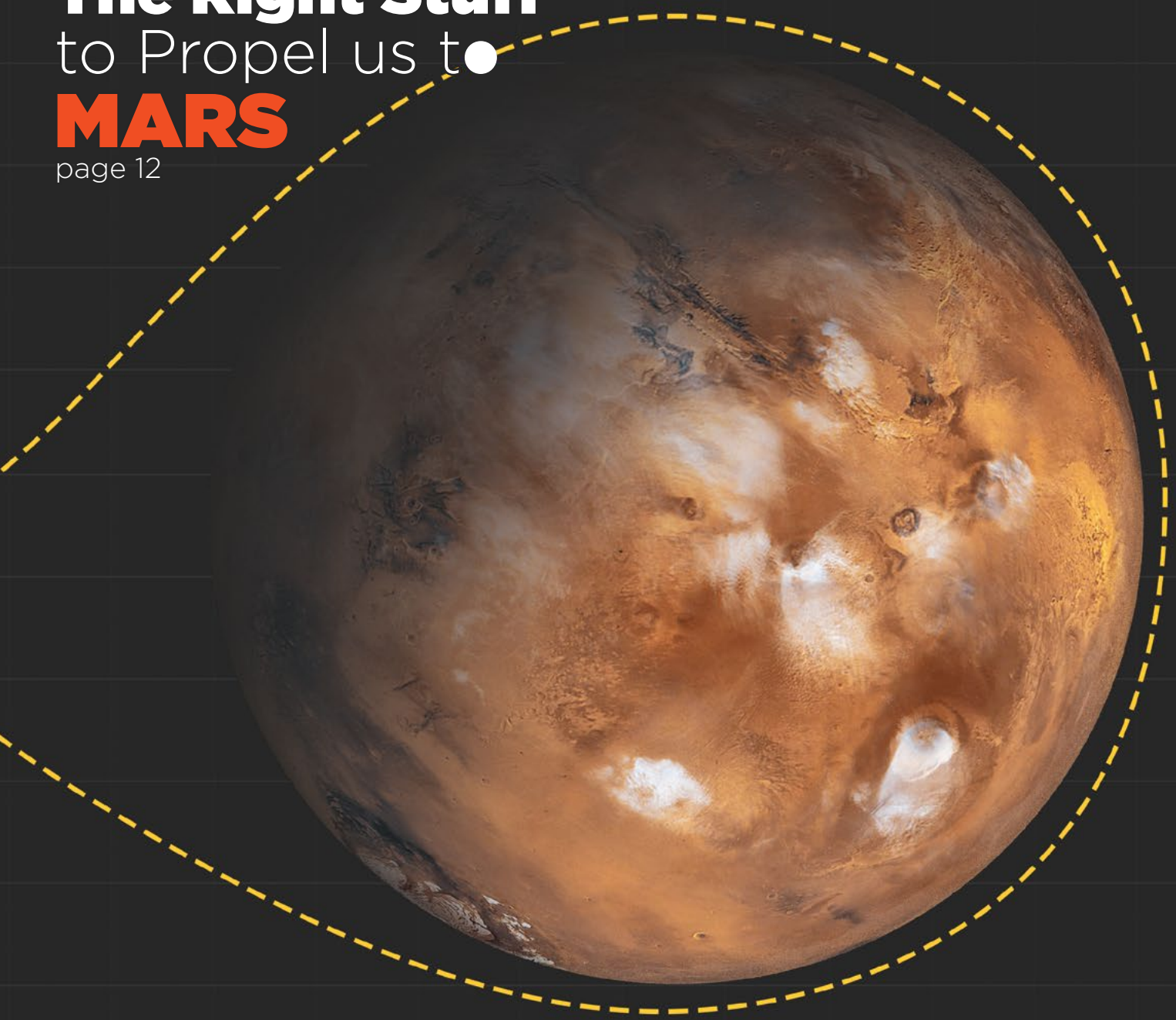
THE SOURCE

ALUMNI MAGAZINE • FALL 2018

The Right Stuff to Propel us to MARS

page 12

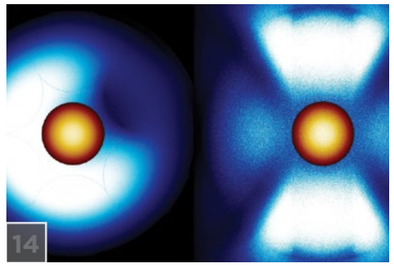


NUCLEAR ENGINEERING

A Department on the Rise • Traveling to Mars • Nuclear Pinch Hitter

Table of

CONTENTS



On the Cover: A team of students are working with UT-ORNL Governor's Chair Steven Zinkle on propelling us to Mars. *Photo by NASA.*

The Source is published annually by the Department of Nuclear Engineering at the University of Tennessee. **ne.utk.edu**

Department Head
J. Wesley Hines

TCE Director of Communications
Christie Kennedy

Project Manager
Melissa Callahan

Designer
Andy Gallaher

Writers
Randall Brown
David Goddard
Whitney Heins

Editorial Assistant
Rachel Bashore

Printer
University Printing and Mail

From the Department Head

This is a truly exciting time for us here on Rocky Top. The university recently welcomed its largest freshman class and the quality of students is amazing. The Tickle College of Engineering also welcomed its largest-ever freshman class, including a record percentage of women. As for our department, we have 56 new freshmen with 20 percent bringing in enough AP credits to make them sophomores and an average math ACT score that is the highest in the college.

I am happy to report that our ABET accreditation visit found no shortcomings. Having a perfect ABET score is attributed to the hard work of our dedicated faculty and staff. This improvement shows we are not only growing and educating top students, but also our educational outcomes are being met.

If you come visit us, you will quickly find out that Pasqua Hall is gone. Pasqua served our department well for many years, but we simply grew out of it and are excited for our new building. In December, we moved into the former home of Earth and Planetary Sciences—now the Nuclear Engineering Building. The design for the $129 million new engineering complex is complete and we are in the process of approving construction documents. Foundation work will start later this year, with the opening scheduled for 2021. The new building will triple our department's footprint and include 23 new laboratories and several unique research capabilities. The Pasqua name will live on as we are naming our largest classroom Pasqua Hall.

When I say we grew out of our building, I really mean it. Last year, we had 368 students, our largest class ever. Our 132 PhD students was the largest nuclear engineering PhD student class in the history of the United States. Additionally, we graduated 24 PhDs, which was the largest graduating class in US history, and yes, they are all getting challenging jobs at government agencies, universities, and in industry. With a faculty of only 15, this feat certainly attests to the quality and hard work we invest in our students. I am truly fortunate to work with such a talented group of scholars.

We recently started a Nuclear Engineering Hall of Fame and have had six inductees to date. These alumni have been extremely successful in their chosen areas: as entrepreneurs, industrial executives, and government leaders. Their continued engagement with the university has a positive influence on our directions and success. Alumni investments in our department continue to propel us forward and provide the priceless donation of strategic thought and advice on our advisory boards.

As we continue toward our goal of becoming the number one nuclear engineering department in the country, we need your continued support and engagement. Please feel free to reach out, visit us, and strengthen our relationships.

Wesley Hines
Charles P. Postelle Distinguished Professor
Chancellor's Professor
Department Head, Nuclear Engineering

BEST of the BEST

by David Goddard. Photography by Shawn Poynter.

In 2018, the Department of Nuclear Engineering graduated 24 doctoral students—a record number for any nuclear engineering program in the United States. Ever.

But success like that doesn't just happen overnight. It was the result of foresight, planning, growth, and making careful considerations over a period of years to create the most well-rounded and high-value program possible.

