Novum, the U-M solar car team’s newest solar-powered electric vehicle, races through the Australian outback during last October’s Bridgestone World Solar Challenge, a 3,000-kilometer race from Darwin to Adelaide. Novum is a drastic departure from conventional solar car design; it delivered a second-place finish in the race, the U-M team’s best-ever results. Learn more about Novum’s radical design on page 11.

PHOTO: Evan Dougherty
ACCELERATING BOLDER IDEAS

FOCAL POINT SKY HIGH

A novel funding program enables aggressive research exploration

Michigan Engineering has set its sights on enhancing its culture of creativity, innovation and daring, and is implementing a unique approach to investing in faculty research as a key part of the plan. Three new funding programs, enacted as part of the research pillar in the Michigan Engineering 2020 strategic plan (see p. 16 for details), will enable researchers to explore the boundaries of creative thought and risk-taking. The programs draw inspiration from entrepreneurial funding models, introducing three separate funding options that are analogous to early-, mid-, and late-stage funding for a startup business. However, the analogy is not one-to-one – commercial viability is not the main or only goal. Instead, it is about engaging in bold research.

“We’re doing this to catalyze and incentivize faculty – especially teams of faculty – to pursue high-risk, high-impact ideas,” said Steve Ceccio, associate dean for research and Vincent T. and Gloria M. Gorguze Professor of Engineering. “Our hope is that these new funding mechanisms will give faculty the freedom to be more daring in pursuing new research ideas that are not yet ready for more traditional research funding agencies.”

The program builds on the existing success for funding research at Michigan Engineering. Faculty are already accomplished researchers and are good at attracting funding for their projects. These initiatives leverage this track record of success to broaden and define areas of scientific and technological leadership, creating incentives for teams to form, and acknowledging and supporting the resources required to pursue transformational ideas.

“The intent is to reinforce and expand our research excellence and the capabilities of our faculty, better positioning teams to secure support from external partners,” said Alec D. Gallimore, the Robert J. Vlasic Dean of Engineering. “We aim to help foster an ecosystem that celebrates bold thinking, embraces noble failures and engenders intellectual curiosity. I am excited to see what happens when we open new doors for our faculty to explore.”

Gallimore is also an Arthur F. Thurnau Professor, and the Richard F. and Eleanor A. Towner Professor of Engineering.

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“A novel funding program enables aggressive research exploration”

ACCELERATING BOLDER IDEAS

RESEARCH ACCELERATOR

Up to $250K

Faculty can apply to the Research Accelerator for a one-time investment of funds to accelerate an idea. It is similar to angel investors or accelerators in a startup funding model in that it provides a jumpstart.

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“A novel funding program enables aggressive research exploration”

ACCELERATING BOLDER IDEAS

CLUSTERS & THEMES

Up to $25K

These seed investments are meant to kickstart an idea that is earlier-stage or has not yet taken definitive shape.

A cluster is a group of faculty with related expertise. For example, a dozen researchers working in microfluidics across campus could organize to buy a piece of equipment or hire someone to run a joint lab.

Themes form when faculty with similar research interests – but different expertise – join to tackle a problem. This could be sorting cancer cells or reducing carbon emissions. Funds could be used to organize a workshop or conference, or to hire a student to help the group work together.

The Blue Sky initiative supports transformational concepts – high-risk, high-reward ideas. While it is analogous to the later-stage, higher-dollar contributions of venture capital funding for entrepreneurs, the goal is not to launch a company. Instead, teams will progress through a series of defined milestones to consistently assess the development of their concept, and will have a strategy in place to explore and secure external investments to develop and expand the concept. This could come from a federal entity like NASA or the NSF, or from a corporate partner.

Blue Sky will give teams the resources to aggressively pursue an idea to either reinforce or define Michigan’s leadership position in areas ranging from revolutionizing mobility to utilizing big data.

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What is a Michigan Engineer?
Kudos for Corinne
Groovy guy unmasked
FlexDex
Superhydrophobia

**What is a Michigan Engineer?**

Raymond Barry (BSE EE '77)

I thought it would be interesting to Laura Murphy's story in the fall 2017 issue about the definition of a Michigan Engineer.

It hurt to read that Laura Murphy had so many negative experiences that led her to earn her BSE ME – I had hoped that Michigan Engineering would be a more inclusive today. I too had a very lonely journey in CH-E 40 years ago. With rare exception, no one wanted to be my lab partner or ask me to join a study group.

Laura, it made all the difference in the world for me to establish a connection with a professor and see the bigger picture. I was very grateful that I received encouragement from Dr. Han, Dr. Cutt and especially Dr. Fogler. I'm proud to be a Michigan Engineer. I hope that Laura comes to be proud as well and finds a way to make a difference for the next generation of engineers.

Sue (Pierce) Green (BSE ChE '78)

Laura Murphy's account of her experience in the 1970s is extremely similar. With electronic media, the expense of a photo spread, from the Bentley Historical Library's publication can be virtually eliminated. What a waste! It would be great to see a revival of something similar. With electronic media, the expense of publication can be virtually eliminated. What a waste! It would be great to see a revival of something similar.

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By: Sabrina Jocelyn-Aucourt

**Kudos for Corinne**

Harry Blum

Essential to Laura Murphy's story is a photo published in the "Something Groovy This Way Comes" photo essay.

Laura Murphy's story is essential to Laura Murphy's story. If she had not come to understand what was going on, she would be one of the most important, if not the most important, part of our university experience.

I'm editor of the Technic at that time, and the last page of each issue was our humor page. Here we were having a bit of fun at our own expense, hiding in the disguise so no one would realize we were reading this publication. I'm the one on the left, and Chuck Schibs is the one on the right. I'd be curious to know who you got the picture from.

Working on the Technic would prove to be an important and invaluable part of my university experience and education. The thing I learned there would pay dividends the rest of my life, writing, leadership and commitment. What we published was never as important as our participation in the publication.

All student organizations are difficult to sustain both financially and with human resources. Therefore, it is no surprise that the magazine met its demise only a few years later, but no less disappointing. We had an office in East Engineering where the college furnished and graciously allowed us to use, but I suspected that would end with the move to North Campus.

It would be great to see a revival of something similar. With electronic media, the expense of publication can be virtually eliminated. What would be even better is a related for-profit class that would draw students in. Raymond Barry (BSE EE ’77)

We got the photos, along with the others in the photo spread, from the Bentley Historical Library on North Campus. – Editor

**Groovy guy unmasked**

As I am both a former employee of the Wilson Student Team Project Center and a four-year member of the Winning Formula SAE team, Laura Murphy's account of her experience in a campus machine shop resonated strongly with me. The training procedures and attitude of the shop in Laura's story are unsafe and undermining of a Michigan Engineering facility. No student should ever be discouraged from exploring the full breadth of Michigan's resources nor made to feel embarrassed when she is hesitant about using high-energy machine equipment.

I trained hundreds of Michigan students in the safe operation of mills, lathes and other machinery in hands-on sessions. Instructional videos simply aren't enough to enable safe use of a lathe.

Ryan Kraft (BSE ME ’10)

This is a beautiful story. Imagine how great Haiti would be if even a small percentage of the ones that leave come back to help. Amazing.

Alain Emmanuel

I loved the article from the University of Michigan, it really highlights your career and the obstacles you encountered. I'm proud of you and what you're doing for our country.

Djéhane Franck

The article from the University of Michigan is superb! Emotional and stimulating at the same time. I love the photo of the laptop on the bucket. Bravo chérie!

Congratulations! You are a role model for young people.

Wolf Petersen Geelin

"We try hard, we try different ways until it works." That is the attitude to have!

Sabrina Jocelyn-Aucourt

**FlexDex**

Ramesh Joachim Sanon and Matthew Schneider

I am very proud to say I was a part of this team in the early stages of development. It is absolutely amazing to see the progress the team has made since my departure. This is what Michigan Engineering is all about!

I simply cannot wait to see the positive effect this device will have on patients, surgeons, and hospitals not only in the United States, but across the globe!

Congratulations FlexDex!

Matthew Schneider

I am so proud of Corinne! She has been my mentor since 2014, helping me with my my thesis and introducing me to the bigger picture. I'm very grateful to have had this opportunity to work with Corinne.

Laura Murphy’s story is essential to Laura Murphy’s story. If she had not come to understand what was going on, she would be one of the most important, if not the most important, part of our university experience and education. The thing I learned there would pay dividends the rest of my life, writing, leadership and commitment. What we published was never as important as our participation in the publication.

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We got the photos, along with the others in the photo spread, from the Bentley Historical Library on North Campus. – Editor

**Superhydrophobia**

Ramesh Joachim Sanon and Matthew Schneider

It’s raining, geeks

Responses to our bicentennial article on the development of an uncrackable water-repellent coating.

This is pretty cool! I’m curious about sheer force – how does the material behave under it? Also, how is it made out of? Thanks! Anand Jay Kalra

The coating is made of fluorinated polymer nanotubes mixed with a specialized water-repellent molecule called “KASOS.” It’s sprayed on and bonds tightly to the surface below.

Editor

It’s raining, geeks

A caption on page 45 of the fall 2017 issue incorrectly stated that students were reading a GE J79 turbojet engine for a wind tunnel experiment. The engine was a display model provided as a gift by General Electric. The article "Out of the Cold War’s Shadow" should have stated that the Tomahawk missiles launched at Syria in April of 2017 borne 0.5-ton chemical warheads, not 500-ton. Also, Robert Awtar was the co-inventor of the Enda Gayr rather than the pilot.

Corrections

Have something to share? Email us at MichiganEngineer@umich.edu

Matthew Schneider
Knee replacements might be on their way to an upgrade thanks to a new synthetic cartilage made with Kevlar, a material best known for bulletproof vests. The material was developed in the lab of Nicholas Kotov, the Joseph B. and Florence V. Cejka Professor of Chemical Engineering.

Like real cartilage, it's mostly made of water – more than 80 percent – in addition to the Kevlar fibers and a hydrogel that's common in contact lenses. The fibers build a tough framework while the hydrogel fills in gaps, trapping the water in chambers. The water resists stresses on the network. But the network can also yield – releasing some water only to recover it later when the stress is removed. It works a bit like a sponge. No other synthetic material comes as close to the unique “liquid strength” of cartilage.

**Photo:** Biophysics group, Adolphe Merkle Institute

**FROM KEVLAR TO CARTILAGE**

Inspired by the electric eel, a flexible, transparent electrical device could lead to body-friendly power sources for implanted health monitors and medication dispensers, augmented reality contact lenses and soundless other applications.

Designed by Michigan Engineers collaborating with researchers from the University of Fribourg in Switzerland and the University of California, San Diego, the soft cells are made of hydrogels and salt and generate a steady buzz of electricity at high voltages but low currents, a bit like an extremely low-volume but high-pressure jet of water.

Electric eels can synchronize the charging and discharging of thousands of cells in their bodies simultaneously, says Max Shlein, a professor of materials science and engineering. Shlein applied a unique origami solution to the large sheets of hydrogels, devising a way of folding a flat sheet of gels so the right cells come into contact in the right order.

