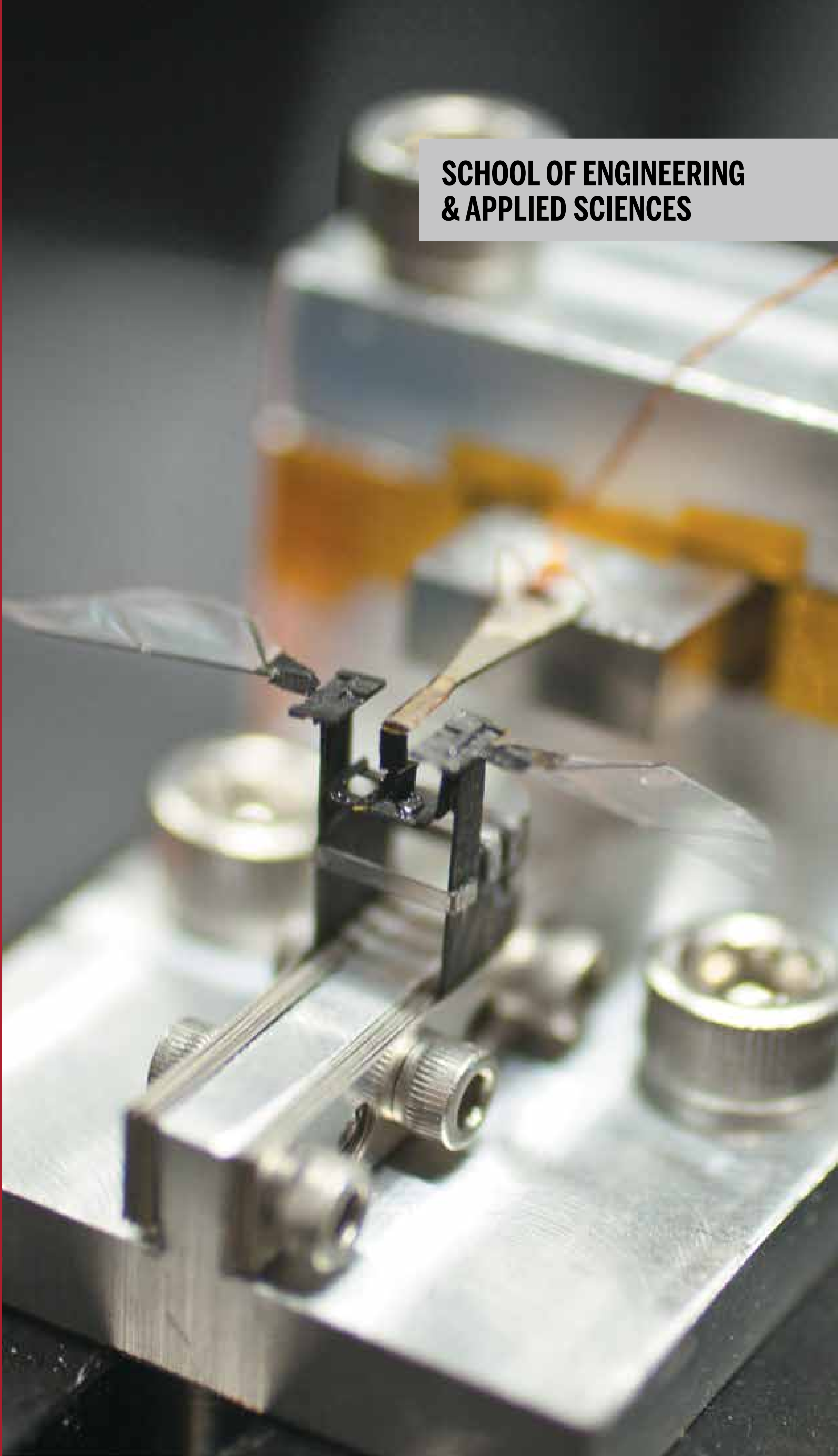
THE HARVARD CAMPAIGN FOR ARTS & SCIENCES

SCHOOL OF ENGINEERING & APPLIED SCIENCES



THE HARVARD CAMPAIGN
FOR ARTS AND SCIENCES

HARVARD IS A PLACE OF DISCOVERY FOR PEOPLE LEADING POSITIVE CHANGE IN THE WORLD, BE THEY SCIENTISTS, SCHOLARS, OR STATESMEN; POETS, PERFORMERS, OR ENTREPRENEURS.