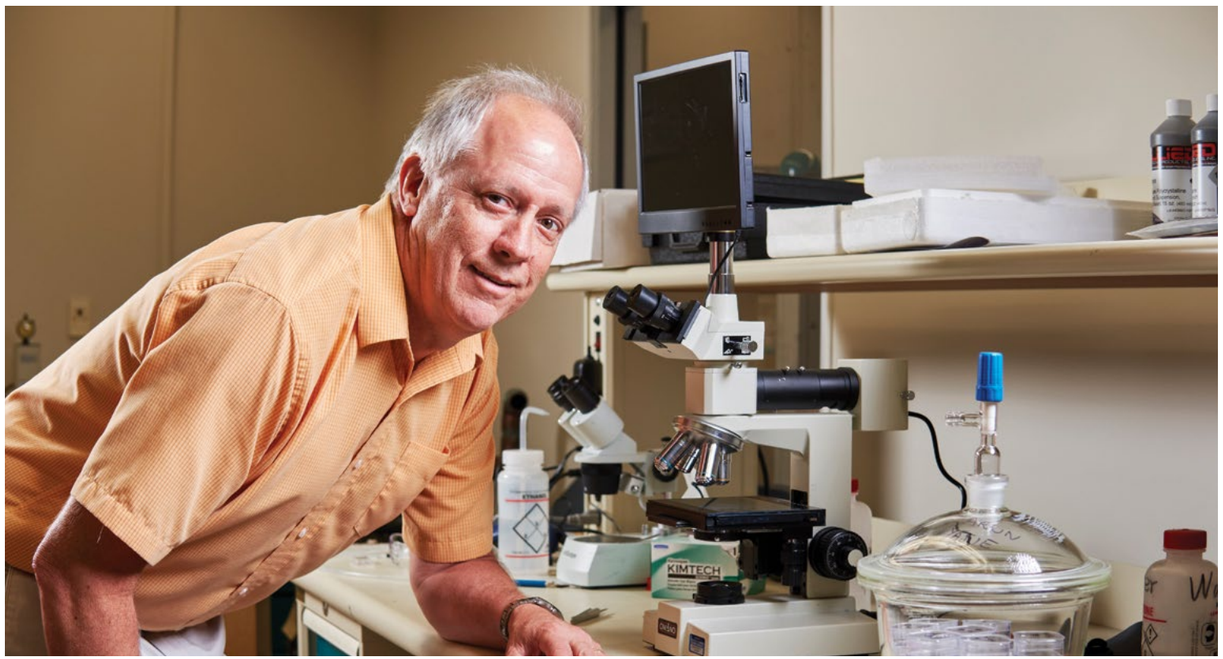
Recognizing a Problem

In 2007, the department had seven faculty members. By the time Wes Hines became department head in 2012, there were 12. He knew if the department were to reach its goal of making more significant scholarly contributions to the field, that number would have to grow even higher.

By 2014, the department had grown to 17 tenured or tenure-track faculty members. The department now also houses five full-time research faculty and two joint UT-Oak Ridge National Laboratory Governor's Chairs: Brian Wirth for computational nuclear engineering and Steven Zinkle for nuclear materials.

"Expanding the faculty like we did has allowed us to engage in new research areas that we weren't able to before, notably nuclear materials and nuclear security," Hines said. "It also increased activity across the board, gave our faculty a chance to be more engaged with students, and significantly ramped up our overall research portfolio."

The department was now on the move.



Shifting Focus

Another key moment in the department's upward trajectory was its decision to position its research focus on tackling some of the nation's biggest challenges.

But in order to handle those new opportunities, the department first had to increase enrollment, particularly among doctoral students.

In 2008, doctoral students were just one-third of the department's graduate enrollment, but have since risen to around 85 percent. Since 2012, the number of doctoral students has increased from 47 to 132.

"Doctoral students take four to six years to graduate as opposed to the one or two years needed for a master's," Hines said. "That's important, because as the percentage of doctoral students increases, so too does the average time we have students and it takes several years to make research contributions that can impact national needs."

It has also increased the department's importance to the regional economy. Chances for professional development abound in the area, which has the largest concentration of nuclear industry anywhere in the world.

Students now had opportunity, both scholastically and post-graduation.

Research

While the department has always had an outpouring of research, the importance and value of its work to the world around has increased as steadily as faculty hires and enrollment.

"Hiring Governor's Chairs in nuclear security and nuclear materials aligned us with important national research needs," said Hines. "These top faculty not only solidified our relationships with local research partners in Y-12 and ORNL, they also changed our research culture. We are focused on larger, more impactful research topics and funding opportunities."

The department has taken a leading role in nuclear materials, in particular.

Materials Science and Engineering's William Weber, the UT-ORNL Governor's Chair for Radiation Effects on Materials, has several projects that are in line with the department's work, while the UT-ORNL Joint Institute for

Advanced Materials further strengthens the department's work and collaboration in nuclear materials.

Nuclear security is another area of global importance that, as Hines hoped, has grown into an area of strength for UT. The US Department of Homeland Security has turned to the department multiple times for expertise, including supporting:

- Laurence F. Miller (now Professor Emeritus) and his work developing neutron detectors;
- Jason Hayward and a colleague in the Min H. Kao Department of Electrical Engineering and Computer Science who have developed a portable radiation detection device;
- Eric Lukosi and colleagues from the Department of Materials Science and Engineering who are working on low-cost scintillators for radiation detection.

In addition, faculty have given talks and received awards at the highest levels of national and international agencies, students have increasingly won US Department of Energy scholarships and fellowships through the Nuclear Energy University program, and national recognition from peers has solidified the department as a consistently top-ranked program.

UT's proximity to ORNL and the Y-12 Nuclear Security Complex has also helped attract top minds and talent to both the faculty and student body, thanks to joint faculty positions and research projects being conducted at facilities such as ORNL's Spallation Neutron Source.

"Scholarship, research funding, faculty, students; all of those things are tied into one another," Hines said. "It's hard to be successful as a department or in any of those areas without the other three also being solid."

The foundation was set.

Setting the Bar

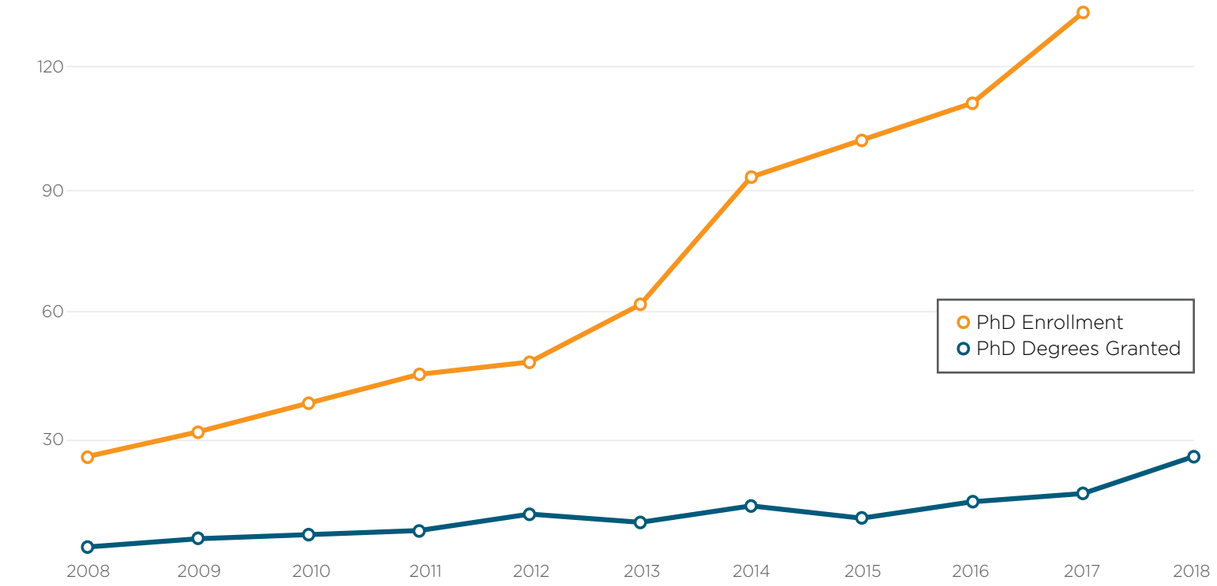
The class of doctoral students who set the record for the largest nuclear engineering class in US history didn't come to UT with that goal in mind.

They didn't come because of $129 million complex that is finally under construction.

They didn't come on a whim.

They came because the department is energized by a stellar faculty with big ideas who are conducting meaningful research in one of the country's top places to study nuclear engineering.