**Photo:** Joseph Xu

The device can’t hold a candle to the electric eel, which can pump out far more power in short bursts to zap prey or defend itself. But the researchers say they have taken an important first step that advances a fundamental understanding of soft power sources.

**ELECTRICITY, EEL STYLE**

“WE ALREADY KNOW THAT HALL THRUSTERS WORK WELL IN SPACE. THEY CAN BE OPTIMIZED EITHER FOR CARRYING EQUIPMENT WITH MINIMAL ENERGY AND PROPELLANT OVER THE COURSE OF A YEAR OR SO, OR FOR SPEED — CARRYING THE CREW TO MARS MUCH MORE QUICKLY.”

– Alec D. Gallimore, Robert J. Vlasic Dean of Engineering, in Popular Mechanics

Gallimore leads research on the X3, a prototype Mars engine under development by U-M, NASA and the U.S. Air Force. The X3 is a 500-pound Hall thruster that recently broke records for operating current, power and thrust generated by a thruster of its kind. Gallimore is also the Richard F. and Eleanor A. Thurnau Professor, an Arthur F. Thurnau Professor and a professor both of aerospace engineering and of applied physics.
The solar car team's 14th vehicle took second place in the 2017 Bridgestone World Solar Challenge. No U-M team has ever placed so high. Here's how they did it:

**RELIABILITY**
Novum spent almost no time on the side of the road. The caravan pulled to the shoulder just once, for only a few minutes, to repair an internal aero component that was causing a power spike. The team credits the simplification of Novum's design and mechanical systems, which were less prone to failure. They also point to its 4,135 miles of testing.

**STABLE DYNAMICS**
An optimized battery design contributed to a lower center of gravity. For simulated worst-case-scenario crosswinds, Novum's suspension allowed for a deflection of under 3.5 mm, ensuring that the car didn't produce more lift than the previous car, Aurum.

**STREAMLINED SHAPE**
Michigan was one of only two top teams that raced a skinny, monohull car – a radical departure from the proven catamaran design that dominated the field. Novum is 43 percent narrower than Aurum.

**HIGH-EFFICIENCY SOLAR CELLS**
With an average efficiency of 35 percent, multi-junction gallium arsenide (GaAs) cells work better at hotter temperatures than their silicon (Si) counterparts, allowing for a smaller car. (Si cells run at about 24 percent efficiency.) So teams that select them are required to use less. But this year, teams could proportionately use 32 percent more GaAs cells as compared to Si than in 2015. The potential payoff was too good to ignore.

"WE TOOK A CHANCE ON GOING WITH A SMALL CAR, AND WE'RE GOING TO BE AHEAD OF THE CURVE FOR YEARS TO COME BECAUSE OF THAT."
Neil Dasgupta
Team faculty advisor and assistant professor of mechanical engineering

"WHAT WE HAVE TO DO IN THIS COUNTRY IS MAKE SURE WE DON'T TEACH OUR CHILDREN TO HATE. KINDNESS IS SOMETHING YOU CAN GIVE AWAY, AND YOU'LL NEVER UNDERSTAND THE IMPACT THAT YOU HAD ON ANOTHER."
Colin Powell, a retired four-star general and former secretary of state and chairman of the Joint Chiefs of Staff, who visited with engineering and ROTC students before speaking to more than 2,000 people in Hill Auditorium. Powell joined Alec D. Gallimore, the Robert J. Vlasic Dean of Engineering, for a conversation on geopolitics, race and wisdom for the next generation as part of the 2017 James R. Mellor Lecture.

U-M has tripled its investment into daring, boundary-crossing research through Mcubed, a one-of-a-kind, $30 million funding program spearheaded by engineering professors in 2012. Mcubed rapidly gives seed grants to teams of three professors from at least two different disciplines and does not require a formal application process.

**$94M**
Follow-on funding to Mcubed projects

**476**
Interdisciplinary projects jump-started

**225+**
Studies published in peer-reviewed journals

**60+**
Other results such as companies & artistic exhibitions

Mcubed was approved for another three-year cycle that opens in fall, 2018. Read more at umicheng.in/mcubedRA

**HIGH-RISK, HIGH-REWARD**
U-M has tripled its investment into daring, boundary-crossing research through Mcubed, a one-of-a-kind, $30 million funding program spearheaded by engineering professors in 2012. Mcubed rapidly gives seed grants to teams of three professors from at least two different disciplines and does not require a formal application process.

"M-Air will allow us to push the edge of our algorithms and equipment in a safe way, where the worst that can happen is it falls from the sky," said Ella Atkins, professor of aerospace engineering. "With this facility, we can pursue aggressive educational and research flight projects that involve high risk of byzantine or loss of control – and in realistic wind, lighting and sensor conditions."

The M-Air outdoor fly lab opened in February, making U-M the only university in the nation with advanced robotics facilities for air, sea, land and space. The netted, four-story complex offers 9,600 square feet for tethered flight.

"What we have to do in this country is make sure we don't teach our children to hate. Kindness is something you can give away, and you'll never understand the impact that you had on another."
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"We took a chance on going with a small car, and we're going to be ahead of the curve for years to come because of that."
Neil Dasgupta
Team faculty advisor and assistant professor of mechanical engineering
A CURE FOR THE COMMON CONCRETE

The United States faces a backlog of roughly $500 billion in necessary road and bridge repairs. And for many communities, the problem is getting worse over time. The cost of maintaining aging infrastructure is soaring, new projections show. A solution is a non-traditional mix: Michigan engineers believe its extended life will more than pay for itself in the long run.

The Michigan Engineer

By Ian Hiskens, Vennema Professor of Engineering and professor of electrical engineering and computer science

By Ian Hiskens, Vennema Professor of Engineering and professor of electrical engineering and computer science

Electric vehicles (EVs) play a vital role in decarbonizing road transportation. As society moves toward a more sustainable energy future, we anticipate that the population of EVs will steadily increase. So too will the energy requirements for charging all these vehicles, placing great strain on the electricity generation and supply infrastructure.

We addressed an important aspect of this challenge by establishing a decentralized approach to optimally schedule EV charging, making the best use of the fleet of generators that supply the electricity grid. Namely, EV charging should be distributed across the overnight “valley” in electricity demand.

The total load of a power system varies continually throughout the day: low overnight, when most people are asleep, and high during the day’s commercial and industrial activities. The shape of this daily load variation differs from day to day, and across seasons and regions, but typically displays a peak around 6 to 8 p.m., when most people arrive home and enjoy their electricity-intensive evening activities. This peak demand determines the number and size of power stations, or amount of generation, that is needed.

It would be tempting for EV owners to start charging their vehicles as soon as they arrive home from their commute. However, that would add even more load to the evening peak, requiring more expensive generation to be brought into service. Many utilities currently offer incentives for EV owners to postpone charging until around 10 p.m., for example. This helps spread the total demand and achieves better utilization of generation, but as the number of EVs grows, this strategy may become inadequate. The ideal solution minimizes electricity generation costs by scheduling EV charging to exactly fill the overnight load valley.

In order to establish rigorous results, we considered a fairly abstract version of the large-scale EV charging problem. In doing so, though, we found that this Nash equilibrium is, in fact, the optimal valley-filling strategy predicted by central optimization. A range of examples illustrates our main results, in particular the fast convergence rate of the iterative algorithm.

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The ideal solution minimizes electricity generation costs by scheduling EV charging to exactly fill the overnight load valley. One way of achieving the optimal valley-filling strategy would be for a central controller to tell every EV when it could charge and at what rate. Not only would this approach be computationally challenging, it would not likely be embraced by EV owners, who would probably prefer more autonomy. Instead, we have established a decentralized process in which the EV owners make autonomous charging decisions but do so in a way that exactly achieves the ideal solution, minimizing generation cost and stabilizing demand.

The decentralized EV charging control problem that we studied can be thought of as a form of non-cooperative game, in which a large number of self-interested EV owners compete for electricity resources over the charging horizon (the evening hours). Our proposed process involves an iterative exchange between a central utility and each EV. The utility initially broadcasts a prediction of the non-EV base demand over the charging horizon. With this broadcast information available, each EV independently determines its minimum-cost charging strategy. The utility collects these tentative charging strategies from all EVs, sums them to get the total aggregate EV demand over the horizon, and broadcasts that updated demand information back to all the EVs. This process repeats until the optimal charging strategies proposed by all the EVs no longer change.

In our process, the EVs interact through the common electricity price signal. We established conditions for the existence of a Nash equilibrium and proved that the decentralized (iterative) optimization process converges to the unique Nash equilibrium. Furthermore, we showed that this Nash equilibrium is, in fact, the optimal valley-filling strategy given by central optimization. A range of examples illustrates our main results, in particular the fast convergence rate of the iterative algorithm.

In order to establish rigorous results, we considered a fairly abstract version of the large-scale EV charging problem. In doing so, though, we laid a foundation for designing and analyzing emerging decentralized processes for determining optimal EV charging strategies. Future EV drivers may be able to provide their preferred charging hours to a system that optimizes for lowest cost, obtaining the best possible rates while also helping the overall grid by filling the demand valley efficiently.

“Decentralized Charging Control of Large Populations of Plug-in Electric Vehicles,” published in the January 2013 issue of IEEE Transactions on Control Systems Technology, is the journal’s most highly cited paper over the past five years.
A TURBO BOOST FOR
3-D PRINTING

A new Michigan Engineering algorithm allows 3-D printers to “read ahead” of their programming during production so they can work faster and with greater accuracy.

HOW IT WORKS

Ohio State uses the analogy of a person trying to deliver a speech in a large hall. In order to reach the ears in the farthest rows, that speaker would have to shout. A megaphone might solve the problem. But if the speaker continues shouting, their voice will be loud and distorted. Using the megaphone in a normal voice, however, produces the right clarity and volume.

The algorithm developed by Okwudire’s team acts similarly — allowing the 3-D printer to throttle up and down to prevent distortion.

“Our software is like that person who realizes their voice is going to be overly amplified. It acts preemptively.”

— Chinedum Okwudire

Going too fast causes 3-D printers to vibrate, leading to the reduced quality of the final product shown above. If the printer can anticipate which parts of the program will cause the greatest vibrations, it can adjust speed accordingly.

Michigan Engineers have created an algorithm designed to throttle printing speeds up and down depending on the demands of the program, allowing for faster production times with higher quality (seen above). Developed by Chinedum Okwudire, an associate professor of mechanical engineering, the algorithm could double speeds and lead to broader use of 3-D printing.

Developed by Chinedum Okwudire, an associate professor of mechanical engineering, the algorithm could double speeds and lead to broader use of 3-D printing.

BEFORE:
Printed on a HICTOP Prusa i3 3-D printer at ~2X speed

AFTER:
Printed on a HICTOP Prusa i3 3-D printer at ~2X speed WITH Michigan algorithm

LEGO FOR SYSTEM DESIGN

Today, you essentially need a PhD to design a new computing system — or you need people with that level of expertise on your team. It’s one of the reasons analysts worry that the industry is stagnating — caught between physical limits to the size of silicon transistors and the skyrocketing costs and complexity of system design.

A new, $32 million center at Michigan Engineering aims to change this, streamlining and democratizing the design and manufacturing of tomorrow’s computing systems.