FINANCIAL AID

HOUSE RENEWAL & THE STUDENT EXPERIENCE

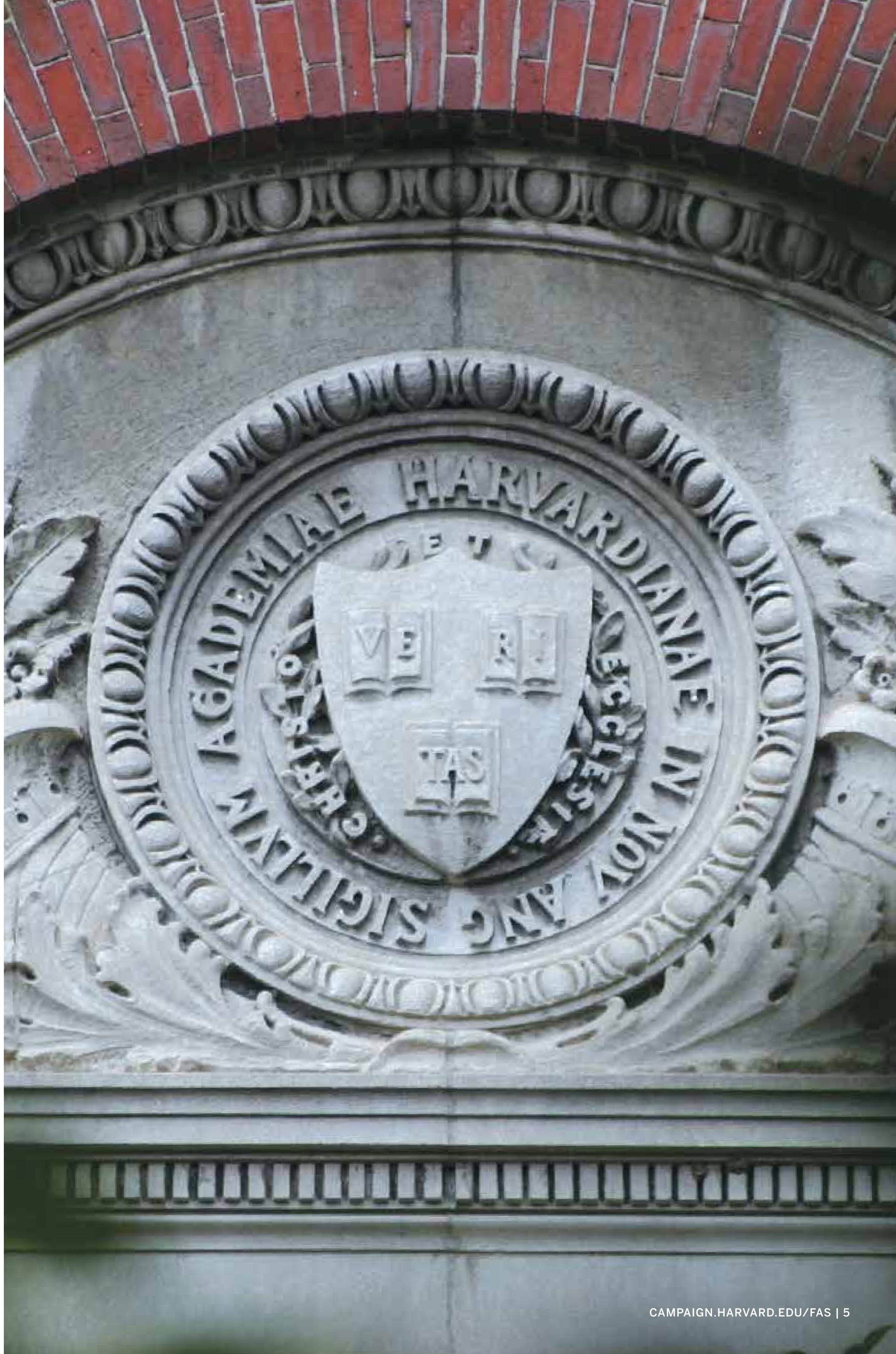
FACULTY & OUR SCHOLARLY ENTERPRISE

LEADING IN LEARNING

SCHOOL OF ENGINEERING & APPLIED SCIENCES

DEAN'S LEADERSHIP FUND

Right: A detail from Pierce Hall, which is at the center of the SEAS campus and activities



HARVARD, AND THE WORLD, NEED SEAS

FROM DEAN CHERRY A. MURRAY

Designed for the future, SEAS is a new kind of school of engineering and applied sciences.

Given the complex nature of problems such as climate change, the global demand for energy, cybersecurity and privacy in a digital world, and providing clean water, a modern infrastructure, and health care for a growing population, what fields will be most relevant in the next century? How can we bring together the vast expertise and resources of Harvard to address these challenges? What is the most effective way to educate students so that they can have real-world impact on these problems, regardless of their fields of study?

All of these global problems involve engineering and technology. Yet none can be solved with technology alone.

Anchored in the liberal arts, SEAS brings a multidisciplinary approach to complex challenges. Our faculty, intellectually outstanding and technically superb, and our students, passionate about making a positive impact on real-world problems, have propelled SEAS to become a catalytic force within one of the world's great universities.

SEAS is organized around world-class teaching and learning and world-changing research. Our educational mission is twofold:

- **Engineering for All:** to provide all Harvard undergraduates with an understanding of technology, engineering design, and the application of scientific and mathematical knowledge that the next generation of leaders will require to navigate in an increasingly complex technological world; and
- **Broad-Minded Engineers and Applied Scientists:** to give concentrators a rigorous education of depth and breadth, combining a strong technical foundation in fundamental engineering and applied sciences with critical thinking, creativity, entrepreneurship, and a grounding in the liberal arts that allows them to understand the societal context of their technical work.

Embracing these twin challenges—to rethink and dramatically expand the place of engineering in higher education and to reimagine the role of engineers in society—SEAS is a leader in innovative teaching. Our curriculum includes active learning and engineering design, and we are increasingly utilizing "flipped classrooms" and integrating peer-based learning into our classes. Our introductory courses provide gateways where all students can learn and find success.

We have an extraordinary record of accomplishment in our first years as a School, but we are just beginning to realize our potential. SEAS will become a unique—and singularly important—school, collaborative and interdisciplinary by nature and by design. By connecting engineering and applied sciences with the arts and humanities, natural sciences, social sciences, and the professions, our faculty, researchers, and students will pioneer new knowledge and applications to address broad global challenges.