It started with a plan that was laid before they finished their undergraduate work, was followed through in detail, and has now come to fruition.



"We didn't set out to have the largest class of doctorates, or even really with any other goal in mind," Hines said. "We just wanted to be the best we could be, the best we knew we had the potential to be. Our goal was just to be our best."

At spring commencement, they were just that: the best. ***Ever.***

Undergraduate Opportunities

Graduate students aren't the only ones to have new experiences made available in the department in recent years.

Knowing one of the big moments of an undergraduate student's college experience comes through studying abroad, UT and the department struck a deal with Czech Technical University to create a nuclear-focused program.

Still going strong in its sixth year, it has allowed a dozen nuclear engineering students to travel to Prague each year for two weeks to learn about reactor operation, reactor physics, and measurements of reactor parameters.

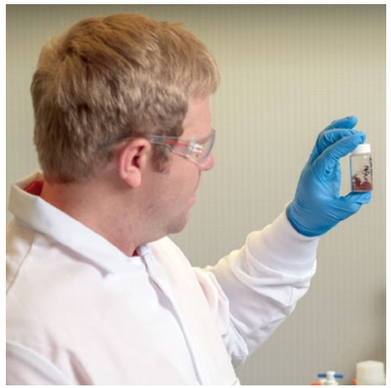
The program also incorporates tours of historical sites in the Czech Republic and Austria, including Prague Castle and St. Stevens Cathedral, and visits to places of nuclear significance, including the headquarters of the International Atomic Energy Agency and a working uranium mine.

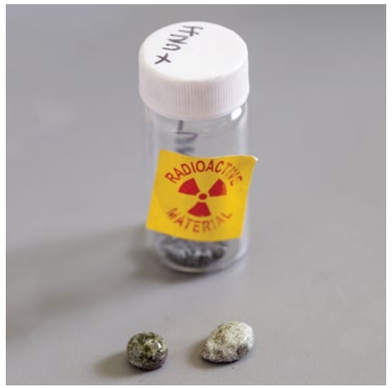
"It's been a sought-after experience since we launched it, and a highlight for students," Hines said. "It is not uncommon for us to have much more demand from students than we have space."

Before, During, & After
THE BOMB

by Whitney Heins. Photography by Shawn Poynter.

Barely a day goes by that news of a nuclear threat doesn't make it into the headlines. And, what if the unthinkable happens?





From left to right: John Auxier II works with a sample of dissolved melt glass in his lab; surrogate nuclear melt glass representative of New York City; three samples including ground up surrogate melt glass that will be shipped to Los Alamos National Laboratory in the foreground, dissolved melt glass in the left background vial, and a diluted, dissolved sample in the right background vial.

Time is of the essence to ensure survivors are safe and those responsible are stopped from doing more harm. Too much time spent trying to figure out what happened, how it happened, and who did it could cost lives and money.

John Auxier II, research assistant professor of nuclear engineering, is on the job. His research, funded by the US Departments of State, Defense, and Homeland Security, is one of few in the country that seeks quick and easy ways to answer such questions throughout the entire bomb cycle.

"Our research is everything from the front and back end of nuclear forensics," he explained, likening his research work to the popular television show CSI, short for crime scene investigation. "We're trying to figure out systems that enable first responders to get information on-site within hours rather than having to send it to the lab and wait for days. Getting data faster helps decision makers make their next move faster."

Auxier, who is on faculty at the UT's Bredesen Center and the Institute for Nuclear Security, conducts research within the framework of three scenarios—when suspicious material is intercepted, when a bomb is detonated, and the aftermath. His work seeks to find information that can answer critical questions such as—what kind of bomb was it (aka did it have plutonium or uranium, or was it a "dirty" bomb)? Where did it come from? Who is responsible for it? And what threat still looms?

At the front end of the bomb cycle—finding suspicious material—Auxier and his students are working on a method where responders can determine what the material is by using handheld lasers while at the scene. The laser method, known as Raman spectroscopy, characterizes the surface of the material by illuminating it using a single color of light. The way the light interacts with the material can reveal the material's makeup and even when it was last machined.

This information can help decision makers narrow down a list of suspects since not every country has access to the same kinds of bomb-making materials. Also, US intelligence may know when countries likely engineered certain types of bombs or bomb-making materials.

During a bomb explosion, Auxier and his students are tapping into cameras such as those in ATMs, security systems, and people's cell phones, to gather information about the weapon. Using a fifteen-inch industrial-grade torch—the same kind used to paint airplane wings—they create atomic lines that they then video for review.

"When atoms get excited, they give off a light like the yellow glow from a street light, for example," said Auxier. "We can look at the particular colors in that spectrum and relate it back to certain elements, and that can tell us what materials are in the bomb."

After the fireball is gone and smoking rubble is left, Auxier and his students are investigating another method using handheld lasers, called laser induced breakdown spectroscopy. When this laser is shined on the rubble, it turns the debris into plasma that emits light holding clues to the elements within. This method gives responders an initial idea of the type of bomb that was used and enables them to collect good samples for more detailed analysis at a lab.

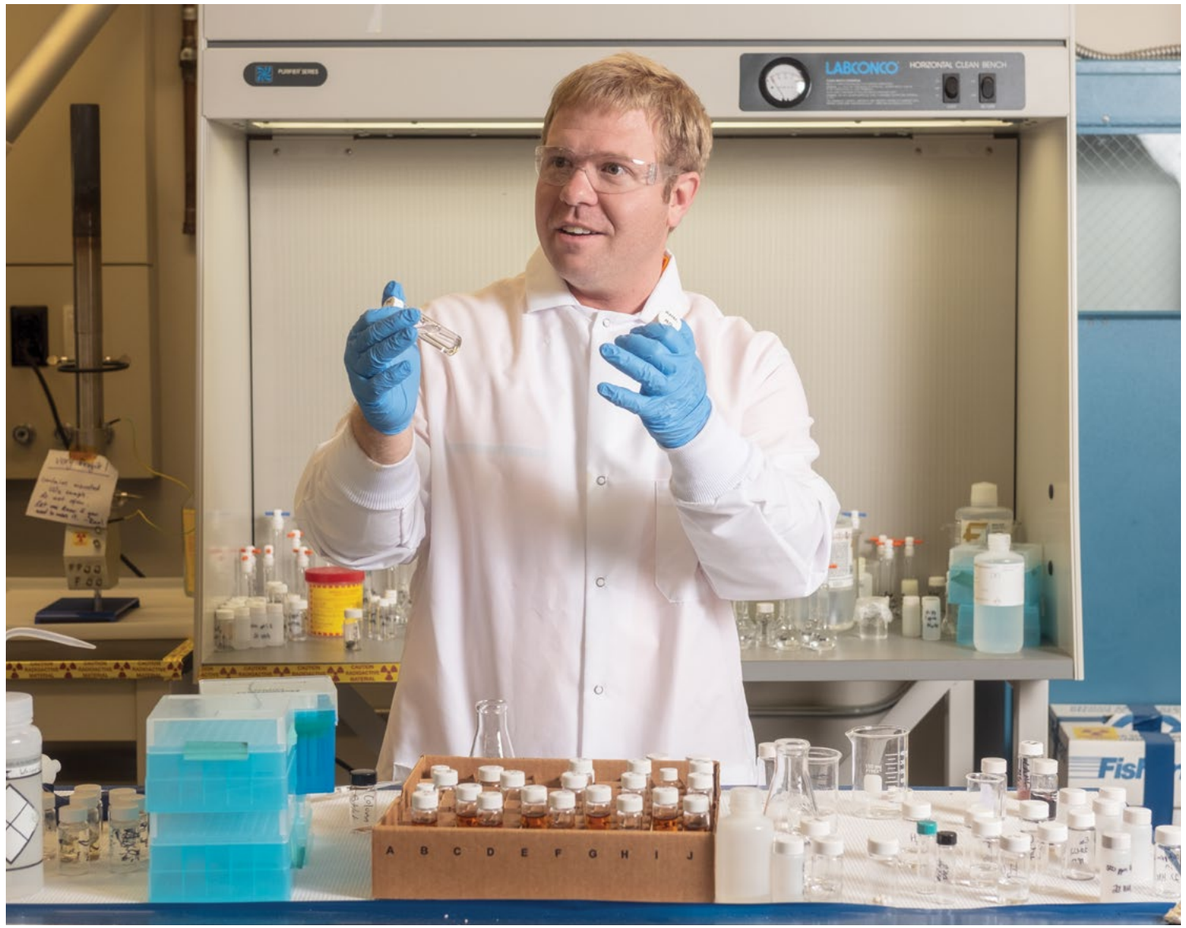
Auxier calls himself an "innovative collaborator," saying he would not be able to do what he does without the help of his students.