The Center for Applications Driving Architectures, or ADA, will develop a transformative, “plug-and-play” ecosystem to encourage a flood of fresh ideas in computing frontiers such as autonomous control, robotics and machine learning. Its name was inspired by Ada Lovelace, the 19th-century mathematician and writer who is considered the first computer programmer.

“We want to make it possible for anyone with motivation and a good idea to build novel, high-performance computing systems,” said Valeria Bertacco, the Arthur F. Thurnau Professor and professor of Computer Science and Engineering who leads the center.

“I would like to see newly minted college grads doing hardware startups.”

ADA’s funding comes from a consortium led by the Semiconductor Research Corporation and the Defense Advanced Research Project Agency (DARPA). The five-year project involves researchers from Harvard, MIT, Stanford, Princeton, the University of Illinois at Urbana-Champaign and the University of Washington.

Among their key tasks, the researchers will identify patterns in the core algorithms of emerging applications — such as virtual reality, machine learning and augmented reality — in order to map those algorithms to new, tailored computational blocks. They will develop reusable, highly efficient algorithmic hardware accelerators for those computational blocks. And they will devise an open-source chip scaffold for these new, accelerator-centric systems.

“One will no longer need to send a design to the fab and wait for a chip to come back,” Bertacco said. “They may still need a clean room to assemble a system, but this will be much simpler and more economical.”

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Michigan Engineering strives to anticipate the global, technological and educational changes ahead, and position our institution to lead the evolution of 21st-century engineering research and education for the benefit of the common good.

We will use a startup investment model to spur innovative and collaborative research to solve grand challenges. Three funding approaches will be piloted, providing early-stage investment, mid-level investment modeled after "angel" investors and high-level strategic funding through a venture capital model.

We will ensure that every Michigan Engineering student benefits from an educational experience that is among the finest in the world. We will introduce academic innovations consistent with preeminent engineering education, including new pedagogical and technological delivery methods, beyond-the-degree experiences and access to learning for students and professionals around the globe.

We will align our promotion process, incentives and career development with our core values to foster a culture of daring, leadership and inclusivity. Three initiatives we will undertake include articulating the tenure-track criteria, incentivizing faculty and staff for activities that are creative or daring, and creating culture-building activities and practices to increase understanding and adoption of our vision, mission and values.

See more about the vision, mission and values that will enable our strategic plan: strategicvision.engin.umich.edu
As buses rumble by on State Street, environmental engineering undergrad Alexandra Prince tunes into her classwork in front of Angell Hall.

PHOTO: Joseph Xu
It’s unclear when, exactly, NASA’s $1.5 billion Parker Solar Probe will be incinerated by the heat of the sun’s corona. But by the time that happens, the sedan-sized probe will have racked up an impressive list of superlatives. Parker will have become the fastest human-built object, reaching speeds of up to 430,000 miles per hour in its final orbits around the sun. It will also travel closer to the sun than any man-made object before it — within 3.8 million miles of the surface. Perhaps most importantly, it could help prevent massive electrical blackouts unlike anything Earth has seen before.

In the midst of this historic undertaking, you’ll find Justin Kasper, a principal investigator on the Parker mission and a climate and space sciences and engineering professor at U-M. Ahead of the summer 2018 launch, he agreed to walk us through what promises to be an amazing road trip.

STORY BY JIM LYNCH
DESIGN BY STEVE ALVEY
When Parker goes up, it will go in style. Named after American astrophysicist Eugene Parker, the probe will ride on a Delta IV Heavy, touted as the world’s largest-capacity rocket in regular use.

Kasper describes the Delta IV Heavy as “three massive rockets in a line, bolted together and launched all at the same time.” Its use for a scientific project like the Parker Solar Probe is a first. The massive launch vehicle is normally reserved for government or military projects.

Delta IV’s manufacturer, United Launch Alliance, touts the rocket as delivering “our nation’s most critical national security missions for the National Reconnaissance Office and the U.S. Air Force.” The solar winds Parker will work to understand, and weather events in the sun’s corona we detect via satellites, are part of what makes the mission “critical” in the eyes of researchers.

Why such a large rocket for a probe that only weighs about 1,000 pounds? It has more to do with slowing the probe down than speeding it up.

“Earth moves around the sun at about 30 km per second,” Kasper said. “You can’t just use any rocket to slow you down by tens of kilometers per second.”

The power and fuel capacity of the Delta IV, along with an eventual gravity assist from Venus, will get the solar probe velocity down to a point where it can orbit the sun.

**THE SOLAR THREAT**

Within hours of leaving the launchpad in Florida, Parker will cruise past its first milestone, the Solar Dynamics Observatory (SDO). Essentially a floating camera, SDO sits about 76,000 kilometers from Earth. It gives us our first warnings about what scientists call “space weather,” electromagnetic activity in the sun’s atmosphere that could potentially cause disturbances here on Earth.

Major disturbances are rare, with the most extreme documented incident occurring back in 1859. But today’s world is far more reliant on electricity; and solar weather could cause severe damage to the power grid, wiping out electricity to large swaths of the planet for months or years.

Each day, instruments onboard SDO capture and relay a terabyte of images of activity in the sun’s corona—the images hint at possible space weather threats to Earth. But scientists can draw only limited conclusions from them now.

Parker is built to change that. Collecting information directly in the sun’s atmosphere will enable better interpretation of SDO’s images to determine whether trouble may be coming our way.

The worst trouble usually starts with sunspots, strong magnetic fields that crop up along the surface of the sun, and cause the atmosphere above to twist. The buildup of magnetic energy leads to a sudden release, called a solar flare, that emits radiation outward.

Such an event creates a coronal mass ejection, a burst of hot plasma sent into space. We get good looks at these ejections when they first happen thanks to SDO. With a major solar flare, the observatory’s images capture the initial release from the sun, but not what happens after it leaves the atmosphere and flies off into space. And that’s when it becomes a potential threat to earth.

“A large coronal mass ejection might involve an amount of plasma or radiation in the solar atmosphere that’s roughly equal to the amount of water in Lake Michigan that goes from rest to about three million miles an hour in tens of minutes,” Kasper said. “That’s an incredible amount of energy.”

Kasper likens the data awaiting the probe’s instruments and sensors to the Rosetta Stone.

“Until we have a spacecraft that can enter the sun’s atmosphere to directly measure electric fields and magnetic fields, take an inventory of the kinds of particles there and their activity — we just won’t have the basic relationships established to figure out which of our theories are correct,” he said. “These are the data points we’ve been missing.”

**BREAKING FREE**

When Parker leaves the launchpad in Florida, Parker will cruise past its first milestone, the Solar Dynamics Observatory (SDO). Essentially a floating camera, SDO sits about 36,000 kilometers from Earth. It gives us our first warnings about what scientists call “space weather,” electromagnetic activity in the sun’s atmosphere that could potentially cause disturbances here on Earth.

Major disturbances are rare, with the most extreme documented incident occurring back in 1859. But today’s world is far more reliant on electricity; and solar weather could cause severe damage to the power grid, wiping out electricity to large swaths of the planet for months or years.

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BORROWING ENERGY

"Haven't we passed that before?"

It's the kind of thing you don't want to hear from the backseat on any long trip, particularly one where you've logged a trot of more than 30 million miles.

But the Parker Solar Probe will do a lot of backtracking during its multi-year trip. In fact, it will go back and forth between Venus and the sun seven times out of necessity. With each pass, Venus's gravity draws Parker closer, tightening the probe's elliptical path.

"The only way we get close to the sun is to borrow energy from Venus," Kasper said. "Each gravity assist lowers our perihelion, getting us closer and closer to the sun until, at the end of the mission in 2025, we close within ten solar radii."

The seven Venus flybys will lead to a total of 24 orbits over the seven-year mission. Parker's nearest pass will make it closest manmade object to the sun. The previous record-holder, Helios 2, remains in this part of space more than four decades after its own launch from Cape Canaveral.

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While NASA never intended for the probe to return to Earth, Venus represents a point of no return.

"There is no coming back because we can only lose energy with Venus," Kasper said. "Once we have that first encounter, we slow down. We can never make it back out to Earth's orbit."

But that's okay; there's history to be made up ahead. The last planet standing between the Parker Solar Probe and the sun is another soon-to-be-familiar landmark – Mercury. Just after the spacecraft passes it, about 27 million miles from the sun, it will break the current record for the closest manmade object to the sun. The previous record-holder, Helios 2, remains in this part of space more than four decades after its own launch from Cape Canaveral.

The seven Venus flybys will lead to a total of 24 orbits over the seven-year mission. Parker's nearest pass will make it closest manmade object to the sun at an estimated 3.7 million miles.

PARKER'S TOOLBOX

Sampling the sun's atmosphere requires NASA to pack the Parker Solar Probe with a variety of sensing and optical equipment. The gear is aimed at providing answers in four different areas of scientific inquiry.

In the FIELDS experiment, Parker will measure the strength of the magnetic and electric fields in the corona with voltage sensors and magnetometers. It will also probe the absolute plasma density and electron temperature.

Parker's second task is cataloging the energetic electrons, protons and heavier ions that are accelerated in the atmosphere as well as in the inner heliosphere. Included in this Integrated Science Investigation of the Sun (ISIS) is the [1] Energetic Particle Instrument – a made-up of one double-ended high-energy telescope and a pair of low-energy telescopes.

You don't go on a good vacation without taking pictures, and the probe boasts a pair of telescopes designed to capture activity in the corona and farthest out from the sun in the inner heliosphere. Their Wide-field Imager for Solar Probe (WISPR) is designed to capture images of the solar wind and plasma in the atmosphere.

Kasper will ride herd over the Solar Wind Electrons and Protons (SWEAP) investigation. Going beyond images, SWEAP will use its [2] trio of sensors, including a sun-facing Faraday cup, to break down the makeup of the solar wind – counting the electrons, protons and helium ions it includes and measuring their velocity, energy and temperature.
ATTITUDE ADJUSTMENTS

Someone on or near Nov. 1, Parker Solar Probe will make its first orbit in the sun's atmosphere. At this point the spacecraft's ability to held course becomes most crucial. Solar pressure on the craft's heat shield will try to spin the probe around, threatening to burn up some sensitive equipment onboard.

The constant course corrections and adjustments needed at this point can't be handled 90 million miles away. The distance is too far for the real-time piloting needed and the margin for error is going to be slim. Even a few degrees change in the craft's attitude could incinerate most of it in seconds.

"At closest approach, the probe will be the fastest object ever made – moving at 430,000 miles an hour," Kasper said. "The spacecraft has to constantly and actively point the shield toward the sun."

To do this, the probe utilizes onboard autonomous technology – a slightly more sophisticated version of what you'd find in today's driverless vehicles.

A trio of onboard computers constantly take in data about the probe's orientation – steering by Parker's relation to the stars and the time of day and altering course with bursts from small rocket thrusters. Those three computers must constantly agree about what's going on. Any individual reading the other two computers don't agree with is overruled.

"Diving into such an extreme environment requires backups. A buildup of radiation or a solar flare erupting nearby can temporarily blind the probe's cameras. Should that happen, Parker would use its onboard gyroscope and a snapshot of its last heading to steer the craft for up to two days.