The University and our community of alumni and friends have a grand opportunity—and a responsibility—to embrace SEAS and to invest in the extraordinary contribution it can make to Harvard. We invite you to join us.

GOAL $450 MILLION

The Maxwell Dworkin Laboratory, named after the mothers of the building's donors, Microsoft Chairman William H. Gates III COL '77, LLD '97 (hon.) and Microsoft CEO Steven A. Ballmer '77, is home to much of SEAS' computer science and electrical engineering activities, as well as undergraduate design spaces. It stands on the site of the former Aiken Computation Laboratory, built in the 1940s to house a 50-foot-long "giant calculator."

THE CAMPAIGN WILL ALLOW SEAS TO:

ADDRESS THE CHALLENGES OF GROWTH

Enrollments at SEAS are growing. To sustain the quality of teaching, advising, and research at a world-class level, SEAS will increase the number of ladder faculty from 70 to 90 and boost innovation funds for the start-up research programs of new faculty members.

FOSTER MORE EFFECTIVE TEACHING

SEAS will integrate design across the curriculum and create a Learning Incubator to provide faculty with the guidance and resources to become even more effective teachers.

SUPPORT WORLD-CHANGING RESEARCH

SEAS will expand the scale and depth of high-impact, breakthrough research. Our faculty are solving big, complex problems on the frontiers of translational life sciences, computational science and engineering, energy, environmental science and engineering, robotics and controls, and nanophotonics and nanoelectronics—fields in which Harvard has a distinct advantage.

CREATE NEW INTERDISCIPLINARY DEGREE PROGRAMS

These will broaden the curriculum with the creation of distinctive new master's degree programs, some in collaboration with the Graduate School of Design, the Business School, and the Medical School. The new degree programs will span traditional disciplines and prepare students for professional practice or an academic career.

MAKE ENTREPRENEURSHIP UBIQUITOUS

By infusing innovation, creativity, and risk taking across the curriculum and leveraging i-lab, alumni, and industry partnerships, SEAS faculty and students are making entrepreneurship for the social good part of the Harvard culture.

CREATE A DIVERSE INTELLECTUAL COMMUNITY

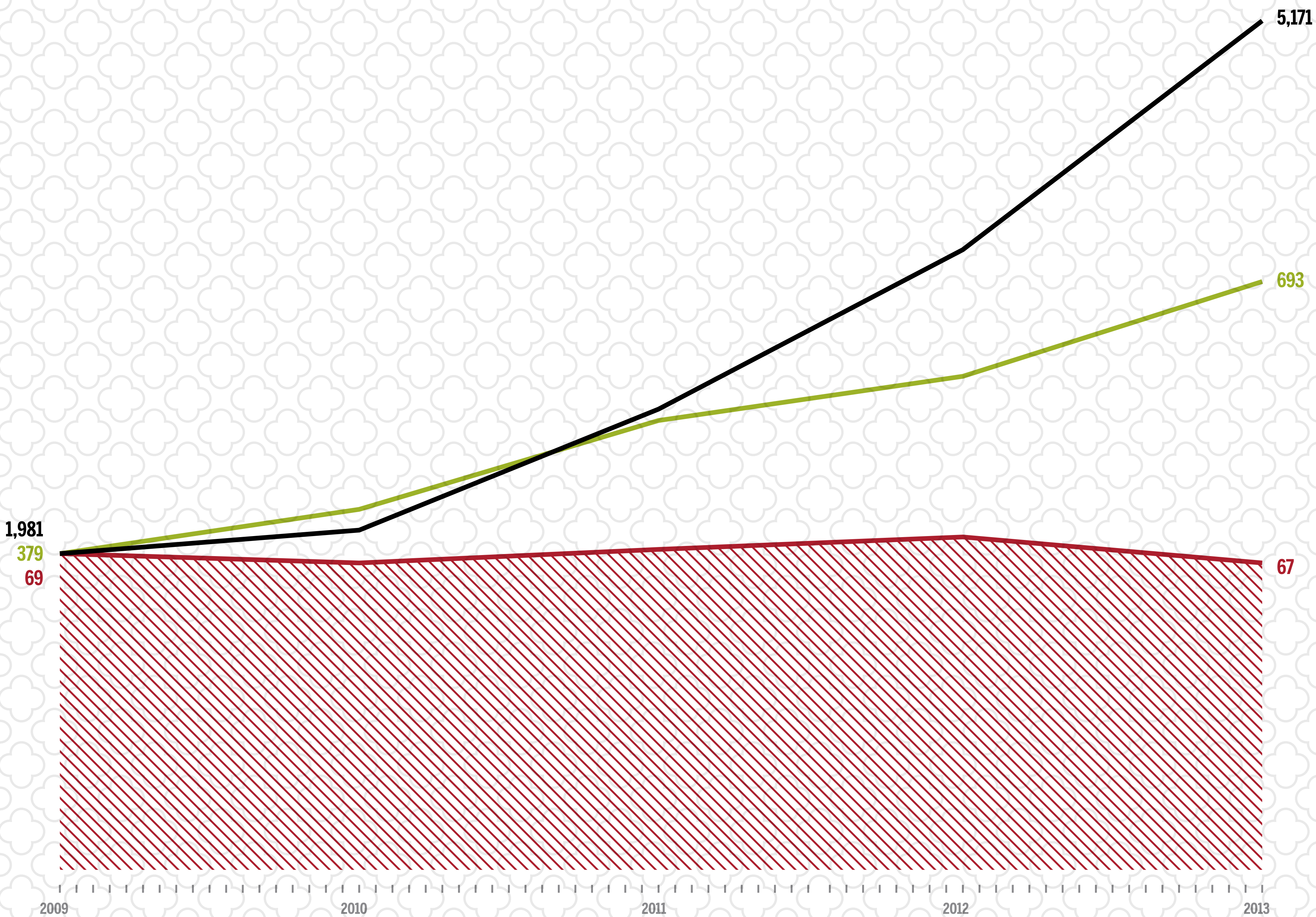
The proportions of women (33 percent) and of U.S. underrepresented minorities (more than 12 percent) concentrating at SEAS are already significantly above the average of U.S. undergraduate engineering schools. SEAS aspires to further increase the representation of these groups among undergraduates, as well as among graduate students, faculty, and staff.