> **"I've had the great opportunity to work with really talented students. We all fit in a small office and throw ideas on the whiteboard. And, I have a lot of bad ideas. The students critique me. They don't understand the limitations, so they look at problems a different way and push science forward."**
>
> **—John Auxier II**

Auxier is passionate about doing research that supports students locally and can provide a pipeline of skilled workers to US national laboratories and government.

He's also very passionate about doing "fantastically cool science"—and making our world safer.

"We are trying to solve some very challenging problems and create a skillset we hope we never have to use."



Pinch-Hitter & Nuclear Grandpa

Writing and Photography by Randall Brown.

Lawrence Heilbronn has established a solid reputation in his 10 years with the nuclear engineering department. He was named the John D. Tickle Associate Professor, earned the department's Professor of the Year award four times, and often pinch-hits in the nuclear engineering department.

"He is commonly asked to fill in when other faculty are on travel," said Department Head Wes Hines. "I see this as bringing in a 'ringer,' since his teaching is so well regarded by the rest of the faculty."

Heilbronn was a scientist at the Lawrence Berkeley National Laboratory from 1991 to 2008, when Professor Lawrence Townsend told him about a faculty opening here.

"It was perfect timing, because I had been searching for opportunities to teach and work with university students," Heilbronn said. Townsend acted as a faculty mentor for Heilbronn, who hadn't previously taught. "I had no formal training in education, but I was still somewhat young enough to remember what worked and what didn't work for me as a university student."

He knew from his own student experience that the concepts taught in courses really became clear when applied to the research he conducted.

"As much as possible, I try to create application-based assignments that utilize the fundamentals I cover in class," Heilbronn said. "I've also found that tying in current events covered in the popular media with materials covered in class is an effective method to emphasize the relevance of what is being taught."

His approach makes strong connections with students and earned him a somewhat before-his-time nickname.

"Heilbronn is affectionately known as 'Grandpa' for his ability to put student needs first," Hines said.

One thing Heilbronn likes to emphasize in the classroom is what goes on outside of the classroom—encouraging students to be active members of the department, join professional societies, take part in social activities, and become ambassadors for the department.

"It's extremely important for our students to engage in research, co-ops, and internships to gain experience and make connections that help them take the next step into professional life," he said. "As such, I make sure students are aware of the opportunities as they come up, as well as help them understand what is expected of them as professionals."

At the core of his teaching methodology, Heilbronn views the faculty role as the last step for students before they become professionals.

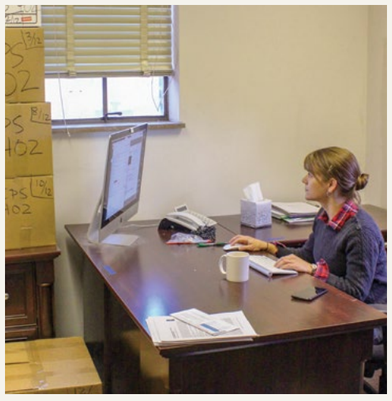
> **"It's up to us to make sure they know what to expect, what they need to know, what it takes to be successful, and to understand that their education doesn't stop when they walk off the stage with their diploma."**
>
> **—Lawrence Heilbronn**

Heilbronn has enjoyed seeing his students succeed well past the commencement ceremony, especially the graduate students he has mentored over the years.

"One interesting success story is my first PhD student, Matthew Beach, who has just taken on a position quite unrelated to his PhD research and research he undertook as a postdoc," he said. Beach currently works as an engineer with the US Navy. "It speaks to his intellectual skills, but also to the versatility of a nuclear engineering degree."

MOVING ON UP

In January, nuclear engineering faculty and staff moved their offices to the newly named Nuclear Engineering Building (NEB) on the Hill. In July, Estabrook Hall and Pasqua Hall was demolished in preparation for construction of the new engineering complex. The department will operate from NEB until 2021, when they will move to their new state-of-the-art home.



Top: Rendering of the south side of the new engineering complex (courtesy MHM in association with Smith-GroupJJR). Bottom, from left to right: Laurence Miller packs up his boxes in Pasqua Hall; Jamie Coble works until the last moment before the move; construction equipment removes Estabrook Hall.

*Construction crews demolish Pasqua Hall on Saturday, July 22. To learn more about the new engineering building and keep tabs on the construction, visit **tiny.utk.edu/gateway**.*

Image courtesy of NASA

On a Scientific Mission To MARS

by Whitney Heins.

For decades, a human mission to Mars has been dreamed, discussed, and even worked toward—but it hasn't happened yet. And there are many reasons, including the significant technical challenges that stand in the way.

For one, it takes a lot of fuel to get there and viable techniques haven't yet been developed to successfully harness enough energy to launch a rocket on a 33.9 million-mile road trip—and then bring it back.

Also, a trip like that would take a long time. More time spent in space means more potentially harmful effects on the astronauts' health. Living in low gravity and being exposed to space radiation for long periods of time changes the human body, as NASA is now finding out, thanks, in part, to a recent year-long space mission by UT alumnus Scott Kelly.

But UT engineering students led by UT-ORNL Governor's Chair for Nuclear Materials Steven Zinkle are working on overcoming these challenges by peering into "exotic" materials that can withstand extreme environments—as in those created by nuclear-powered thermal propulsion.

That's because one promising approach to get a rocket to Mars and back in a shorter time is by going nuclear.

> **"Mars is a relatively close planet but it is much farther away than the Moon. The Moon only takes a couple of days to get to whereas Mars could be six months to a year or longer. Conventional rocket technology doesn't cut it. A higher power rate is desired."**
>
> **—Steven Zinkle**

A nuclear energy reactor can be the answer.

Here's how it would work: cryogenic hydrogen would flow through a heat source causing it to rapidly expand and release a huge thrust that can propel a rocket. The science behind this propulsion approach is well established but a key challenge is identifying materials that can withstand exposure to corrosive hydrogen at the extreme temperatures required for the reaction. The necessary temperatures are roughly 2,500 Kelvin—above the melting temperature for many elements in the periodic table and hot enough to melt steel by nearly a thousand degrees.

This is where exotic materials come in. Shortly after arriving to UT in 2015, Zinkle's doctoral student Kelsa Benensky began work on her prestigious NASA Science Technology Research Fellowship. Her work centers around investigating the compatibility of silicon carbide and ultra-high-temperature ceramics to high-temperature liquid hydrogen. She conducted her testing at a specialized facility at NASA's Marshall Space Flight Center in Huntsville, Alabama, where she exposed the materials to temperatures as high as 2,750 Kelvin. Then she brought back the samples to UT-ORNL's Joint Institute for Advanced Materials to be characterized using the high-powered electron microscopes and other advanced characterization tools to reveal how well they performed.

"Using precision weight change, glancing x-ray diffraction, Raman spectroscopy, and scanning electron microscopy, Kelsa obtains the materials' microstructural and chemical fingerprints to see if there is a change in the surface composition, for example, if it eroded or corroded. Transmission electron microscopy can then be used if anything needs further scoping," Zinkle said.

Benensky's results have been promising. No one had tested the compatibility of these materials with hydrogen at temperatures above 1900 Kelvin before she started her PhD research. Several of the materials she is investigating are doing well at resisting hydrogen corrosion up to at least 2500 Kelvin.

"I'm very grateful to have an advisor who encourages me to step up to the plate on my own projects and allows me the freedom to follow my own research path," shared Benensky, who added she came to UT because of Zinkle's experience working on materials development programs for nuclear space applications.