Should these systems fail, Parker also comes equipped with high-tech temperature sensors attached to series of protruding limbs. When sunlight hits them, they prompt corrective action from the spacecraft.

"It's a lot of effort to protect the probe's scientific payload. But not all of Parker's goals can be achieved from behind the heat shield. To get direct samples of the solar wind, the probe will use a Faraday cup. It's a metal device, the size of a fist, that measures charged particles. To allow those particles to pass through the cup, it needs to 'dip' into the solar wind.

A permanent strut attached to the side of the spacecraft allows the cup to extend beyond the shield and into the solar wind, where it could reach temperatures of up to 1,600 degrees Celsius.

HOW PARKER ENDS

Once the Parker Solar Probe completes that first perihelion, it begins its series of six more trips back and forth between Venus and the sun. Each new gravity assist and series of solar orbits will bring the craft closer and closer to the sun's surface – making history all the way.

That last perihelion is projected to take place in mid-June of 2025.

With fuel provided by the sun, it's unclear when the probe will finally meet its end, but it will ultimately go out in a literal blaze of glory.

"One day, we will run out of fuel for the rocket thrusters that help us control trajectory and the solar probe will no longer be able to compensate for the pressure of the sunlight," Kasper said. "The sun will flip us around and the entire backside of the spacecraft should be incinerated in seconds."

But even the sun's heat won't likely be capable of erasing all traces of the Parker Solar Probe.

"The carbon heat shield, the Faraday cup and some other parts should be able to survive those high temperatures," he said.

"So what you'll basically have is a sort of modern blob that will be in a ten-solar-radii orbit – for the next billion years or so."

Satellite and probe images courtesy of NASA
STORY BY JIM LYNCH
PHOTOS BY JOSEPH XU

THE THREAT THAT NEVER SLEEPS: CAN SCIENCE STOP SUPERBUGS?

TRADITIONAL ANTIBIOTICS ARE LOSING THE BATTLE WITH BACTERIA AND MICHIGAN ENGINEERS ARE STEPPING INTO THE BREACH.
Drugs that consumers take regularly—think antidepressants, erectile dysfunction pills or diabetes medications. The payoff on products that mimic the immune system.

“Companies were investing in finding new materials up until 20 years ago,” Sherman said. “Then a new technology—combinatorial chemistry—came along. All of a sudden, robots started making millions of compounds very simply and very inexpensively—all based on known structural entities.”

But many of the old antibiotics, as well as their reconfigured versions, target similar weak points or processes in bacteria. And minor changes in an antibiotic’s makeup, according to a U-M biomedical engineer you’ll meet later, create minor new hurdles for bacteria to overcome on their way to drug resistance.

In the lower levels of U-M’s Life Sciences Institute, Sherman houses the fruits of his underwater endeavors—a library of microorganisms he and his team have pulled from marine sediments around the globe. They represent hope for a new antibacterial M.O.

“What we’re trying to do is actually identify new antibiotics that somehow target either a brand new part of a pathogen’s machinery, or bind to a new part of an old target,” Sherman said. “It’s a wide-open area, and I think we’ve only really explored a small number of the potential effective targets.”

While Sherman investigates what can be found in nature, U-M engineers using nanotechnology are creating a new class of antibiotics—composed of materials hundreds of times smaller than bacterial cells—that are tailor-made to exploit new targets.

Nicholas Kost, Angela Violi and Scott VanEpps are crafting and deploying nanoparticles—dubbed nanobiotics—to intervene in the inner processes that keep bacteria alive. Identifying weak spots in a bacterium’s cell walls and shaping nanoparticles to take advantage of them is the equivalent of designing a key to fit a specific lock.

“Nanobiotics,” a riff on nanoparticles and antibiotics, uses a particle’s shape, size and chemistry to interrupt a bacterium’s survival processes. Endless configurations and sizes are possible with current technology, creating new pathways for the nanoparticles to insert themselves into those key processes. Once it’s there, the nanobiotic effectively disrupts and shuts down that process, causing the bacterium’s death—even in something resistant to traditional antibiotics.

Nicholas Kost, the Joseph B. and Florence V. Cзначek Professor of Chemical Engineering, makes the particles in his lab.

“These are pieces of inorganic material, a few nanometers in size,”
"WHAT IF THIS ONE BACTERIUM MUTATES
SO IT'S NO LONGER
SusCEPTIBLE TO A DRUG?
OR LESS SUSCEPTIBLE TO A DRUG?

MULTI-PRONGED ATTACKS

Cricketer didn’t bring Sriram Chandrasekaran fame as a bowler or batsman the way he imagined growing up in Chennai, along India’s southeastern coast. Yet somewhere, in the sport’s ranking systems and statistical analyses, it still nudged him toward his future.

"If you’re a batsman, you’ve got to outscore your bowler, but if you’re a cricketer, the bowler wins," he said. "I can’t kill the bacteria infecting the device because it’s in a biofilm. So it has to come out, often repeatedly."

Other nanoparticles can be designed to attack biofilms specifically. Graphene, a single layer of carbon atoms Kotov describes as “chicken wire,” can be designed at the microscopic level, two to five nanometers in size.

“We can coat the edges of the particles with some chemistry and it interferes with its processes,” she said. “Then the question becomes: how can we fine-tune the design enough to achieve our goal?”

In one example, the team fashioned nanoparticles into pyramid shapes with long points. Those pointed ends interact with bacterial enzymes.

"Those enzymes also have shapes," Kotov said. "Some have a hole in them, or grooves. Their geometry fits well with the sharp apexes of our nanoparticles."

Bacteria, however, don’t like to have themselves vulnerable. "They dig in, setting up defenses. They’ll bunch and adhere to any surface they can find in the body. And it’s easier for them to hang on to a medical implant than living tissue," VanEpps said.

In this string-of-numbers approach, the bacteria grow in layers and produce a protective gel as a barrier between themselves and immune cells. That gel also keeps antibiotics at bay.

"Even if you assumed a perfect world going forward, one where you weren’t seeing this increase in resistance to antibiotics, biofilms would still be a major problem because regular antibiotics don’t work on them," said Scott VanEpps, a biomedical engineer and ER doctor at Michigan Medicine. "But in reality, the mechanisms inside biofilms foster the development of antibiotic resistance because you have bacteria in close proximity transferring genes."

VanEpps takes the materials provided by Kotov’s lab and tests them to see not only if they work, but how. He has seen firsthand what drug-resistant bacteria can do. For patients, it can create a painful cycle of surgeries to implant devices, remove them once they cause an infection, and replace them with new ones. "Ultimately, taking the devices out of people, that winds up being the solution," he said.

“I can’t kill the bacteria infecting the device because it’s in a biofilm. So it has to come out, often repeatedly."

But roadmaps, while a help, do little to shorten the journey by themselves. And in many ways, researching treatments for drug-resistant bacteria is a race against time.

"Twenty years back, researchers normally measured just one protein at a time," Chandrasekaran said. "You would see papers come out saying, ‘We measured the level of Protein X in something like E. coli, and we observed its levels change over time.’ That would be a whole study in itself."

"Because E. coli has something like 4,000 proteins, just measuring one protein doesn’t tell us much – doesn’t give us the big picture."

In recent years, proteomics technology and improved computational methods have allowed for this kind of deep dive. The experimental tech identifies what proteins T-cells target in the bacteria and the computer modeling helps show why specific proteins are attacked and what the outcome is.

And the data generated creates all kinds of possibilities. "We can now expose different bacteria to immune enzymes in simulations and track what proteins the enzymes go after," Chandrasekaran said. "This gives us a huge amount of data to work with and it’s allowing us to develop computer models of the bacteria before and after T-cells attack.

"When data shows that the enzyme from T-cells blocks a specific protein, I should be able to predict what happens to the cell."

"The system of equations we’ve built mirrors the body’s approach, Chandrasekaran said. "It recreates the multi-pronged approach of T-cells.

So when a drug or enzyme blocks the backup protein, I can now say with confidence that blocking that protein is a way to slow the bacteria down, or possibly, kill it."

While Chandrasekaran brings this approach to fighting bacteria in general, the ancient bug he’s targeting now is a soon-to-be ancient bug already getting the multi-pronged treatment. And that research may be giving us a look at the future of fighting bacterial infections.

Sriram Chandrasekaran uses the blueprint provided by bacteriokilling T-cells and the study of proteomics to design drugs and treatments to combat drug resistance. Knowing which proteins the body naturally targets informs how new drugs or new combinations should work to be most effective.
But its innate tenacity has put it ahead of the game in drug resistance, requiring combinations of antibiotics for treatment as a matter of course. And when it kicks into its highest destructive gear, it still demonstrates the ferocity of earlier centuries—when it was referred to as “captain of the men of death.” In 2006, the disease’s power was on full display in the small South African town of Tsipla Ferry. An “extensively drug-resistant tuberculosis” (XDR-TB) took hold among the population of roughly 3,000. Early on, the local hospital reported 53 cases. All but one died.

A year later, 314 cases had been reported, eventually resulting in 215 deaths. Tsipla Ferry’s region of South Africa is essentially the backyard of Elize Piemar’s youth—a long way from her current life in America’s Midwest. Her academic path wound from a university in Pretoria to a research team headed by Jennifer Linderman, a professor of chemical engineering. Linderman has spent years examining cell behavior and internal processes such as diffusion, the movement of particles in the body, and chemical kinetics, with a particular interest in immunology. With collaborator Denise Kirschner, a Michigan Medicine researcher in microbiology and immunity, the team has painstakingly crafted a computer simulation of the disease as a means of studying it and, it is hoped, finding new ways to treat it.

With the introduction of tuberculosis, Linderman said, a “bacterial begin in the body. One of the hallmarks of that confrontation is the creation of granulomas—dense groupings of immune cells surrounding the bacteria to protect the host. But they also protect the bacteria. “In some cases, the body’s immune system can eliminate the bacteria completely, sterilizing the granuloma,” Linderman said. “That’s if you’re lucky.”

“If you’re not so lucky, the bacteria are growing and dividing and the immune system is fighting them, keeping the levels of bacteria low and in check within the granulomas. Or worse, the immune system is not able to keep the bacteria in control and you develop active tuberculosis.”

To get to the heart of such questions, the team developed computer simulations of the immune response. A powerful resource for such work lies in data collection, and Linderman uses everything she can get her hands on.

Studies of how bacteria behave in a petri dish? Got it. Animal studies, from mouse to macaque, of tuberculosis progression? Check.

In fact, the team collaborates with JoAnne Flynn, a professor of microbiology and molecular genetics at the University of Pittsburgh, and Vronique Danuson of the Public Health Research Institute at Rutgers University, who examine the disease in animals.

“With our development of an in vitro cell model we can take a piece of lung tissue and start with an infected cell, or infected macrophage and see the bacteria dividing.” Linderman said. “We could watch a granuloma grow in simulation.”

Group put together simulations of two antibiotics—isoniazid and rifampin—which are among the most widely used to treat the disease.

And most recently, the team has factored in drug resistance to their tuberculosis simulations.