INVEST IN INNOVATIVE INSTRUCTIONAL FACILITIES

New instruction techniques and facilities will help establish Harvard as a leader in the science of teaching as well as the teaching of science. This includes engineering design studios, teaching and research labs, expanded "smart" teaching spaces, and student community spaces. Many of these facilities will be designed specifically for SEAS as the academic cornerstone of a new science and technology extension of the Harvard campus.

EXCITEMENT ABOUT SEAS:

MORE FACULTY NEEDED TO MAINTAIN MOMENTUM



COURSE ENROLLMENTS

SEAS courses are overflowing with concentrators and nonconcentrators alike. Today's students in all fields want to be engineering literate. CS50, an introduction to computer programming, is (with Economics 10) one of the two classes with the highest enrollment at Harvard.

CONCENTRATORS

Since SEAS became a School in 2007, the number of concentrators has more than doubled. In computer science, it has more than tripled.

SEAS now offers new concentrations in mechanical engineering, electrical engineering, and bioengineering to meet student demand.

FACULTY

The rapid growth of SEAS has been exhilarating—and poses new challenges. To maintain momentum and to sustain the quality of teaching, advising, and research at a world-class level, SEAS must increase the size of the faculty.

INNOVATIVE INSTRUCTION: BRAIN DRILL

CONOR WALSH

ASSISTANT PROFESSOR OF MECHANICAL AND BIOMEDICAL ENGINEERING

ACCORDING TO CONOR WALSH, IT'S NOT ABOUT PRODUCING DEVICES. IT'S ABOUT PRODUCING STUDENTS WHO KNOW HOW TO DESIGN.

Walsh's course, ES 227, actually does both. Collaborating with doctors and clinicians at Harvard-affiliated teaching hospitals, teams of SEAS undergraduate and graduate students learn everything they can about a practical problem—by listening to doctors, analyzing the strengths and weaknesses of existing tools, reading the medical literature, and even observing surgeries.

They then apply their design skills to innovate, ideate, test, and eventually prototype new solutions, like a novel deployable grasper for use in minimally invasive surgery, a soft robotic device to help stroke victims regain functionality in their thumbs, a cervical spine immobilization device that EMTs in the field can use to reduce the risk of neck injury, and a portable cranial drill for use by surgeons treating brain trauma patients.

Students in the class have won national design competitions, published research papers in journals, and applied for patents. Their work may also improve a medical outcome or even save a life.

A cranial drill designed by SEAS students Paul Loschak, Kechao Xiao SM '13, and Hao Pei SM '11 automatically and instantly retracts when it has punctured through the skull, protecting the soft tissues inside.

Advances in fluid dynamics and real-time graphics processing allowed members of the Multiscale Hemodynamics Project to create this image, which shows the blood flow in a patient's artery in three different ways.

INNOVATIVE INSTRUCTION: NEW COMPUTATIONAL SCIENCE & ENGINEERING DEGREES

CAN WE TRANSLATE THE HEALTH RECORDS OF MILLIONS OF PATIENTS INTO IMPROVED MEDICAL CARE?

Can we convert vast quantities of weather measurements into better climate models? Use social media to track outbreaks of infectious diseases?

Today, it is possible to measure things we could never measure before, and SEAS is working to harness the 21st-century "data tsunami" to drive breakthroughs in science, medicine, and government policy.

For centuries, researchers gathered data to answer specific questions. Today, scientists ponder what questions can be asked of the immense volumes of data they have at their disposal. This paradigm shift is leading to an entirely new field of data science. And it is creating a demand for leaders skilled in large-scale computation and advanced mathematical modeling.

At the Institute for Applied Computational Science, SEAS faculty and students are applying computational methods to complex problems in ways never before possible. With a unique professional master's degree in computational science and engineering, a secondary field for Harvard PhD students, and a cutting-edge curriculum, the institute has become a vibrant community for learning and research.

INNOVATIVE INSTRUCTION: A CULTURE OF ENTREPRENEURSHIP

BETH ALTRINGER
VISITING LECTURER ON ENGINEERING SCIENCES

COURSES LIKE THE INNOVATORS' PRACTICE SEEK TO PROMOTE INTERDISCIPLINARY, HANDS-ON INNOVATION.

An organizational psychologist, Beth Altringer wants students "to design something that appeals to them personally, that potentially improves people's lives, and that has real-world, measurable impact."

After taking a week or so to explore what they're passionate about, students pair off and spend several weeks studying human behavior "in the wild."