Another doctoral student, Taylor Duffin, is also doing research in Huntsville analyzing the hydrogen compatibility of ceramic-refractory metal, or "cermet," materials to high temperatures. The plan is for these composite materials to be used as fuel in a nuclear rocket. Zinkle is helping Duffin organize experiments, conduct follow-up characterization, and report his findings.

Without Zinkle and the electron microscopes, Duffin says his research wouldn't be possible.

"Dr. Zinkle has been essential to my project," Duffin shared. "And so have the electron microscopes. Without them I would have to rely on only bulk data like mass loss or size changes without understanding the processes taking place."

There are many reasons for a mission to Mars: curiosity, a future need for resources, and, potentially, even survival. The work Zinkle and his students are doing is getting us closer to one day making such space travel a mission accomplished.

"Before we started these projects, it was a blank sheet of paper," Zinkle shared. "We wondered, 'are some of these high-temperature materials a viable option for this extreme operating environment?' Thanks to the work by Kelsa and Taylor, we have solid experimental results that say 'yes, these are viable options.' And that puts us one more step up the ladder to making this a reality."

Senior Dan Floyd talks through challenges with his teammates.

PULSR POWERS the road to Mars

by Randall Brown.

A team of NE undergraduate students took up the senior design project challenge of providing power for extraterrestrial surface missions—namely, a trip to Mars.

The crew included Gavin Ridley, Dan Floyd, Walter Tebbs, and Patrick Tidwell, with mentoring by Adjunct Assistant Professor Thomas Harrison. They designed PULSR, the Plutonium Ultra-Light Space Reactor, to produce power for a 20-year mission.

"I think the group was, in general, inspired by the radical departure that space reactor concepts can take from terrestrial atomic power in favor of high-power densities and long operating lifetimes," said Ridley. "This presents a very interesting technological challenge, since such power generation has to be delivered in a lightweight package."

The cost of sending a kilogram of equipment to Mars can soar well into six digits, so a lighter design saves dollars.

"Moreover, people can't easily go to check up on the reactor like on Earth," said Ridley. "You have to make many decisions on how the reactor can be monitored, maintained, and controlled remotely."

They found that one of the biggest lessons of the project was in how nuanced computational fluid dynamics can be.

"Generating a good mesh, using the right turbulence models, and setting the right boundary conditions seem at times to be such mathematically difficult problems that it's more of an art than anything," said Ridley.

The team chose to spice up the design by using excess weapons-grade plutonium as fuel. They chose this partly as a symbol of peace—repurposing the material for progress rather than destruction—and partly due to its extraordinary potential as space-reactor fuel. They packed it into a spherical container made of tantaloy, with sodium coolant flowing over it to remove heat.

"The biggest challenge was finding data to back up the fact that there are metals which are corrosion-resistant to liquid plutonium-based fuel," said Ridley. "We would have not undertaken these design decisions if Los Alamos National Lab had not explored liquid plutonium-based fuels as a fast reactor concept in the 1960s."

Still, it was challenging to design a thermal-spectrum reactor which operates on nearly pure Pu-239 and maintains stability.

"We think the design is a success because our calculations show it will be stable and continuously make 20 kilowatts of power over a 20-year lifespan," said Ridley. "Best of all, it will fit in a package weighing in around 60 kilograms."

COBLE maintains winning faculty ENERGY

by Randall Brown. Photography by Shawn Poynter.

One of Jamie Coble's degrees is in reliability and maintainability, so it stands to reason that she has "reliably" measured another strong year in nuclear engineering. The assistant professor stacked up four prestigious awards in the last year, two of which were awarded for the first time.

Coble was named the first Southern Company Faculty Fellow in recognition of her work, and also received the inaugural Ted Quinn Early Career Award from the American Nuclear Society.

"Being named the 'first' of any award is certainly a great honor, but it also comes with a lot of responsibility," she said. "There's a responsibility to maintain my work at the standards for the award, but also to elevate those standards and live up to the prestige of the award."

Her standards also earned her UT's Angie Warren Perkins Award, named for the university's first dean of women, to honor outstanding campus leadership. Within the college, Coble won the 2018 Leon and Nancy Cole Superior Teaching Award for her acumen in the classroom.

"Coble is a truly outstanding young faculty member with the energy and expertise to be highly engaged in teaching, research, service, and outreach," said Department Head Wes Hines. "Most faculty do not attempt to engage all at the same time. However, she does it with excellence."

The faculty fellowship alone has opened multiple doors for her over the last several months.

"I had the opportunity to meet with engineers at Southern Nuclear Company to discuss the opportunities and needs they see for applying data analytics and online monitoring in the operating fleet of reactors to help deliver the nuclear promise of affordable, clean, reliable, nuclear power," said Coble. "We worked together with researchers at Idaho National Lab and Analysis and Measurement Services Corp, as well as others at UT, to develop a proposal to DOE-NE to pursue some of the ideas that came out of those conversations."

Southern Company is a strong partner with the college, providing co-op experiences for large numbers of students and jobs for alumni. Coble has also worked with officers of Southern Nuclear's chapter of Women in Nuclear to launch a mentoring program that pairs their professionals with UT students for virtual mentoring. This continues Coble's ongoing pursuit to inspire and motivate female engineering students.

"We hope to take some of our mentees to the Southern Company Professional Development Summit to meet their mentors face-to-face this fall," she said.

Coble appreciates the recognition from these awards, and the ways that it can resonate with other Engineering Vols.

"I hope that they signal to our students—especially our female students—that we can have a significant impact through our work in nuclear engineering," she said.

Coble sees her own UT experience as invaluable. She watched the NE department grow as she earned her undergraduate and MS degrees and her doctorate (and threw in the master's degree in reliability and maintainability engineering for good measure). She went to work at Pacific Northwest National Laboratory in 2010 and returned to UT as faculty in 2013.

"The education I received was outstanding," said Coble. "Watching the growth of the department was very exciting from the inside. It was an easy decision to come back as soon as the opportunity presented itself."

FACULTY NOTES

Hashemian Joins Tennessee Energy Policy Council

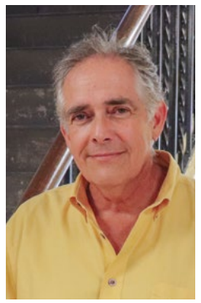
Governor Bill Haslam appointed AMS Corporation President and CEO Hash Hashemian, a nuclear engineering alumnus and adjunct professor, to the Tennessee Energy Policy Council in January 2018.

"I am honored to be appointed by Governor Haslam and look forward to serving our governor, general assembly, and the wonderful state of Tennessee and its exceptional people," Hashemian said.

This 13-member council is designed to provide advice to the governor and the general assembly on how to ensure a safe and stable energy supply using all viable energy resources within the state, how to properly manage these resources, and how to effectively improve the state's energy production and development. Members—who serve a three-year term—include representatives from TVA, local utilities, universities, and environmental groups.

Hashemian frequently lends support to numerous projects and events related to the department and college and was the 2016 recipient of the college's most prestigious honor, the Nathan W. Dougherty Award.

Family, Farming, and Fishing: Ruggles Sets His Retirement Syllabus



Professor Arthur Ruggles will retire in December 2018 after 26 years at UT. His future itinerary includes visiting his grandchildren, tending his farm, and maybe catching a few fish.

"My grandkids live in Paris, France, and it's hard to see them," he said. "So, travel is part of it. Another part of it is subsistence farming—that takes some time."

Ruggles has maintained his Anderson County farm for 10 years, and also helps manage the deer population in the area.

"I put out food plots for them, and monitor them with game cameras," said Ruggles. "If my health holds up, I'll probably do that for another 10 years."

This involvement perhaps echoes his reputation as an educator with a preference for personal interaction.

"Ruggles is an extraordinary teacher who continues to use old-school tactics that the students appreciate," said Department Head Wes Hines. "He engages students and works through problems using 'chalk and talk' rather than PowerPoint slides."

The "chalk and talk" philosophy—lecture reinforced with real-time chalkboard notation—became a part of the Ruggles repertoire following his personal experience with alternatives.