“Now that we’ve built a model that has the bacteria and the antibiotics in it, we can start asking, ‘What if this one bacterium mutates so it’s no longer susceptible to a drug or less susceptible to a drug?’” said Piemar, who continues to collaborate with the team after taking a post at Purdue University last year. “We can change the bacteria’s susceptibility to the drug and its growth rate.”

The work has given researchers a glimpse of tantalizing treatment possibilities, as well as an idea of the Pennstatan team’s potential.

“The problem is that when you treat tuberculosis, you use combinations of drugs,” Linderman said. “Let’s say there were 15 drugs that could be of use. Each can be given in multiple ways—once a week, twice a week, over a month or several months, or in multiple concentrations.”

“We’re talking billions of combinations. And you cannot test them all. It is impossible to test all of the possible drug combinations, dosage combinations and regimens—from animal models through to human testing.”

“I am always attracted by intelligence in nature, and bacteria have clearly shown they can outsmart humans,” Vidi said. “They are tiny and yet they understand that if they work in unison, they can launch attacks we can’t stop.”

“Tuberculosis is a huge problem back home,” she said. “That’s why I kind of can’t let it go.”

Even high-powered computer simulations can’t dog through every potential combination. But they can point researchers in promising directions—toward the drugs and drug combinations that are most likely to produce results.

“It’s the general area of the haystack to look in to find that needle. Using these simulations, we can predict which direction we should be moving in,” Linderman said. “We’re not only looking at existing therapies, including immunotherapy options, but we’re thinking what drugs—new, repurposed or existing—could be used in different combinations that might be effective.”

There’s a sad familiarity to many of the conferences Pienar attends on drug resistance. Inevitably, a presenter will pull up a heat map of areas where resistance crops up most often.

“The threat of the problem at hand—and its truly global implications—has some of the best minds pivoting from other areas and bringing their talents to bear on antibiotic resistance. Angella Vidi’s previous work centered on the chemistry of combution. Scott VanEpps was at, one point, heading down the path of vascular biomechanics. And Sriram Chandrasekaran’s work on proteins could have led him anywhere.”

“I am always attracted by intelligence in nature, and bacteria have clearly shown they can outsmart humans,” Vidi said. “They are tiny and yet they understand that if they work in unison, they can launch attacks we can’t stop.”

From his doctor’s vantage point, VanEpps sees that the research being done at U-M is a vital cog in what will need to be a much larger machine.

“I can’t expect Congress to go up to a drug maker like Merck or GlaxoSmithKline and order them to start developing and making new antibiotics,” he said. “There needs to be a diverse portfolio approach.”

It’s a real solution, he said, lies in a convergence between philanthropic groups, university support and private investment.

“It’s a sentiment echoed by undersea explorer and medical chemist David Sherman.

“There is a lot of discovery underway that is seeing promising success,” he said. “The next phase is the really hard part—getting these discoveries to a point where we can decide if a big investment in the next step is worthwhile.”

Jennifer Linderman’s team utilizes highly-detailed computer simulations to wade through the “zillions” of drug combinations and treatment variables that can impact the progression of tuberculosis. In recent years, the team has focused on TB’s drug-resistant forms.
I stayed in their house, and I learned a lot of things from the Browns. The most important thing I learned, I think, was football. They said, “You need to go to a football game with us.”

I had no idea what they were talking about, but vaguely remembered when I was in Taiwan, my parents were describing football, and they showed no interest. Now, I said to myself, “Now that I am a student at the University of Michigan, I want to be what everyone else is.”

So I went to the game. It was University of Michigan versus UCLA. It took me a very short time to figure out the rules. In my six years at Michigan, I probably did not miss any games. I always went to the games.

But more important, because G.G. Brown was the dean of engineering, many accomplished scholars came to visit. So I had the chance to meet many people. I am very grateful to the Browns. George and his wife were very kind to me. At that time, I really didn’t understand what was going on.

HOW WAS YOUR ENGLISH?

Practically nonexistent.

WOW. HOW DID YOU GO THROUGH SCHOOL WITHOUT UNDERSTANDING ENGLISH?

That’s very interesting because in 1956, the University of Michigan was quite different from the University of Michigan today. There were very few foreign students.

I decided now that I’m here in the United States, if I want to stay here, it’s better I learn all the customs and the language. In order to try to accomplish something, you really have to assimilate yourself to the society. So that’s why I made an effort to learn English.

WHY?

Every month, there was a blue book exam. Even at that time. Students, my classmates, began to notice: Well, there’s this guy, hardly ever making any kind of a stir. And the teacher would call my name, and everybody would laugh because I was asleep. But after a month, people began to take notice of me.

WHAT?

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HOW DID YOU END UP COMING TO MICHIGAN?

I was born in Ann Arbor, Michigan. And three months after I was born, we went to Japan and China broke out. My parents decided to return to China.

So I grew up during wartime in China. I never had a chance to see a movie. I was too young. And I didn’t have a chance to meet many people. I am very grateful to the Browns. George and his wife were very kind to me. At that time, I really didn’t understand what was going on.

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THE REVOLUTION

The discovery of the J/psi caused such a shift in thinking that the period is called the “Revolution.” Here’s how we built up to that moment.

THE BACKGROUND

Accelerator physics. Einstein predicted that mass and energy are actually interchangeable, but it takes a lot of energy to produce a little bit of mass. So physicists started smashing particles into other particles, concentrating the energy to make new particles. These particles are not normally seen because they decay in the form of energy, dominating into ordinary particles – such as protons, neutrons and electrons. They typically do so very quickly, in just a half-second or less.

THE BREAKTHROUGHS

1947: The “pi-meson” is discovered, kicking off the accumulation of a “particle zoo.” These particles, discovered with accelerators, were thought at first to be elementary particles – the smallest particles, from which everything else is made. But as the complexity closed in on a hundred of them, researchers insisted that they were truly elementary.

1949: Six years at Michigan, I probably did not miss any games. I always went to the games. But more important, because G.G. Brown was the dean of engineering, many accomplished scholars came to visit. So I had the chance to meet many people. I am very grateful to the Browns. George and his wife were very kind to me. At that time, I really didn’t understand what was going on.

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Practically nonexistent.

WOW. HOW DID YOU GO THROUGH SCHOOL WITHOUT UNDERSTANDING ENGLISH?

That’s very interesting because in 1956, the University of Michigan was quite different from the University of Michigan today. There were very few foreign students.

I decided now that I’m here in the United States, if I want to stay here, it’s better I learn all the customs and the language. In order to try to accomplish something, you really have to assimilate yourself to the society. So that’s why I made an effort to learn English.

WHY?

Every month, there was a blue book exam. Even at that time. Students, my classmates, began to notice: Well, there’s this guy, hardly ever making any kind of a stir. And the teacher would call my name, and everybody would laugh because I was asleep. But after a month, people began to take notice of me.

WHAT?

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HOW DID YOU END UP COMING TO MICHIGAN?

I was born in Ann Arbor, Michigan. And three months after I was born, we went to Japan and China broke out. My parents decided to return to China. So I grew up during wartime in China. I never had a chance to see a movie. I was too young. And I didn’t have a chance to meet many people. I am very grateful to the Browns. George and his wife were very kind to me. At that time, I really didn’t understand what was going on.

I decided now that I’m here in the United States, if I want to stay here, it’s better I learn all the customs and the language. In order to try to accomplish something, you really have to assimilate yourself to the society. So that’s why I made an effort to learn English.

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WHAT?

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**SPREADING OF PARTICLE PHYSICS, CAN YOU TELL ME ABOUT THE IMPORTANCE OF THE J/PSI PARTICLE?**

When you break the atom apart, you have a nucleus. And if you break the nucleus apart, there are some things that we thought were elementary particles. Protons, neutrons, kaons, mesons, omega mesons, and so forth.

There are a few hundred of them. All of them have a very short lifetime. In 1974, I discovered this J particle. Soon after this, a family of similar particles were observed by many, many groups worldwide. Their unique feature is their lifetime is 10,000 times longer than all the known existing elementary particles. The significance of which you can visualize as follows:

Everybody lives on Earth to about 100 years. But you find some village in the Upper Peninsula where people live one million years. And then these people are somewhat different from ordinary people. And this discovery means our understanding of physics is totally incomplete. New models had to be made. That is why I received a Nobel Prize—mainly because the J particle changed the basic concept of physics.

**HOW DID YOU FEEL WHEN YOU REALIZED THAT YOU’D SEEN SOMETHING THAT WAS REALLY GROUNDBREAKING?**

Basically, you have a feeling that you are really very small. There are so many things you do not know. You thought you understood everything. Not the case at all.

**DID IT MAKE YOU MORE INTERESTED IN TRYING TO BE THE FIRST TO FIND SOMETHING ELSE?**

Yes. I am now doing an experiment on the International Space Station. The idea is very simple: You have heard of the Big Bang origin of the universe. Now, at the beginning of the Big Bang, there is a vacuum. So then suddenly you have a big bang. The universe begins to expand. After 1.5 billion years, we have the University of Michigan, we have a football team, we have you and me.

Now the question is, at the very beginning of the Big Bang, there must be equal amounts of matter and antimatter because otherwise it would not come from a vacuum. Nothing exists in a vacuum. So once you have a big bang, the positive and negative must be the same amount.

**CAN YOU TELL ME MORE ABOUT ANTIMATTER?**

Antimatter exists on Earth. If you go to the hospital, you have a PET scan. That’s Positron Emission Tomography. That position is a positively charged electron, that’s the antimatter of the electron.

You also have protons and antiprotons. You have neutrons, you have antineutrons. So everything has an antiparticle. So the existence of antiparticles is not a question. The question is: If the universe comes from a big bang, where is the universe made out of antimatter? And that’s the question I’m asking on the International Space Station.

**HOW ARE YOU DOING THAT?**

Matter and antimatter have opposite charges. Protons have a positive charge, antiprotons have a negative charge. To distinguish charge, you need a magnet. So when particles go through a magnetic field, positive bends one way, negative bends the other way.

So you need to put a magnetic device on the space station. This is a difficult thing because, as you know, a magnet always points north, the other end points to the south. If you’re not careful, the space station will spin like a magnetic compass.

For many years, nobody can put a magnetic detector in space. And then one day, I figured out a way, together with a group of collaborators at MIT. A magnet that doesn’t turn. All the magnetic field stays inside the magnet. It’s a very simple idea, but it took us 40 years to figure out. And so after we figured it out, we put it in space. So now we can detect matter going one way, antimatter going the opposite way.

**DARK MATTER IS ALSO A TARGET OF THE ALPHA MAGNETIC SPECTROMETER, RIGHT?**

Yes. What is dark matter? If you look at a galaxy, there are thousands of galaxies that have been examined, every galaxy has a closed orbit. A closed orbit means it is a balance of gravitational force and centripetal force. Only when you have forces that are balanced do you have a closed orbit.

Gravitational force is the product of the mass of the galaxy and the mass of the entire universe. Centripetal force is the mass of the galaxy and the speed. And so if you put all this together, you examine the galaxy, you find out the amount of material—the amount of matter you need in the universe—is ten times more than what you see in the universe. In other words, 90 percent of the universe you cannot see.