The students then identify design opportunities, prototype promising concepts, and determine how to best measure impact. Recent projects include a guerrilla gardening effort that monitors air quality and headphones that adjust playlists according to the wearer's heart rate.

COURSES TO INVENTION

From classroom to design lab, experimentation, invention, and innovation are core to the SEAS ethos and environment. SEAS courses help develop the skills and mindset required for successful idea generation and development.

START-UP CULTURE

Dozens of start-ups have been launched by students based on solutions developed in SEAS classrooms and labs. Recent examples:

- Mark43 provides law enforcement with software to track—and ultimately prevent—violent crime.
- Vibrant Composites, Inc. is commercializing a pop-up manufacturing process for producing tiny components and devices at a fraction of the cost of conventional fabrication methods.
- Tivli brings television to students via wireless technology.

CAMBRIDGE CONNECTIONS

With strong ties to the Harvard Innovation Lab, the Experiment Fund, and the diverse strengths of Harvard's graduate and professional Schools, SEAS students thrive in an ecosystem of support for big ideas.

BEYOND THE CLASSROOM

Projects developed in SEAS courses aren't simply forgotten at the end of the semester. Student initiatives like Hack Harvard, Nano Start, Engineers Without Borders, RoboCup, Harvard Photonics, and Women in Computer Science nourish those new ideas. And Nectar Funding from SEAS helps student groups do more.

TECHNOLOGY AND ENTREPRENEURSHIP CENTER AT HARVARD (TECH)

SEAS-based TECH creates an innovation community for students across the University through courses, study groups, mentorships, and special events. TECH also sponsors the I^3 Challenge—imagine, invent, and impact. Winning projects have included clinical record-keeping software to help HIV patients keep up with medication and a phone app that translates movies into alternate languages on demand in the movie theater.

CREATE A DIVERSE INTELLECTUAL COMMUNITY: ATTRACTING TALENT

JENNIFER A. LEWIS
WYSS PROFESSOR OF BIOLOGICALLY INSPIRED ENGINEERING

SEAS IS RECRUITING WORLD-CLASS FACULTY WHO COLLABORATE ACROSS DISCIPLINES—LIKE 3D PRINTING EXPERT JENNIFER LEWIS.

Lewis was highly sought after by prestigious universities far and wide. She chose to join SEAS in January 2013 because of its lack of "stovepipes." Harvard has a "truly multidisciplinary approach," she says. Cutting across the boundaries of engineering, life sciences, and medicine, she is helping to elevate the School as a hub for collaborative research.

Using sophisticated 3D printing technology, the Lewis Research Group is creating very finely tailored structures with electronic, optical, mechanical, and chemical properties. In 2013, they announced new lithium-ion batteries the size of a grain of sand.

The result of Lewis's work: new types of functional materials and devices with applications in medicine and energy, the aerospace and automotive sectors, and consumer goods.

INNOVATIVE INSTRUCTION:
NEW PERSPECTIVES

ERIC MAZUR

BALKANSKI PROFESSOR OF PHYSICS AND APPLIED PHYSICS

IT WAS 22 YEARS AGO WHEN PEER INSTRUCTION PIONEER ERIC MAZUR DISCOVERED HOW TO FLIP A CLASSROOM.

He developed the method after realizing that his physics lectures, though popular, were not helping students master basic concepts. The "flipped classroom" relies on the power of teaching by questioning rather than teaching by telling. Students study before rather than after class, and the classroom becomes a place for active learning, questions, and discussion. Instructors don't lecture; they address areas where students need help.

WORLD-CHANGING RESEARCH: ROBOTICS & CONTROLS

"I WANT TO CREATE SOMETHING THE WORLD HAS NEVER SEEN BEFORE,"

says SEAS graduate student Kevin Y. Ma. As co-lead author of a *Science* paper on flying robotic insects, he's done just that. Half the size of a paperclip, weighing less than a tenth of a gram, with wafer-thin wings that flap 120 times per second, RoboBees can leap, hover, and speed along a preset route.

"Large robots can run on electromagnetic motors, but at this small scale you have to come up with an alternative," Ma notes. "It's about the excitement of pushing the limits of what we think we can do, the limits of human ingenuity."

"THIS [FIRST CONTROLLED FLIGHT] IS WHAT I HAVE BEEN TRYING TO DO FOR LITERALLY THE LAST 12 YEARS," SAYS ROBERT J. WOOD (LEFT), CHARLES RIVER PROFESSOR OF ENGINEERING AND APPLIED SCIENCES AND PRINCIPAL INVESTIGATOR OF THE ROBOBEE PROJECT. "IT'S REALLY ONLY BECAUSE OF THIS LAB'S RECENT BREAKTHROUGHS IN MANUFACTURING, MATERIALS, AND DESIGN THAT WE HAVE EVEN BEEN ABLE TO TRY THIS. AND IT JUST WORKED, SPECTACULARLY WELL."