"In my junior high school, I was on the learner side of the experiment," he said. "Washington County, Maryland, was chosen to be a test bed for distance delivery in closed-circuit, black and white television. You can deliver information this way, and the learning outcomes aren't measurably different. But the students watching television hated it. It's just not engaging."

While Ruggles steers away from PowerPoint dependency, he thinks different approaches can work well for faculty who maintain a personal element and encourage students to appreciate the relevance and usefulness of the material.

"It's helpful if you have some commercial background or some application background," said Ruggles. He built his teaching career on just this type of background, first working for IBM and then returning to school to earn his PhD in mechanical engineering from Renssellaer Polytechnic Institute (RPI) in 1987, after initially considering acoustics. He shifted his focus to nuclear engineering while at RPI, which led him to a research position at ORNL for a while. He began at UT in 1992.

Continued industry collaborations—notably on the Spallation Neutron Source with ORNL, plus later projects with Siemens—led to his recent advances in particle tracking using positron-emission tomography (PET) imaging technologies for applications in health, nuclear safeguards, and multiphysics modeling.

Ruggles will keep tabs on ongoing research, but after Paris he and his wife, Jane, are planning a Colorado fishing expedition.

"I'll let these youngsters take over this wheel for a while," said Ruggles. "I hope that they have a good career. I've had a good career, and I'm ready for something else."

UT-ORNL Governor's Chair Wirth Named American Nuclear Society Fellow

Brian Wirth, the UT–ORNL Governor's Chair for Computational Nuclear Engineering, has been named a fellow of the American Nuclear Society, the group's highest honor.

ANS President Robert Coward said the recognition is in response to Wirth's "advancement of nuclear science and technology through the years." He received the award during the ANS winter conference in Washington, DC, last November.

"Brian is a foremost expert on nuclear fuels and materials, and this acknowledges and solidifies that," said Department Head Wes Hines. "His research in understanding radiation damage to materials and the development of new materials for nuclear energy production is critical, both for UT and ORNL as institutions as well as the drive for clean energy."

Wirth left the University of California, Berkeley, in 2010 to join UT as a Governor's Chair.

His modeling ability has helped researchers around the world gain a better understanding of what will be required for the next generation of nuclear energy production.

The development of fusion as an energy source is particularly challenging, with the need to develop new materials capable of confining plasma gas ions at temperatures several hundred times hotter than current fission reactors.

Wirth's models, research, and computations are allowing that work to proceed and are partly why he was honored by ANS.

"It's a very nice recognition of all the hard work I've put in over the years," said Wirth. "Only a small group of people are ever chosen for this, so to have peers select me for it is humbling and a recognition for myself, as well as all of the researchers and collaborators with whom I've been fortunate to work."

Wirth is the fourth active faculty member in the department to be named an ANS Fellow, along with Hines, Professor Richard Wood, and UT-ORNL Governor's Chair for Nuclear Materials Steven Zinkle. Professors Emeriti Lawrence Townsend and Belle Upadhyaya, joint UT-ORNL faculty Yutai Katoh, research professor Martin Grossbeck, and adjunct faculty Steven Arndt, Hash Hashemian, and Alan Icenhour also hold the distinction.

ANS was founded in 1954 as a nonprofit entity with the goal of promoting nuclear science and technology. It now includes 11,000 members representing 1,600 universities, research centers, and businesses.

STAFF NOTES

Amanda Lovelace

Staff members in the nuclear engineering department earned honors for their hard work and diligence throughout the year. Amanda Lovelace and Ashly Pearson exemplify our team's ongoing standard of excellence.

Student advisor Lovelace won the Department of Nuclear Engineering's Outstanding Staff award for 2018. She advises undergraduate students within the department and coordinates tours.

"I sincerely appreciate the support of the faculty and other staff members within the department, as well as serving in such a welcoming, positive, and team-oriented environment," Lovelace said. "I am truly honored."

Ashly Pearson

Ashly Pearson, senior IT technologist, won the college's Outstanding Staff award for 2018. She keeps the department connected through her IT duties and played a big part in the department's recent move to its temporary office space. Construction is getting underway for the new engineering complex, which will be the new permanent home for nuclear engineering.

"I am honored to have received the award," Pearson said. "I'd like to give special thanks to everyone in the department for all that they did to help with the move, and further thanks to the guys who did all the heavy lifting. Can't wait to do it all again in a few more years."

STUDENT NOTES

PhD Plan Pays Off for Palomares

Raul Palomares showed up for his doctoral studies ready to get things done.

"My primary goal as a PhD student was to be as productive as possible during my time at UT so that I could develop into an independent thinking scientist/engineer and meet the milestones set forth by my funding sources," he said.

His work ethic paid off this year. He received both the department's 2018 PhD Graduate Student award and the UT Chancellor's 2018 Extraordinary Professional Promise award.

"It's a great honor and I'm extremely thankful to receive the two awards," Palomares said. "I'm very humbled that these efforts were recognized by the professors that either nominated me or supported me."

These efforts included publishing 10 peer-review journal articles (four as first author) in his research area—materials under extreme conditions, including radiation effects in materials. Palomares also presented at 14 conferences and technical meetings, including two oral presentations at international conferences in Germany and New Zealand.

He earned Best Presentation awards at both the 20th International Conference on Ion Beam Materials & Modifications and at the 16th National School on Neutron and X-ray Scattering. He also presented as an invited speaker at the 2017 Materials Science & Technology (MS&T) conference.

O'Quinn Chosen for Top Fellowship

Eric O'Quinn, a graduate student in nuclear engineering, was chosen by the Department of Energy's Office of Science for enrollment in its graduate student research program.

The award goes to students identified as having research in areas that the Office of Science deems critical for the nation and provides them research opportunities in a national lab while working on their thesis.

"I was thrilled to find out I had gotten the award," said O'Quinn. "This is a great opportunity, both to continue doing my research and to work with our collaborators at Oak Ridge National Laboratory."

His work revolves around what are known as disordered materials, such as glasses and ceramics, that may have a more complex structure at the atomic level than previously thought.

Due to their design, such materials hold great promise for energy, including use in nuclear fuel and in fuel cells.

O'Quinn will spend his yearlong fellowship working under ORNL scientist Matthew Tucker developing new ways of modeling the data he has collected.

New Fire Screening Draws a Crowd

The discussion panel following The New Fire *screening included Andrew Worral of ORNL, Assistant Professor Steve Skutnik of UT nuclear engineering, filmmaker David Schumacher, and student moderator Amanda Bachmann.*

UT's Women in Nuclear and American Nuclear Society chapters collaborated to present a screening of *The New Fire*, a documentary about young nuclear engineers who work to develop next-generation reactors to help provide clean and safe energy. The screening drew a crowd that nearly filled an auditorium in the Alumni Memorial Building.

Afterward, filmmaker David Schumacher participated in a panel discussion that also included student moderator Amanda Bachman, Associate Professor Steven Skutnik, and Andrew Worrall of Oak Ridge National Laboratory.

"I'm really happy with the turnout," Bachmann said. "I really liked the questions that were asked. They hit on some of the technical and social aspects of the topic."

Bachmann hopes that the film inspired viewers to think about where their energy comes from and ways they can make a difference in advocating for clean energy.

Students Earn Best Paper Awards at ANS Conference

Amanda Bachmann receiving her award.

Ten undergraduate and graduate students recently represented the department at the American Nuclear Society (ANS) Conference in Gainesville, Florida. Amanda Bachmann, Matthew Herald, and their team members brought home awards for the Best Student Papers.

Amanda Bachmann and team members Nathan Gilliam, Jonathan Mitchell, and Michael Cooper earned Best Paper for their work, entitled "Investigating Isotopic Concentration Variability in Used Nuclear Fuel."

"I was able to learn a lot from the experience," said Bachmann. "I felt proud to be representing UT in this way and show what our department is able to accomplish."

She presented the paper as part of the conference's Nuclear Nonproliferation track. The basis of the project is to expand the capabilities of the Separations and Safeguards Performance Model (SSPM) from Sandia National Lab for its use as a nonproliferation safeguard for electrochemical reprocessing of fuel. It is funded through the DOE Office of Nuclear Energy's Nuclear Energy University Program.

