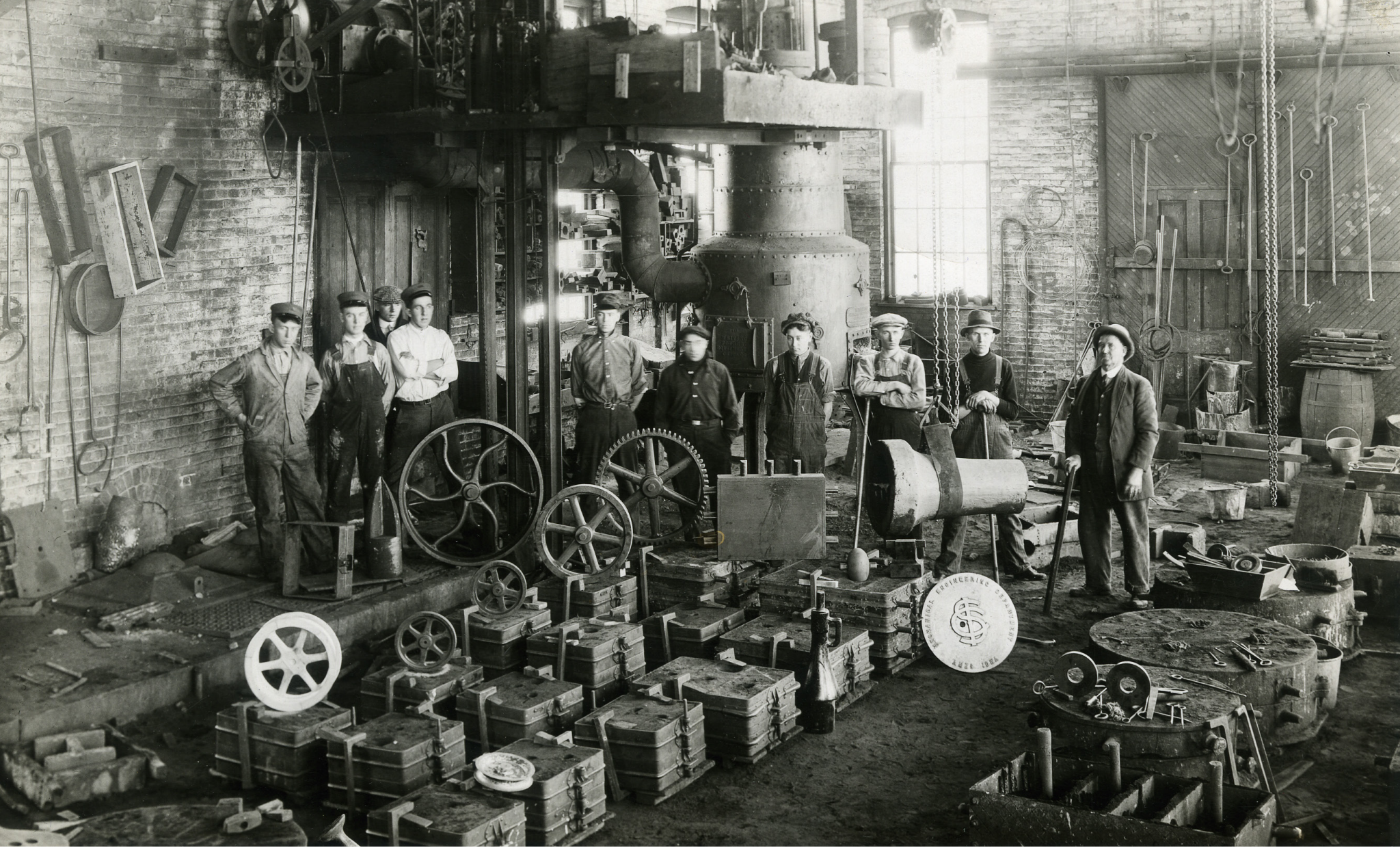
She then conducted industry-approved tests on the textile materials to determine what was best for a book bag with electrical integration including color fastness, abrasion and water resistance. By incorporating design and drafting skills she learned in the ME curriculum, she was able to determine the correct electrical components and proper solar panel size. She also incorporated design features suggested by her survey respondents such as laptop and water bottle pockets, a removable panel, battery storage and the ability to charge a laptop. Much of the research took place in the textile experiment labs and product development facilities inside LeBaron Hall. Beringer also collaborated with Ames-based PowerFilm Solar on this project and received help from now-AESHM Ph.D. graduate Chanmi Hwang and current AESHM doctoral student Bingyue Wei.