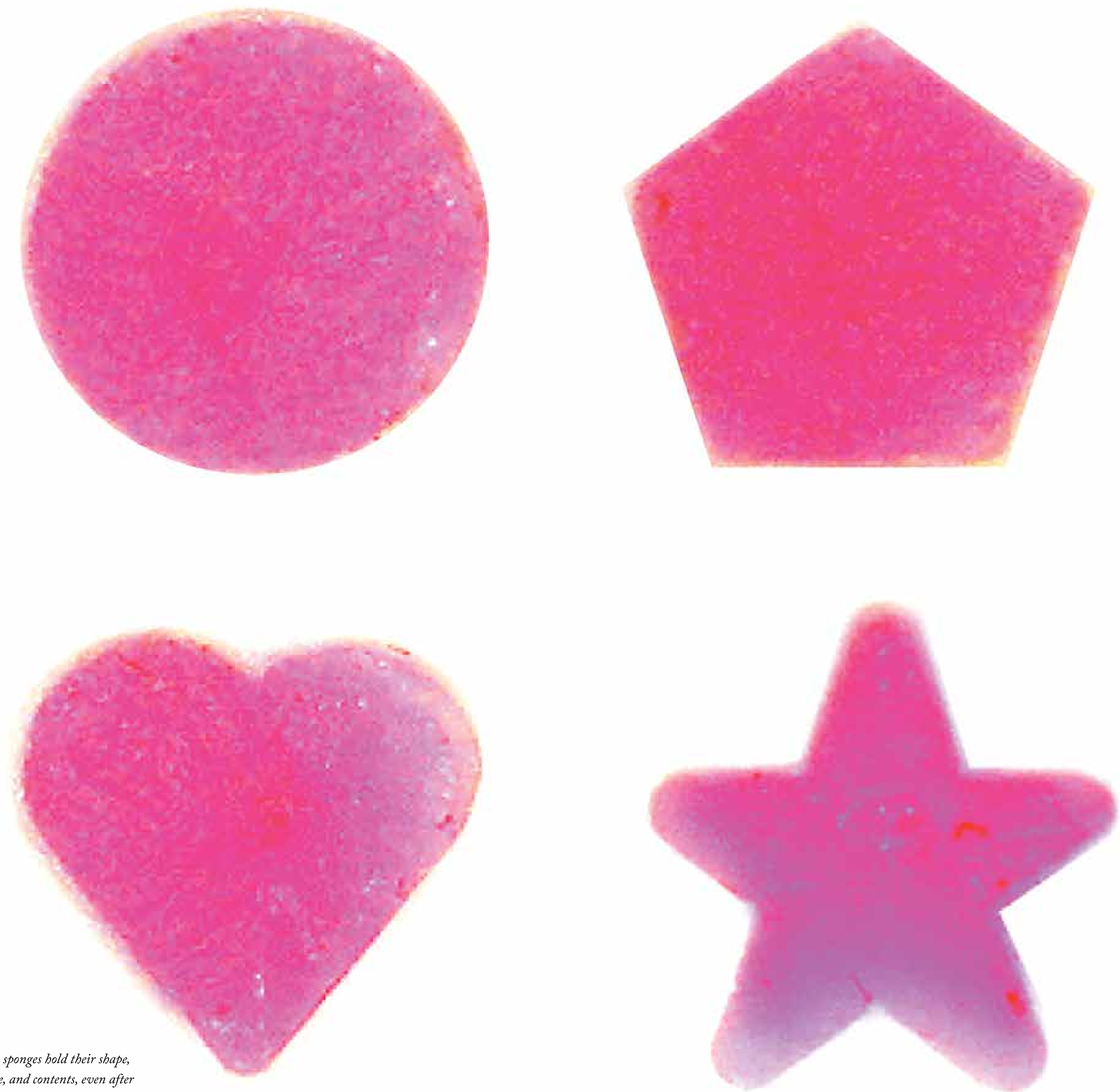
A tiny robotic insect, the size of a penny, can take flight and could one day help with search-and-rescue missions, traffic monitoring, and environmental sensing.