Matthew Herald received the Best Paper award in Thermal Hydraulics for "X-Means Clustering Implementing the Gap Statistic for Multiple Positron Emission Particle Tracking." His research investigated a way to know the number of particles in a scanner's field of view as they simultaneously enter and leave a during a PEPT measurement.

"I hope that because of UT's recent successes at conferences and our record-breaking number of Fulbright Scholars more students will be encouraged to get involved with research," Herald said. He credits his experience with the Engineering Mentor Program for inspiring him to attend numerous conferences. "My mentor was another NE student named Dane de Wet. He encouraged me to attend a conference my first year and offered to show me around. It was an invaluable first experience."

The Engineering Mentor Program is a student organization that pairs first and second year engineering students with an upperclassman mentor in their major.

Herald's project was funded by a grant from the National Nuclear Security Administration through Professor Arthur Ruggles.

Nuclear Decommissioning Minor to Fill National Need

Four nuclear engineering graduates completed the recently launched Nuclear Decommissioning & Environmental Management minor in the past year. UT is the only university that offers a degree or minor in this area.

Students in nuclear or civil and environmental engineering are encouraged to consider adding this discipline to their major program of study. Expertise in decommissioning is poised to become a sought-after skill as more facilities age.

The minor consists of 15 hours across these courses:

- NE 404, Nuclear Fuel Cycle
- NE 433 or NE 233, Principles of Health Physics
- CE 340, Construction Engineering and Management I
- NE 406, Radiation Shielding
- NE 542, Management of Radioactive Materials

Department Head Wes Hines joined representatives from the Energy, Technology, and Environmental Business Association (ETEBA) at the first annual Decommissioning Strategy Forum, held in June 2018 at the Gaylord Opryland Resort and Convention Center in Nashville, Tennessee.

"We have had many companies interested in employing summer interns in this discipline, and several more approached us at the forum," said Hines.

For more information about ETEBA, visit ***eteba.org***.

For more information about the Decommissioning Strategy Forum, visit ***tiny.utk.edu/decommisioning***.

Students Recognized by DOE

Three NE students won awards in the 2018 Innovations in Nuclear Technology R&D Awards announced in April. The awards are sponsored by the Department of Energy Office of Nuclear Technology R&D.

- **Kelsa Benensky (PhD)** — Second Place prize in the Open Competition in the category of Advanced Fuels.
- **Eric O'Quinn (PhD)** — Prize in the Competition for Students at Universities with Less than $600 Million in 2016 R&D Expenditures.
- **Gavin Ridley** — Prize in the Undergraduate Competition

First Step Awards

The First Step award is given to any student who gets his or his first peer-reviewed journal article accepted for publication. The student must also be listed as the first author. Awardees are recognized with an announcement to the department, posts on social media, a display of the paper in the Nuclear Engineering Building, and with a presentation at the annual departmental banquet.

2018 First Step Award Recipients (to date):

- **Zachary Bergstrom**, A Molecular Dynamic Study of Subsurface Hydrogen-Helium Bubbles in Tungsten
- **William F. Cureton**, Grain Size Effects on Irradiated CeO_2, ThO_2, and UO_2
- **Peter J. Doyle**, Modeling of Dislocation Channel Width Evolution in Irradiated Metals
- **Elan Herrera**, LISe Pixel Detector for Neutron Imaging
- **Anagha Iyengar**, Systematic Measurement of Fast Neutron Background Fluctuations in an Urban Area Using a Mobile Detection System
- **Seth T. Langford**, Three-dimensional Spatiotemporal Tracking of Fluorine-18 Radiolabeled Yeast Cells via Positron Emission Particle Tracking
- **Jennifer Littell**, Coded Moderator Approach For Fast Neutron Source Detection and Localization at Standoff
- **Zhengzhi Liu**, Detection of Missing Assemblies and Estimation of the Scattering Densities in a VSC-24 Dry Storage Cask with Cosmic-Ray-Muon-Based Computed Tomography
- **Angela L. Lousteau**, Determining ^{235}U enrichment in bulk uranium items using dual-energy interrogation with delayed neutron measurement
- **Michael Moore**, Thermal Diffusions of Mixed Valence Ce in ^{6}Li Loaded Silicate Glass for Neutron Imaging
- **Dallas Moser**, Lattice Optimization for Graphite Moderated Molten Salt Reactors Using Low-enriched Uranium Fuel
- **Cody A. Nizinski**, Production and Characterization of Synthetic Urban Nuclear Melt Glass
- **Eric O'Quinn**, Inversion in Mg1-xNixAl2O4 Spinel: New Insight into Local Structure
- **Raul I. Palomares**, Defect Accumulation in Swift Heavy Ion-Irradiated CeO_2 and ThO_2
- **Nitant Patel**, Positron Emission Particle Tracking in Pulsatile Flow
- **Hunter N. Ratliff**, Simulation of the GCR Spectrum in the Mars Curiosity Rover's RAD Detector Using MCNP6
- **Gavin Ridley**, A Method for Predicting Fuel Maintenance in Once-Through MSRs
- **Mikah Rust**, Intrinsic Radio Activity of KSr2I5:Eu2+
- **Jacob Shamblin**, Probing Disorder in Isometric Pyrochlore and Related Complex Oxides
- **Michael B. Shattan**, Detection of Uranyl Fluoride and Sand Surface Contamination on Metal Substrates by Hand-held Laser-induced Breakdown Spectroscopy
- **Guinevere Shaw,** The Detection of He in Tungsten Following Ion Implantation by Laser-Induced Breakdown Spectroscopy
- **Angela T. Simone**, Performance of a Boron-Coated-Straw-Based HLNCC for International Safeguards Applications
- **Vikram Singh**, Dynamics and Control of Molten-salt Breeder Reactor
- **Ryan Sweet**, Fuel Performance Simulation of Iron-Chrome-Aluminum (FeCrA1) Cladding During Steady-State LWR Operation
- **Matthew C. Tweardy**, A Point Kinetics Model for Estimating Neutron Multiplication of Bare Uranium Metal in Tagged Neutron Measurements
- **Cody Wiggins**, A Feature Point Identification Method for Positron Emission Particle Tracking with Multiple Tracers
- **Thomas Wulz**, Realization of Deep 3D Metal Electrodes in Diamond Radiation Detectors

ANS Scholarships

This year the American Nuclear Society bestowed 11 scholarships on our students during its annual meeting in San Francisco, June 11–15. That number, a record for the department, is the latest sign of recognition of UT as a national leader in nuclear engineering education.

Undergraduate Category

Sophomore
Madison S. Ratner

Robert T. (Bob) Liner Memorial Scholarship
Matthew Herald

Hans P. Loewen Memorial Scholarship
Madison N. Allen

Decommissioning, Decontamination & Reutilization Division Undergraduate Scholarship
Coleman R. Curran

Charles (Tommy) Thomas Memorial
Kalie R. Knecht

Fusion Energy Division Dr. Kenneth R. Shultz Undergraduate Scholarship
Ashley Goluoglu

Operations and Power Division Scholarship
Andrew V. Volkovitskiy

Graduate Academic Excellence

Fan Zhang

James F. Schumar Scholarship
Jessica L. Bishop

Robert E. Uhrig Graduate Scholarship
Dan C. Floyd

Join Jamie. Join the Journey.

"The work my team and I pursue pushes forward on Delivering the Nuclear Promise—clean, safe, reliable energy generation in the US and abroad. I am extremely proud and honored to be the inaugural Southern Company Faculty Fellow, a position which opens doors to collaborations that meaningfully benefit our students, including mentorship and job exploration."

—Jamie Coble, Southern Company Faculty Fellow

Join the journey to help other faculty like Jamie Coble provide experiences for engineering students. Call **865-974-8890** or visit **giving.utk.edu/nuclear**.

JOIN THE JOURNEY

COMMUNITY **OUTREACH**

Department Hosts Alcoa Students

by David Goddard.

The department welcomed around 30 students from Alcoa High School in early May as a way to introduce them to what nuclear engineering has to offer.

During their visit, the students heard from professors, asked questions to a panel of current students, and toured some of the labs where nuclear research takes place.

It was part of the high school's effort to engage students in science and physics and demonstrate the practical use of that knowledge.