After developing a near-final prototype she submitted an abstract and a 30-page paper about her project to the International Textile and Apparel Association Best Student Paper competition in April. She was notified the following month that her project had received first place. She completed the final product in October of 2018 then had the opportunity to present her research at the International Textile and Apparel Association (ITAA) Annual Conference in Cleveland, Ohio in November.

Beringer has presented at the National Conference on Undergraduate Research in Oklahoma, Research at the Capitol in Des Moines, and the Iowa State Conference on Undergraduate Research in Ames. Additionally, she has worked in the Experimental Multiphase Flow Lab, overseen by Ted Heindel, Bergles Professor of Thermal Science and a professor of mechanical engineering.

"In Dr. Heindel's lab I help run X-ray experiments and do much of the designing and construction for the experiments. I often use Boyd Lab to fabricate parts as well as the water jet in Sukup Hall," said Beringer. "I also complete research by writing programs, analyzing data from X-ray experiments, and presenting my findings."

Beringer plans to complete her degree in May 2019 and after graduation will work in Des Moines, designing and consulting green energy systems for new buildings. After that she plans to attend graduate school to pursue a doctorate in the renewable energy field.



ME at Iowa State prepares to celebrate 150 years

Iowa State Agricultural College formally opened its doors to students in March of 1869. Two courses of study were offered at the time of the opening of the college: agriculture and mechanic arts. Next year, 2019, will mark the 150th anniversary of the first class of students entering Iowa State. Among that class was Edgar W. Stanton, mechanical engineering's first alumnus who would go for nearly half a century serving his alma mater in various faculty and administrative roles including four stints as Acting President. Iowa State's ME department plans to publish a book highlighting the achievements of Stanton and other aspects of the department's illustrious history. Here are a few of those highlights that will be covered in the book:

- **1895:** Elmina Wilson, a drawing instructor, became the department's first female faculty member.
- **1908:** Florence Kimball graduated with her ME degree, making her the department's first female alumna.
- **1914:** Walter Madison graduated with his ME degree, making him the department's first African American alumnus.
- **1918:** ME chair Warren Meeker led the program that provided roughly 500 enlisted men with training in machine shop, auto mechanics, and repair processes as part of the war effort.
- **1942:** Various engineering departments at Iowa State offered technical training courses to assist with the war effort.
- **1944:** ME student Bob Sauer was part of the Iowa State Cyclone team that made it to the Final Four of the college basketball tournament.
- **1953:** Iowa State conferred its first PhD degrees in mechanical engineering.
- **1970:** ME grad and former Cyclone lineman Ed Bock became the first Iowa State player inducted into the College Football Hall of Fame.
- **1974:** Former ME student Berkley Bedell was elected to the U.S. House of Representatives serving Iowa's 6th congressional district from 1975 to 1987.
- **1980:** ME grad Thomas Evans was elected to the U.S. House of Representatives, serving Iowa's 3rd congressional district from 1981 to 1987.
- **2016:** Iowa State surpassed Georgia Tech to became the nation's largest undergraduate mechanical engineering department.
- **2017:** Iowa State's PrISUm solar car, led by a ME student, traveled to Australia to compete in the Bridgestone World Solar Challenge for the first time in school history.