WORLD-CHANGING RESEARCH: TRANSLATIONAL LIFE SCIENCES

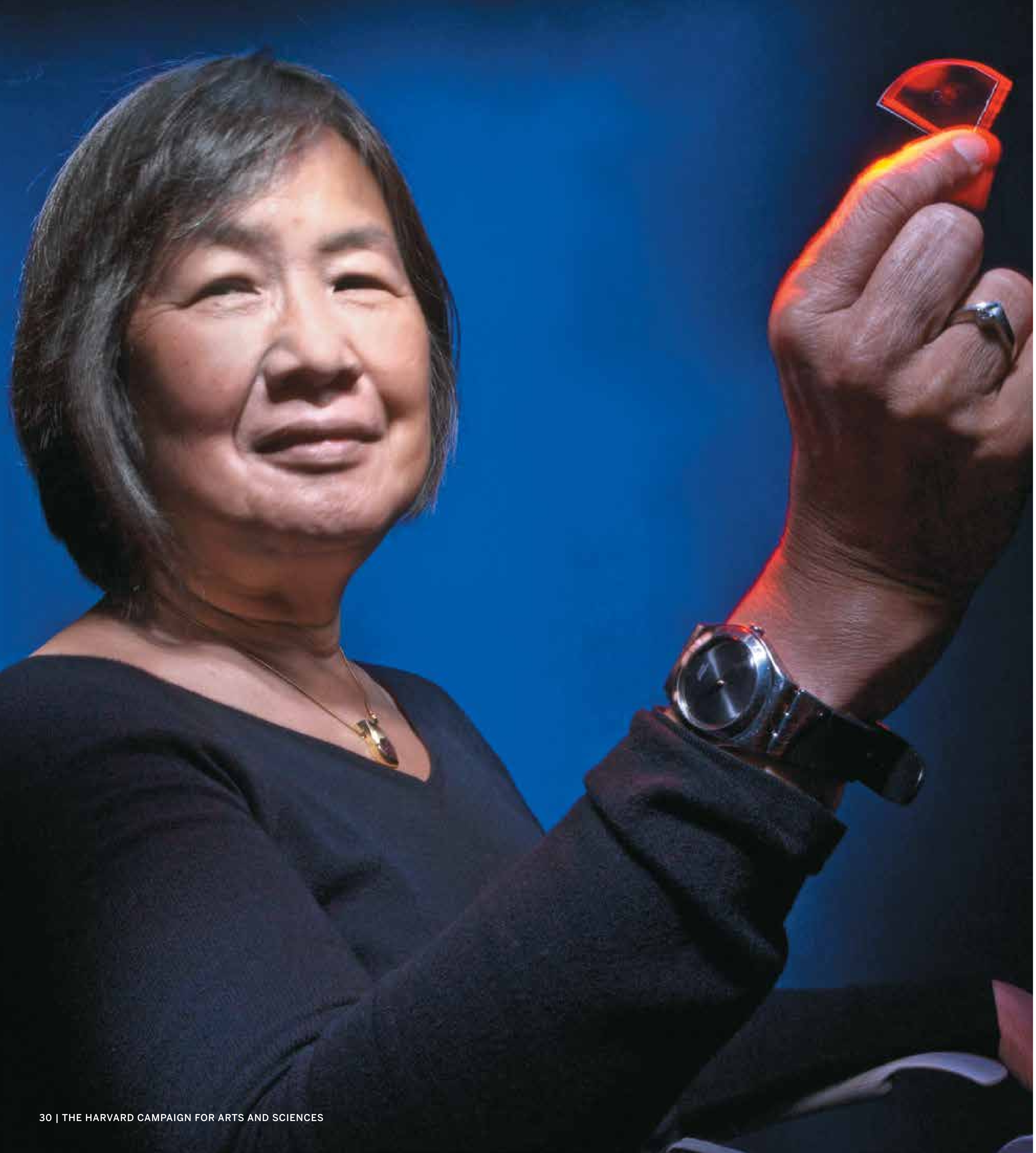
DAVID MOONEY
ROBERT P. PINKAS FAMILY PROFESSOR OF BIOENGINEERING

"IF YOU WANT TO INTRODUCE SOME MATERIAL INTO THE BODY TO REPLACE TISSUE THAT'S BEEN LOST OR IS DEFICIENT, THIS WOULD BE IDEAL", SAYS DAVID MOONEY.

Bioengineers at Harvard, led by Mooney, have developed a gel-based sponge that can be molded to any shape, loaded with drugs or stem cells, compressed to a fraction of its size, and delivered via injection. Once inside the body, it returns to its original shape and releases its cargo before degrading safely.



The tiny sponges hold their shape, structure, and contents, even after they're pushed through a syringe.



WORLD-CHANGING RESEARCH:
NANOPHOTONICS & NANOELECTRONICS

EVELYN HU

TARR-COYNE PROFESSOR OF APPLIED PHYSICS
AND OF ELECTRICAL ENGINEERING

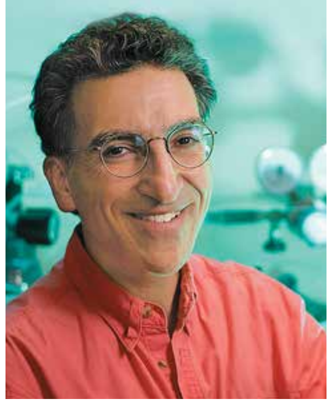
"YOU CANNOT PLAN INNOVATION. YOU CANNOT PLAN DISCOVERY."

This is what Evelyn Hu believes. "But if you're lucky, you'll do something important, and it'll be important in ways that you never imagined."

Nanophotonics—the manipulation of light via materials that are engineered at the nanoscale—creates the devices that light up LED screens, read Blu-ray Disc players, and detect pollutants in the atmosphere. Not bad for a field that is barely 20 years old. Leading researchers at SEAS like Hu use nanophotonics to revolutionize sensing, imaging, and computing.

WORLD-CHANGING RESEARCH:
ENERGY GENERATION & STORAGE

MIKE AZIZ PHD ’84
GENE AND TRACY SYKES PROFESSOR OF MATERIALS AND ENERGY TECHNOLOGIES



HOW DO WE STORE RENEWABLE ENERGY WHEN THE SUN ISN’T SHINING OR THE WIND ISN’T BLOWING?

Some of the most promising green energy sources are only available intermittenly. Researchers like Mike Aziz and his students are exploring the science of what is and is not possible in energy generation and conversion.

To promote such research, a team led by Harvard engineers and chemists is developing a new type of storage device—a flow battery that may yield cost-effective, grid-scale electrical energy storage based on eco-friendly, small organic molecules.

Of their efforts, Aziz says, “These are long shots that 10 years ago I wouldn’t have taken. But now it’s worth investing some effort into them because the stakes are so high.”

**WORLD-CHANGING RESEARCH:
ENVIRONMENTAL SCIENCE & ENGINEERING**

STEVEN WOFSY

ABBOTT LAWRENCE ROTCH PROFESSOR OF ATMOSPHERIC AND ENVIRONMENTAL SCIENCE

STEVEN WOFSY TOOK "A SLICE OUT OF THE ATMOSPHERE" TO SEE HOW IT WAS WORKING.

Recently, Wofsy led a series of 64 research flights that collected data from throughout the atmosphere, from the North Pole to the South Pole—and then made the findings available to all. Wofsy's ambitious study collected the first high-resolution, vertically resolved measurements of more than 90 unique atmospheric species, helping researchers better understand the carbon cycle and sharpen global climate models.