"If students can get involved in research, get hands-on experience, that's 10 times more effective than any lecture or reading," said Jonathan Grissom, a science teacher at Alcoa. "This is a good chance to open their minds to careers and fields they might not know about otherwise."

One tour stop included a visit with Associate Professor and Pietro F. Pasqua Fellow Maik Lang in his lab in the Science and Engineering Research Facility.

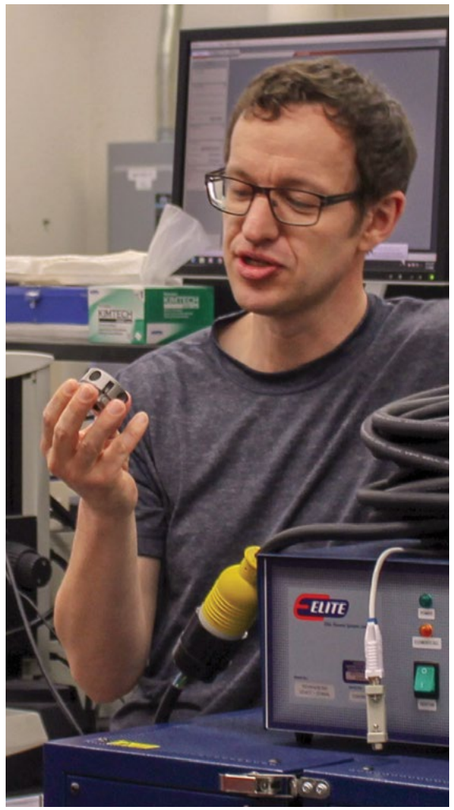
Lang and his research assistants explained how the work they do helps develop materials for use in the harsh environment inside nuclear reactors.

The high school students also learned various ways that UT faculty and students test such materials and how those tests are used to impact the real world.

"We need to be able to see how materials perform in extreme environments, and the combination of engineering, physics, and science allows us to do that," said Lang.

He also explained the opportunities students coming to UT have to collaborate with Oak Ridge National Laboratory and the key relationship UT and ORNL share.

Students also heard about UT's freshman engineering programs, student organizations, experiences current students have had and the paths they have taken, and some of the college's initiatives that are aimed at easing the transition to college life.



Shining a Light on Nuclear Energy

by Laura Tenpenny.

"Outreach and community engagement is imperative for the nuclear power industry....Because the industry has not done a good job of marketing to the public, misinformation from the nuclear naysayers finds an easy home in the hearts and minds of much of the public. The nuclear industry at large is finally recognizing the need for targeted, accessible outreach."

This is according to Jamie Coble, assistant professor of nuclear engineering, who has been busy addressing this need in local elementary schools.

Coble and fellow UTNE colleagues and students have visited multiple schools, including Belle Morris Elementary, to read *Marie's Electric Adventure* to local school children, mainly first- and second-graders. The book follows a girl, Marie, whose investigation into her nightlight's sudden loss of electricity leads her to a nearby power plant and an obliging tree named Adam, who explains what the plant does, how it works, and why her nightlight stopped working.

"Marie finds out that her nightlight was extinguished due to a power line failure, not because of an issue in the nuclear power plant," Coble explains.

Coble and friends helped the kids grasp the complex nature of nuclear energy explained in the book through activities like the "Nuclear Dance," in which children act out the many components of nuclear power production and distribution, all the way from the reactor core to electricity user.

"The kids LOVED the experiments," said Louanne Nicely, library media specialist at Belle Morris Elementary.

"Programs like this one broaden the students' realm of understanding about areas, concepts, and ideas that they may not have access to otherwise. The students' reactions when they 'got it' [from the hands-on activities and small group interaction] were priceless!"

The book, produced by the Duke University chapter of the North American Young Generation in Nuclear (NAYGN), was designed to have precisely this impact: to educate children on the benefits of nuclear power and socialize the fact that it is a safe form of energy.

Coble hopes to continue sharing this book with local schools and kids' groups and looks forward to NAYGN's sequel, which will target a slightly older age group.

"As well as spreading the word on nuclear power," Coble adds, "by interacting with college students, I hope that the children see themselves as future college students—hopefully someday in UTNE!"

Hall of Fame Inductee, Gordon Fee

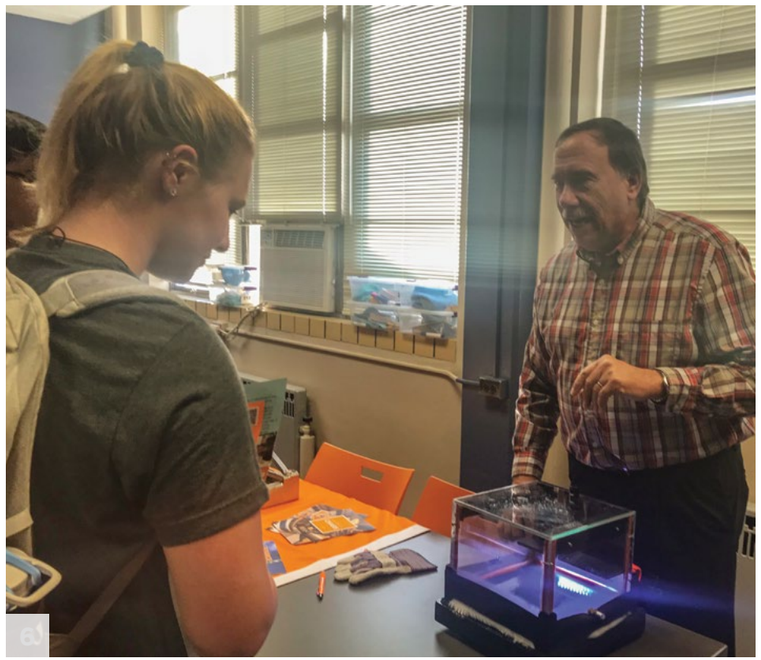
by Laura Tenpenny.

Gordon Fee spent his years as a master's student at UT, completing his degree in nuclear engineering in 1962. This hard work, in addition to his bachelor's degree in physics from Penn State University, propelled him to his first job out of college as a manager at Union Carbide. He later oversaw the Oak Ridge Y-12 National Security Complex as plant manager before concluding his 40-year career as president of Lockheed Martin Energy Systems. Throughout his professional life, Fee's passion for education never wavered. In 2013, he was recognized by the Tennessee State Legislature for the many improvements made through his efforts to the state education system. Fee has served in multiple voluntary roles in various non-profit and government organizations related to education, including the Tennessee Department of Education, where he acted as executive director of the School to Career Initiative, earning one dollar per year for this employment. His academic pursuits also extend to UT, where he spent time as a chancellor's associate in the mid-nineties and has served on the Dean's Advisory Board for the College of Arts and Sciences since 1999.

AROUND THE **DEPARTMENT**

Photography by Randall Brown and Ashly Pearson.

1. The department presents at the 2017 Boo in the Courtyard Halloween costume competition. This year's theme was "herding cats."
2. NE faculty, staff, and students gather to eat and be merry at the 2017 holiday potluck.
3. Department Head Wes Hines prepares to lead his staff during the college's annual Boo in the Courtyard Halloween costume competition.



4. NE students (L–R, Amanda Bachman, Jonathan Wing, Robert Corrigan) run different nuclear engineering student society booths at Engineers Day 2017.
5. NE senior Robert Corrigan and Associate Professor Ron Pevey speak with students at the 2017 Engineering Fundamentals fair.
6. Associate Professor Ron Pevey demonstrates a cloud chamber at the 2017 Engineering Fundamentals fair.
7. NE senior Andrew Volkovitskiy takes measurements for the ANS shielding competition at Engineers Day 2017.

TICKLE
COLLEGE OF ENGINEERING

DEPARTMENT OF NUCLEAR ENGINEERING

301 Nuclear Engineering Building
1412 Circle Drive
Knoxville, Tennessee 37996-1410
Phone: 865-974-2525
Email: utne@utk.edu
Web: ne.utk.edu

utnuclear

utkne

big orange. big ideas.

Preparing for the Unthinkable
PAGE 6