This is not only true for our galaxy, it’s true for thousands of galaxies that have been examined. That’s why it’s called dark matter. It’s called dark matter because you cannot see it. Nobody knows what dark matter is like. But the collisions of dark matter become energy. Energy can change into matter from relativity. And so you can produce positrons and antiprotons. So by measuring these particles, you can try to get a hint of what is going on with the origin of dark matter. In fact that’s what we’re doing now: We are measuring cosmic rays, particles shotting through space.

**AND THIS SHOWS UP AS AN EXCESS OF ANTIMATTER IN YOUR DETECTOR? AS IN, MUCH MORE THAN YOU WOULD EXPECT?**

Huge excess! Enormous excess of positrons and antiprotons. Much more than from ordinary collisions of cosmic rays. So something new—something new phenomenon is there.

It will take some time for us to pin it down. But up to now, we have collected more than 100 billion cosmic rays, up to an energy of a trillion electron volts [in other words, a particle with the same kinetic energy as a flying mosquito]. And all this phenomena, all the things we have collected, cannot be understood by the knowledge of existing cosmic ray physics.

**WHY HADN’T OTHER COSMIC RAY EXPERIMENTS CAUGHT IT?**

Before us, there have been many experimental measures of cosmic rays by balloons and small satellite. Balloons, you can send to space, but not to 400 kilometers above earth. They normally fly to about eight kilometers. So you still have atmosphere above.

Also at night, when the temperature cools down, the balloon tends to fall to the ground. Balloons tend to stay aloft for a few days to a maximum of a month or two. So you cannot make a precise measurement.

**WHAT ARE YOUR FAVORITES?**

Small satellites normally do not carry a magnet. If you don’t carry a magnet, you cannot distinguish positive charge and negative charge. So this is the first time you have a very large particle physics type detector in space. In basically every other experiment, you always do more than one year for your data.

**WHAT IS DARK MATTER?**

It’s a very simple idea, but it took us 40 years to figure out. And so after we figured it out, we put it in space. So now we can detect matter going one way, antimatter going the opposite way.

**DOES IT MAKE YOU MORE INTERESTED IN TRYING TO BE A BIGGER SCIENTIST?**

Yeah, because it took us nearly 20 years to put this device up in space. And in the foreseeable future, there are probably no similar detectors in space. So we have an obligation to get it right because nobody else can perform the same measurements.

This is the same data, same detector. But to achieve an accuracy of one percent, a judgment call is needed. What is a real particle signal, what is background. From the data there is always a human element. Most of the time people don’t agree. But I want to understand why.

Eventually, people reach agreement.

**HOW DID IT FEEL WHEN YOUR EXPERIMENT LAUNCHED AND WAS INSTALLED ON THE SPACE STATION?**

I was quite excited. We used many different detectors in accelerator. And in accelerators, if you have something you’re worried about, you can shut down the accelerator and go in and take a look. I remember when the space shuttle took off, I was quite concerned. Because suddenly, I could not check anything.

Fortunately, most of the elements are redundant. The electronics and the computers sometimes have faulty redundancy, and the minimum is two fold redundancy. So if one goes bad, another one can switch and replace it.

**AND FINALLY, FOR THE FOOTBALL FANS, WHAT ARE YOUR FEELINGS ABOUT OHIO STATE?**

When I was at Michigan, the first thing I learned was not physics—the first thing I learned was “Beat Ohio State!”

I remember one year, Michigan did not do well. The Michigan-Ohio State game was always the last game. The stadium had a capacity of 100,000 people, but that year, because Michigan had done so badly, and it was raining heavily, there were only about 5,000 people in the stadium. And I was one of them.

A few years ago, I went to visit Ohio State. They invited me to give a speech about my experiment. They announced I was from Michigan, and I heard this “Boo-oo-oo” noise. When it was my turn to do the talk, I told them I came from Michigan, and today is the first day I actually realized that Ohio State has classrooms on its campus! 
Galaxies are spinning too fast. At least, if you consider the amount of matter in them – there isn’t enough gravity to hold them together. They should contain about five times more matter to produce that gravitational force. This is why scientists believe there is “dark” matter floating out in these galaxies, helping to hold the stars together.

**DARK MATTER IS ITS OWN ANTIMATTER**

Dark matter particles are their own antiparticles. If they bump into one another, they’ll revert the energy, a process called annihilation. This energy can then become any kind of particle-antiparticle pair. Because antiparticles are rare, they can be measured to infer the presence of dark matter.

**MEASURING ANTIMATTER**

Ting and his colleagues are looking for antimatter – in order to get hints about dark matter – through a particle physics detector on the International Space Station.

The central component of the detector, called the Alpha Magnetic Spectrometer, is a large magnet. When particles pass through this detector, positively charged particles curve one way and negatively charged particles curve the other way. The scientists combine this information with a measure of the mass to determine a particle ID. Some are regular matter, such as electrons. Others are the corresponding antimatter, such as positrons.

A certain amount of antimatter is expected from cosmic ray collisions (particles that are catapulted out of exploding stars), but if dark matter particles are running into one another, we should see more.

**SO HAS THE DETECTOR FOUND DARK MATTER?**

It has measured a suspicious trend in the positron spectrum – or how the frequency of positron detections changes at higher and higher momentum measurements. The curve resembles what you’d see if there were dark matter particles with masses of about one teraelectronvolt – roughly 1000 times more massive than a proton. But it doesn’t entirely fit a smoking gun – this pattern could also come from proposed physics related to exotic post-supernova stellar remnants known as pulsars. Still, by the end of the experiment in 2024, Ting is optimistic that we could have an answer.
MAPPING THE GAPS

Why do smart students fail and how do social systems influence their success? Understanding mentorship and community to create engineers.

STORY BY Cara Gonzalez
PHOTOS BY Joseph Xu
one of her first engineering classes, Joi Mondisa encountered a problem — one that would lay the foundation for her life’s work as an engineering education researcher.

In the late 1990s, she had graduated at the top of her class at a multicultural high school in suburban Chicago. She had always excelled in math and science and worked well with other students. A college major in engineering seemed a perfect fit.

But at university, it was different. In one of her very first class discussions, she attempted to contribute to the group discussion. However, her ideas were ignored.

“It was like” – she mimes tapping a microphone – “‘Is this thing on?’”

Mondisa noticed that some of her classmates chose not to sit next to her. And while classmates would work together on the homework, no one collaborated with her.

She grew uneasy. What was she doing wrong? She confided in a trusted faculty member – someone who would become one of her most influential mentors. But he had a hard time understanding Mondisa’s experience. He is a white man. She is an African-American woman.

This situation was not unique – not for her, or other underrepresented minority (often referred to as URM) students. A steady stream of studies from the 1990s to today has shown that many African-American students experience a “chilly” campus climate at predominantly white institutions. In a challenging major like engineering, this lack of connection provides, at best, little support for the student, and at worst, withdrawal from the field.

Scholars say it’s partly to blame for the low numbers of URM students in engineering.

Mondisa got through both her undergrad and grad school. In 2014, she attended Michigan Engineering’s NextProf, an annual workshop for women and URM early career scientists and engineers who are contemplating careers in academia. Today, Mondisa is at Michigan Engineering as an assistant professor of Industrial and Operations Engineering (IOE) and an engineering education researcher.

From this unique perch, she is analyzing systems within engineering education. She’s taking a quantitative approach to answering one of the most complicated questions in engineering education research: What is the role of social community in the retention of engineering undergrads, especially URMs?

“The curriculum for engineering is hard already. On top of that, an intimate knowledge of the higher education system is required to be successful,” says Mondisa. “Learning to navigate the system can be extremely difficult.”

Industrial and operations engineers analyze and optimize some of the most complex systems known to humankind in areas such as health care, ergonomics and disaster planning. From her uniquely valuable experience, Mondisa aims to illuminate what mentoring methods, approaches and programs actually work — and why she began by studying the mentors themselves.

“The work could have implications not just at U-M but across engineering.”

“I really believe we need a diverse group of engineers if you want to have good engineering practice in this country,” said Mark Driskin, the Clyde W. Johnson Professor and chair of the Department of Industrial and Operations Engineering. “To design anything, you want a very diverse group of engineers and potential users.”

Mondisa’s engineering education colleagues agree. “Mondisa works alongside her IOE colleagues, teaches IOE classes, and her research is in alignment with the department, but it’s outside of the scope of what they’ve normally done,” said Cindy Finelli, director of the Engineering Education Research Program and associate professor of Electrical Engineering and Computer Science. “So here at U-M, the work that Joi is doing is directly tied to IOE.”

LOST POTENTIAL AND REVENUE

Mondisa earned her bachelor’s degree in engineering in 2001 from the University of Illinois at Urbana-Champaign. She worked in industry for ten years and completed an MBA during this time. Then she returned to school and earned her master’s in industrial engineering and PhD in engineering education. In 2016, she accepted a tenure-track position at U-M.

“Then why are success stories like hers still so rare? The engineering workforce is no more diverse now than it was when Napster debuted and Y2K was a looming concern. In 2001, when Mondisa graduated, 1.74 percent of engineering bachelor degrees were awarded to African-American women. In 2015, almost fifteen years later, the number had fallen to below 1 percent. In fact, African-American and Hispanic students are more, not less, underrepresented at top universities than they were 35 years ago.

Both academically and professionally, the representation of women and minorities in engineering has either plateaued or started to backslide for the past two decades. In 2014, women accounted for 24 percent of the engineering workforce, down from 25 percent in 2001. And at the same time, African-American and Latino workers represent 25 percent of the general workforce, but just 16 percent in advanced manufacturing, 15 percent in the computing sector and 12 percent of engineers.

That’s years of lost potential for diverse engineers. It could also add up to lost revenue for the entire industry. McKinsey researchers in 2015 found that companies in the top quartile for racial and ethnic diversity are 35 percent more likely to have financial returns above their respective national industry median. And companies in the top quartile for gender diversity are 15 percent more likely to have better financial returns.

Engineering is a career with high status, big paychecks, and opportunities to contribute to society. It’s an elite program of study that can break cycles of generational poverty. Engineering degrees are prized across cultures. This exceptionalism has created a system of educating engineers that many believe is calibrated to allow only a certain variety of student to survive. It can be cutthroat and competitive. And that might push out students who don’t exactly fit the mold.
Not everyone sees that as a problem. In a 2016 nationwide survey of engineers co-sponsored by the Society of Women Engineers, 16.8 percent of male engineers expressed the view that diversity is threatening the quality of the profession and that women now have unfair advantages. Compare that to 3.6 percent of male lawyers in a similar survey.

U-M, as well as other engineering education researchers like Mondisa, are working hard to shift this attitude for the sake of the profession, and in support of the common good.

ENGINEERING EDUCATION: THE NEXT FRONTIER

Engineering education research is an emerging field, a discipline that came to prominence in the 1990s. Concerns were mounting: the supply of engineers wasn’t adequately meeting the demands of a nation facing increasing global competition and an appetite for technology.

In 1995, the National Research Council, part of the U.S. National Academy of Sciences and the U.S. National Academy of Engineering, published “Engineering Education: Designing an Adaptive System,” which outlined the steps to address the “needs and realities” of the United States and the world in the 21st century. The council imagined which outlined the steps to address the “needs and realities” of the United States and the world in the 21st century. The council imagined what it would take to educate the top talent from the competitive high schools, are at risk of failing, especially in their first year.