WORLD-CHANGING RESEARCH:
COMPUTATIONAL SCIENCE & ENGINEERING

HANSPETER PFISTER

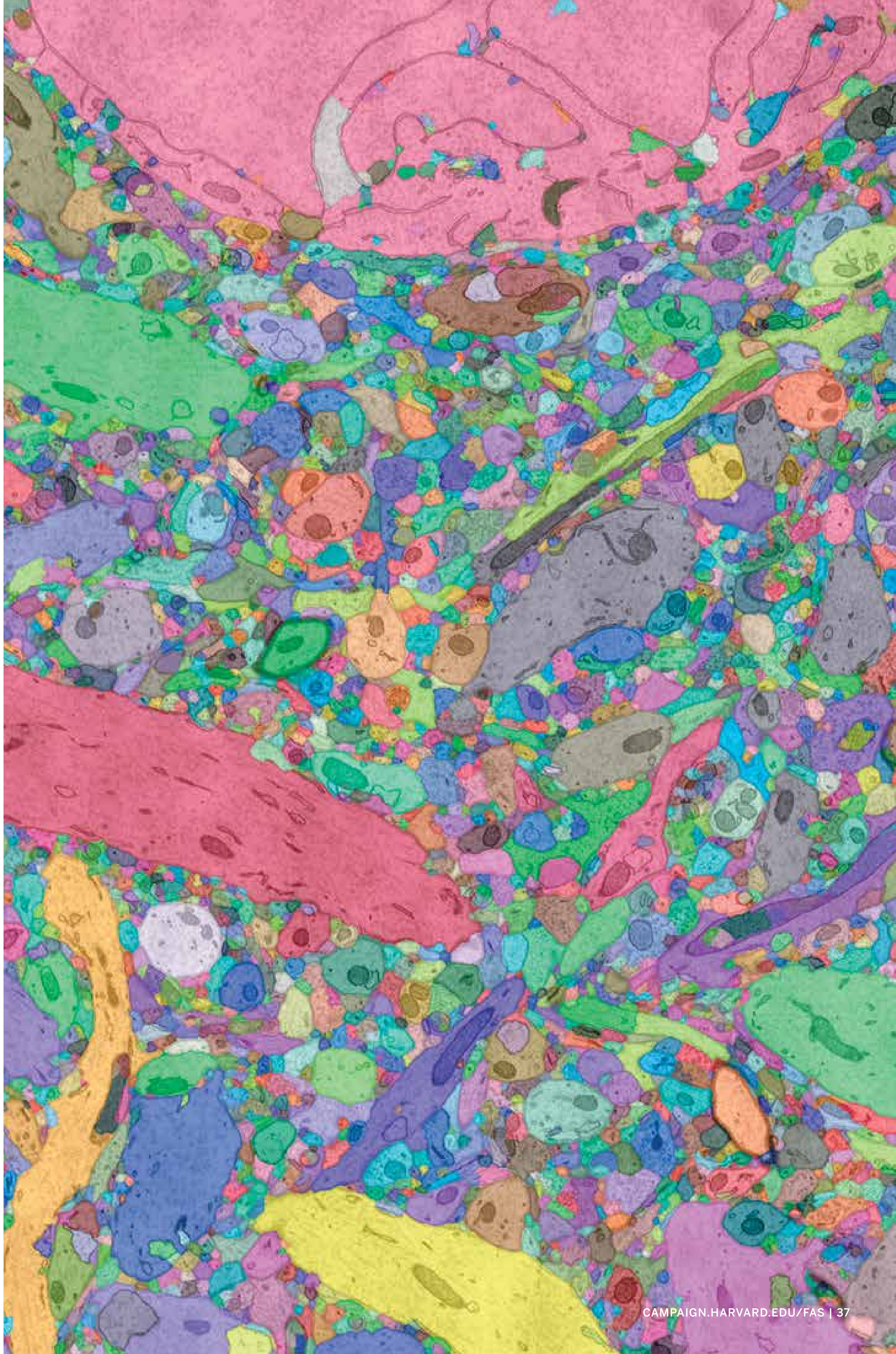
AN WANG PROFESSOR OF COMPUTER SCIENCE

HANSPETER PFISTER IS MAKING A THREE-DIMENSIONAL MAP OF THE BRAIN.

Working with the Connectome Project, which aims to understand how all the neurons in the brain grow and communicate, he has a big challenge on his hands. Consider the pea-sized brain of a mouse. When neuroscientists at Harvard's Center for Brain Science slice it thinly and capture high-resolution images of each wafer, that tiny brain turns into an exabyte of data. That's 10^{18} bytes, equivalent to more than a billion CDs.

What can you do with such a huge collection of images—and how would you even view it? The problem is hardly unique to the Connectome Project, but Pfister has the answers. An expert in high-performance computing and visualization, he developed software that loads just a small section at a time but also intelligently matches one image to the next, creating a 3D map of the brain.

Pfister's tools can now be used by scientists to navigate large data sets in any field—for example, astronomers processing radio-telescope images or environmental scientists analyzing atmospheric data. That's the power of computation.



WE INVITE YOU TO JOIN US *in this campaign so that Harvard continues its leadership and influence in the world at a time of dynamic and accelerating change.*

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Designed and produced by Harvard Alumni Affairs and Development Communications

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