One of the keys to this, Mondisa believes, is community. And one of the crucial benefits of community is mentorship – from both peers and faculty members.

A MECHANISM FOR SUCCESS – MENTORSHIP

Mondisa believes that mentorship matters. Research shows that mentoring minority college students makes them twice as likely to stay in school as their non-mentored peers, and to have higher GPAs. When she launched into her engineering education PhD program, Mondisa, like many researchers, was interested in studying protégés. As she reflected on her own experience, she flipped the model: She really is a great mentor,” she said.

Throughout the rest of her undergraduate career, he shared with her what she describes as “social capital.” He illuminated the internal structure of higher education and how the world of research worked, unlocking key pieces of information that she needed to keep reaching for the next step.

“I saw mentorship as the mechanism that needed to be studied. Protégés are the beneficiaries of mentoring.”

In her research, she is examining how and why mentoring works – in the context of engineering.

In her current research, she uses mixed methods – both qualitative and quantitative approaches. In a qualitative study, Mondisa interviewed underrepresented minority STEM mentors. Results from this study indicated that mentors share coping strategies and knowledge about their experiences with their protégés. Mentors also use cultural and social capital to motivate and connect. In addition, she found that some mentors take a holistic approach to mentoring their protégés and they encourage them to advocate for themselves.

THE SAVING GRACE OF COMMUNITY

Mondisa knows firsthand how social factors can loyal over an undergraduate experience.

During her undergraduate career, some people went out of their way to let her know they didn’t think she belonged. For example, they asked her if she was admitted into the program under the university’s affirmative action plan. These social roadblocks began to stall her upward trajectory.

Mondisa found what she called “her saving grace” in a group of students who were experiencing similar phenomena in their classes.
“In higher education, having a support system can be crucial for people of color, who may face additional obstacles and challenges.”

They were her fellow Metis Scholars at the University of Illinois at Urbana-Champaign. The program provided a social community for Mondisa, where she could find the support she needed to get through. “We’d say, ‘We all got into this program. We’re all good students. We all got through.'" says Mondisa. They became a tribe who helped each other survive. They met for study groups, exam prep and an occasional movie. “That community was critical for my survival. We were all from different backgrounds – black, white, city and suburban kids, as well as kids from farms and rural areas. What was also important is that we were not remedial students,” Mondisa said. “We were the high-achieving, ‘cream of the crop’ students from our high schools, as well as kids from farms and rural areas.”

One of the findings of the study was a significant relationship between connectedness and race. The connectedness mean for whites was 3.75 out of 5 and 3.47 out of 5 for non-whites. Based on the findings, the study called for more research about why non-whites feel less connected, in order for universities to improve the effectiveness of mentorship programs for these populations. Overall, the research reveals the underpinnings of social community. “The more we understand it, the better we will be at fostering it. This research can help colleges identify sources of a lack of social community, as well.”

The Social Community Model was used in this research. The Social Community Model is a framework that can be used to examine participants’ program experiences and outcomes and empirically assess engineering mentoring programs like the Metis Scholar Program.

Such programs have been successful in promoting student retention and many engineering schools have similar programs, including the University of Michigan's M-STEM program. Mondisa studies the social mechanisms within these programs. She pays close attention to the participants’ outcomes, such as their ability to be resilient, engage in communities of practice and build social capital. In a social community, group members need to share a similar mindset. They don't necessarily have the same ethnicity, socioeconomic status or other demographics. But they are a part of a community because they share values and goals like becoming an engineer or passing a class. Mondisa noted that people in such a community tend to experience a reduction in friction and an increase in cooperation. They work toward similar ends and share knowledge with everyone in the community – no matter their demographic differences.

The model offers a way of understanding the costs and rewards for all members who create social support through the back-and-forth of their interactions. It can be as simple as spending time solving problems they understand and receiving help from other individuals about problems they cannot solve. But they also gain social capital, which they can “spend” in their community – for example, trading chemistry notes for a bit of tutoring on last night’s calculus homework. When you’re an outlier, you will need an extra-strong social support system because you’re going to have additional pitfalls to handle. Mondisa says, ”In higher education, having a support system can be crucial for people of color, who may face additional obstacles and challenges.”

Mondisa points to a painting that hangs in her office. On a background of white, she says, “I feel pretty good about the campus climate here.”

A portrait of a black female dressed in a graduation gown hangs in Mondisa’s office. It comes from a community workshop that she and her engineering education advisor attended while at a conference, and serves as a reminder of the role her community has played in her life.
T he late Glenn F. Knoll, a highly esteemed professor of nuclear engineering and radiological sciences, spent more than 50 years at U-M from his PhD onward. In such a close-knit department, his wife, Gladys Hetnauer Knoll (BSN ’78, MSN ’80), is in a part of the NERS family. Now, Gladys Knoll has established the Glenn F. and Gladys H. Knoll Department Chair of Nuclear Engineering and Radiological Sciences, tying their legacy to the position that Glenn Knoll held from 1979 to 1990. The endowment creates a discretionary fund for the chair. Ron Gilgenbach, current NERS chair, is the first to hold the new title.

“My hope is that this endowment will be an inducement for a top-notch candidate to come to U-M NERS. After all, it’s important to maintain that number-one ranking,” she said.

Glads has her eye on the future of the department, as NERS is in the midst of a search for the chair who will take office in September when Gilgenbach steps down after eight years.

“My hope is that this endowment will be an inducement for a top-notch candidate to come to U-M NERS. After all, it’s important to maintain that number-one ranking,” she said.

Glads also has endowed the Glenn Knoll Scholarship Fund and the Glenn F. Knoll Lecture, and has provided resources to name the Glenn F. Knoll Nuclear Measurements Laboratory in the Nuclear Engineering Laboratory.

There is a lot of science in the products we use every day. For example, fibers must absorb moisture and odor as well as they did on the day they were made. This is a seemingly simple example in a range of everyday products – diapers and shampoo behave, leveraging Michigan Engineering’s strengths at modeling and simulation to find new possibilities.

“Three years ago, we declared our strategic partnership between P&G and the University of Michigan and since then, we have been able to have focused and fruitful collaborations leveraging the strong multidisciplinary innovation ecosystem that the university has to offer,” said Kathy Fish, Chief Technology Officer, P&G & Gamble Company.

“Buffer for new PhD students”

When doctoral students start at U-M, they immediately need to find a project that will provide funding. For international students in a new culture, this can be challenging. Thanks to an endowed fund established by Liming and Zhenhuan Yu, first-year international doctoral students are eligible for fellowships that provide a buffer. The funds will cover their first- or second-semester tuition, stipend and health care costs.

Liming Yu established an auto supply company in China. His son, Zhenhuan (MSE IOE ’17), earned his master’s degree at Michigan Engineering after the family learned about U-M through the Joint Institute.

“Supporting joint institute students”

Michigan’s BME department is innovating its novel teaching practices and experiential curriculum development. In addition, Michigan’s BME department – which lies at the interface of Michigan Engineering and Michigan Medicine – is innovating its novel teaching practices and experiential learning modules. These will be adapted by the two universities to meet the specific opportunities at Shantou.

Students from the Joint Institute between U-M and Shanghai Jiao Tong University are eligible for need-based support when they enroll at Michigan Engineering, thanks to an endowed fund from Jackson and Muriel Lum. Jackson Lum was a professor in QCC of the City University of New York and an electrical engineer. The husband and wife originally emigrated from China. Jointly they built up an electronics business in New York.

Although the reasons for investment in Michigan Engineering vary, there are a growing number of examples of donors with connections to China. Sometimes the connection is based on the deeply personal experience of an alum; other times it is based on the promise of mutual learnings from opposite sides of the globe. A common thread, however, is how they often benefit students.

“Connecting to China”

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“A new partnership between U-M and Cavium Inc., a San Jose-based provider of semiconductor products, will create a powerful new big data computing cluster available to all U-M researchers.”

The $3.5 million ThunderX computing cluster will enable U-M researchers to, for example, process massive amounts of data generated by remote sensors in distributed manufacturing environments, or by test fleets of automated and connected vehicles.

“U-M scientists are conducting groundbreaking research in big data already, in areas like connected and automated transportation, learning analytics, precision medicine and social science,” said Eric Michielssen, associate vice president for research-advanced research computing, the Louise Ganiard Johnson Professor of Engineering, and professor of electrical engineering and computer science. “This partnership with Cavium will accelerate the pace of data-driven research and opening up new avenues of inquiry.”

Syed Ali, Cavium’s founder and CEO and a U-M alumnus (MSE EE ’81), added, “I know from experience that U-M researchers are capable of amazing discoveries. Cavium is honored to help break new ground in big data research at one of the top universities in the world.”

Along with applications in fields like manufacturing and transportation, the platform will enable researchers in the social, health and information sciences to more easily mine large, structured and unstructured datasets. This will eventually allow, for example, researchers to discover correlations between health outcomes and disease outbreaks with information derived from socioeconomic, geopolitical and environmental data streams.

Cavium is a leading provider of semiconductor products that enable secure and intelligent processing for enterprise, data center, wired and wireless networking.

- Dan Meisler, Advanced Research Computing
ON STRATEGY

Four questions for members of the Leadership Advisory Board

How can Michigan Engineering gather the best ideas to improve its strategic direction? One of several ways is through its Leadership Advisory Board (LAB). It has tapped an impressive array of leaders for this group. The board’s charge is to provide strategic insight, guidance and assistance to the dean to execute the College’s vision and mission. Members, many of whom are alumni, are selected based on a demonstration of outstanding professional achievement, commitment to the long-term vitality of Michigan Engineering and enhancement of the LAB’s breadth and diversity.

We checked in with these thinkers to see what resonates with them about the direction of Michigan Engineering.

OUR FOUR QUESTIONS:

1. You’ve heard a lot from the Dean and other College leaders about the development and meaning of the vision and mission. What excites or impresses you about it?

Schmitt: I love the vision’s focus on being a thought leader of engineering research and education for the benefit of the common good for the 21st century. This statement is powerful, long-term oriented and inspiring.

Washington: I am both impressed and excited about their commitment to cross-disciplinary research, where they clearly recognize that big innovations and discoveries happen at these cross-disciplinary intersections.

Lesser: I am both impressed and excited about their commitment to cross-disciplinary research, where they clearly recognize that big innovations and discoveries happen at these cross-disciplinary intersections.

2. What’s a key strength or opportunity for Michigan Engineering?

Schmitt: Students at Michigan Engineering are encouraged to pursue bold and investment in the next generation of engineers and leaders.

Lesser: Their proximity to the heart of the U.S. automotive industry is an important strength and opportunity for Michigan Engineering. They have a unique opportunity to help drive the reinvention of the automotive industry in areas like electrification, autonomy and connected smart vehicles more than any other university in the world.

Washington: As good as it is, I am really energized by the goal to take it to the next level in terms of research contributions, community involvement and investments in the next generation of engineers and leaders.

3. How about something to be careful about?

Schmitt: Focus on the biggest leverage actions that will make the most significant impact versus becoming too activity driven.

Lesser: Think carefully about how to incent these professors to stay in academia while still participating in this important evolution.

Washington: Technology is dramatically changing the way work is done, and at an accelerating pace. This is true for companies, governments and universities.

4. What person or book has most influenced your ideas about strategy or success? In one sentence, explain why.

Schmitt: Dr. Elliott Jaques most influenced my ideas about strategy and success because of his substantial work during which he studied large and small organizations, both for-profit and not-for-profit, all over the world, and the people in them for 50+ years and identified several important things that must be in place to ensure high organizational performance and effectiveness. His research and conclusions significantly shape my views about leadership, organization design to drive the strategy and managerial practices that must be in place.

Washington: Jim Collins’s book “Good to Great” flags the importance of getting the right people on the bus and having the right culture to drive success; getting these right will make everything else so much easier, productive and enjoyable.

Lesser: The book I recommend most often is “Give and Take” by U-M grad and Wharton professor Adam Grant. For me, it is a very different business book than others I’ve read, challenging some of our traditional assumptions around what makes people successful in business and in life. Creating environments that encourage “givers” strengthens cultures, promotes creativity, and allows everyone to achieve higher levels of success. That’s true for businesses and for academic institutions.

Bonus question for alumnus Rich Lesser: What’s something you learned at Michigan that you view as connected to your success?

Lesser: The combination of great problem-solving, creativity, persistence and strong teamwork are the foundations of making real change happen, driving progress and building both individual and collective success.

Schmitt: The leading objective of the Victors for Michigan campaign is to make a difference in the lives of students. Contribute to the future of Michigan Engineering. Visit: engin.umich.edu/giving

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STATUS OF THE VICTORS

Michigan Engineering set its goal high in Victors for Michigan, a U-M fundraising campaign in recognition of the 200th anniversary of the university in 2017. The College is on track to meet its $1 billion goal, including the $400 million goal for philanthropic support.

HELP US FINISH STRONG!

The leading objective of the Victors for Michigan campaign is to make a difference in the lives of students. Contribute to the future of Michigan Engineering. Visit: engin.umich.edu/giving

*As of January 2018
STOP, HEY, WHAT’S THAT SOUND?

As several Michigan Engineer readers correctly pointed out on Facebook, this is an anechoic chamber. All those spikes and pads are made of horsehair and rubber, meant to soak up radio waves. While a similar chamber still operates on North Campus, this one was located in the Theater Building at Willow Run Research Laboratories in Ypsilanti. Built in the 1960s, it remained in use until 2015, when the remaining Willow Run facilities were demolished to make room for a new autonomous and connected vehicle facility.

The man in the chamber is Ralph Hiatt, EECS professor. One of only a few chamber experts in the world at the time, he helped design this one. The PUSH, EXIT and NO SMOKING signs were added because designers worried that users wouldn’t be able to find the door in the event of an emergency.

PHOTO: Bentley Historical Library
Every engineer learns by reading books. Fewer learn by writing them. But then, Karl Iagnemma (BSE ME ’94) has always followed his own path. After graduating first in his class at U-M with a mechanical engineering degree and earning a PhD in philosophy and robotics from MIT, it seemed that he could let his sights on whatever he chose. He chose to write.

“At Michigan, I had taken an English elective from a professor named Charles Baxter, who was a revered personality on campus. He had a big influence on me, he taught me to love writing and make it a part of my life,” Iagnemma said. Iagnemma did just that, publishing “On the Nature of Human Neur” in 2003 and “The Romantic Interaction,” a collection of short stories, in 2006. The books were successful in their own right, but Iagnemma says the experience of writing them also informed the success of nuTonomy, the autonomous vehicle software startup he co-founded in 2013 and recently sold to Delphi.

While the path from fiction writer to autonomous vehicle entrepreneur might not seem obvious, it was a natural progression for Iagnemma. “Writing a novel was incredibly difficult. And when you tackle a project like that, you learn to empathize with people who are doing hard things,” he said. “Writing books felt like the first act and this company and this project like that, you learn to empathize with people who are doing hard things.”

As part of Delphi, nuTonomy plans to add more than 100 new employees. Its expertise will power Delphi’s planned launch of autonomous mobility services in cities worldwide. Iagnemma’s success in the autonomous vehicle space hasn’t dulled his urge to write — in fact, he says the process of starting the company has given him plenty of new material.

“It has been interesting to see the difference between the myth and the reality of starting a company,” he said. “There’s this fascination with the reality of starting a company and the myth of starting a company. You’re experiencing some of the most state-of-the-art research in the world. And you’re doing it a car felt like travelling ten years back in time. Today it’s the opposite — when you get into a driverless car, you’re experiencing some of the most state-of-the-art research in the world.”

For Iagnemma, working in the auto industry is about more than safety. A metro Detroit native, he has the car business in his blood. “My father worked in the auto industry and I interned at GM during a period when the auto industry was not a hotbed of innovation. Getting into a car felt like travelling ten years back in time. Today it’s the opposite — when you get into a driverless car, you’re experiencing some of the most state-of-the-art research in the world.”

While engineers earn plenty of titles and accolades, “The Honorable,” isn’t usually one of them. But Hon. Kristine Svinicki (BSE NE ’88) has earned that distinction by bringing her nuclear engineering chops to the sometimes-controversial field of nuclear safety.

As chair of the U.S. Nuclear Regulatory Commission (NRC), her depth of understanding of the real and perceived risks of nuclear energy helps to shape U.S. nuclear policy, ensuring that safety concerns are rationally addressed.

While she started out doing technical work at Idaho National Laboratory immediately after earning her degree, she quickly recognized that the work done at the lab was driven by policy decisions. She pursued that avenue, moving on to Capitol Hill to advise U.S. senators on topics such as nuclear energy and national security. She was first appointed to the NRC in 2008 by then-President George W. Bush. In recognition of her extraordinary achievements and distinction, she is the 2017 recipient of the Michigan Engineering Alumni Medal, the highest award offered by the Michigan Engineering Alumni Board.

“I’m very honored the College would consider a recipient in the policy space rather than someone who took a more technical path,” she said. Svinicki said that the work done at the lab was driven by policy decisions. She pursued that avenue, moving on to Capitol Hill to advise U.S. senators on topics such as nuclear energy and national security. She was first appointed to the NRC in 2008 by then-President George W. Bush. In recognition of her extraordinary achievements and distinction, she is the 2017 recipient of the Michigan Engineering Alumni Medal, the highest award offered by the Michigan Engineering Alumni Board.

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While startups are the punk rock of business. You go out to start an industry or do something great.”

Song has no intention of leaving town as the company grows. “I’d like to see a shift in the culture of the community where we’re not so afraid to try big things — to see them work or see them fail,” he said. “Startups are the punk rock of business. You go out to start an industry or do something great.”

Duo Security now ranks among the world’s most valuable private SaaS companies with total funding of $119 million, and a company post-money valuation of $1.17 billion. It has more than 10,000 customers and protects more than 500 million logins worldwide every month.

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Engineering can be elegant. But drop-dead gorgeous? U-M alum Randy Torno’s (BSE ME ’73) handmade boats fit solidly into both categories. And perhaps that’s no surprise, since he has always considered himself an artist first and an engineer second.

Torno has dedicated much of his life to creating things that are both beautiful and functional: airplanes, furniture, ceramics, stained glass, and these days, custom wooden boats. Together with his wife, Janet, he founded Torno Boat Works in 2014, using his engineer’s grit and artist’s eye to fashion gliding, glistening works of art.

He’s meticulous about every detail, right down to the Dutch varnish he uses to give them just the right smell. He hand-picks every stick of wood, using local sources when he can.

“Design and composition make my boats unique,” Torno said. “I like hand-working things. I feel that has value. I think people appreciate [my boats] because it’s not one out of a hundred.”

Torno has mastered an impressive variety of historical and modern boat styles: English birding canoes, kayaks, scale models, even a reproduction of a 1930s boat called a Gentleman’s Runabout.

“I have always liked to design and build functional things in my career and for myself. Building allows me to use my engineering knowledge and skills as well as my artistic background to create something that is superior in design and performance. However, the best part is that they are great to use.”

Torno worked for several years as a model builder at Ford Motor Company until teaming up with fellow U-M alum Phil Jenkins (BSE ME ’47) at Jenkins Equipment Company, which later became part of International Equipment Solutions. These days, he spends much of his time in his home workshop in northwest Ann Arbor. And, of course, out on the water, where he and Janet often canoe together.

Torno has been involved with boats all his life, racing three-point hydroplanes in high school and sailboats as an adult.

He also admits to another, nerdier passion: spreadsheets, which he has used to hone his boat-building process to a science. It takes him about 50 hours to put a boat together from start to finish. When he’s not building boats, Torno builds furniture for friends, and he has also helped develop an educational curriculum in patents and copyrights for students at Washtenaw Community College.

His lifelong passion for art and engineering is a combination that lends a special quality to the work he does, and Torno takes great pride in it. That passion hasn’t slowed down, and Torno doubts that it ever will.

ALUMNI NOTES

MICHIGAN MADE

Have a story you’d like us to consider for the next issue’s Alumni Notes? Let us know by sending an email to MichiganEngineer@umich.edu with “Alumni Notes” in the subject line.

BRAIN HACKS

What has three cubes, weighs seven tons and sways like a tree in the breeze? That would be “3 Cubes in a seven-axis relationship,” the 25-foot tall Philip Stewart sculpture that was recently installed in front of the George G. Brown Laboratories. In many ways, the piece is the ultimate brain hack.

“I want it to raise the hair on the back of your neck,” explains Stewart. He went through 68 design iterations, and it shows. Not only does each cube rotate, but the whole structure slowly sways, leaning into impossible-looking angles only to bend back the other way when the wind turns.

To make it happen, he combined classic sculpture with modern engineering. He limited the top two cubes with tunable gas struts that give them just the right resistance to the wind. They’re attached to two ends that work like balance scales, held on with a system of ceramic alloy spindle and transfer bearings built to last centuries. Stewart did the math himself with an elaborate system of spreadsheets.

“I got to the point where I could see the motion of the cubes in the numbers on the spreadsheet,” he said. “But when they took the ropes off the final sculpture, I still jumped out of the way. That was when I knew it was a success.”

CUBE CONUNDRUM

While the 14,000-pound sculpture’s three cubes look identical on the outside, they’re very different on the inside. Their weights were carefully calibrated to keep the sculpture in perfect balance. Can you guess the approximate weight of the bottom cube? Is it:

A: 3,000 pounds
B: 6,000 pounds
C: 9,000 pounds
IN MEMORIAM

1940s
41 Mitchell J. Zolik 8/31/17
40 John W. Anderson 9/10/17
42 Alice L. Johnson 12/22/17
40 Glen A. Nelson 7/22/17
40 James R. Christianson 9/20/17
41 Martin L. Meetz
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DO YOU ARDUINO?

First-year Michigan Engineering student Jenny Sokol assembles an Arduino, an open-source electronics platform built for experimentation. Sokol participated in CS KickStart, a student-run summer program that offers hands-on experience to young women with an interest in computer science. Facilitated by Computer Science and Engineering, it’s designed to help boost the enrollment and persistence of women in the field.

PHOTO: Joseph Xu