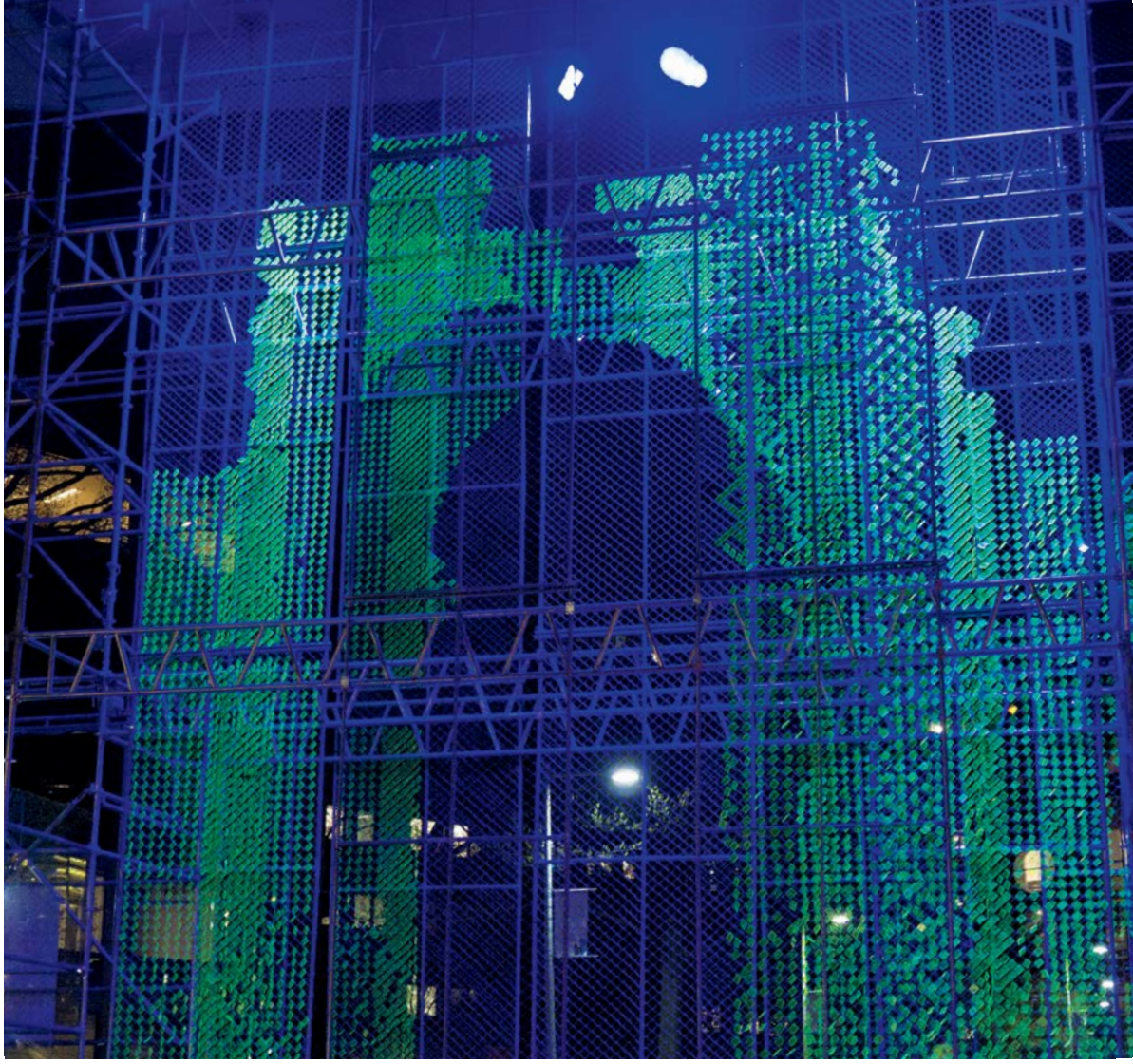
Why do you ask?

The power of wanting to know



Azra Akšamija's 2016 *Memory Matrix* installation at MIT conjured the ghostlike apparition of a recently destroyed Syrian landmark, formed by 20,000 pixels (inset) bearing the outlines of other vanished artifacts.

PHOTOS, FROM LEFT: AZRA AKŠAMIJA, EDWARD RICE

On a spring evening in 2016, a wind howled across the plaza in front of MIT's Wiesner Building and through a 30-foot-high art piece titled *Memory Matrix*. The storm ripped tiny green Plexiglas elements from their scaffolding, scattering them across the pavement. For the installation's creator, Azra Akšamija PhD '11, the unexpected wind animated the message of the piece, delivering an answer, of sorts, to a question that greatly interests her.

In fact, Akšamija, an associate professor in MIT's Art, Culture and Technology (ACT) program, had built *Memory Matrix* upon several questions. What are the core values of architecture? How do we preserve cultural heritage? Why do certain images of destruction inspire more empathy than others? How can we raise awareness about the destruction of cultural heritage in the Middle East and North Africa region without broadcasting images manufactured by the destroyers? These questions bubbled up from Akšamija's own background as a native Bosnian who experienced the devastation of war, as well as from the occasion for which the installation was created, the centennial of MIT's Cambridge campus. The piece she conceived to explore these questions—collectively funded by more than 20 MIT departments and programs—was an ephemeral monument, an arrangement of 20,000 hanging "pixels." When viewed from a certain spot, the pixels resolved into the silhouette of Palmyra's third-century Arch of Triumph, one of Syria's best-preserved historic treasures until it was blown up in 2015 by the militant group ISIL. Each pixel was laser-cut with the contours of other vanished or threatened cultural artifacts.

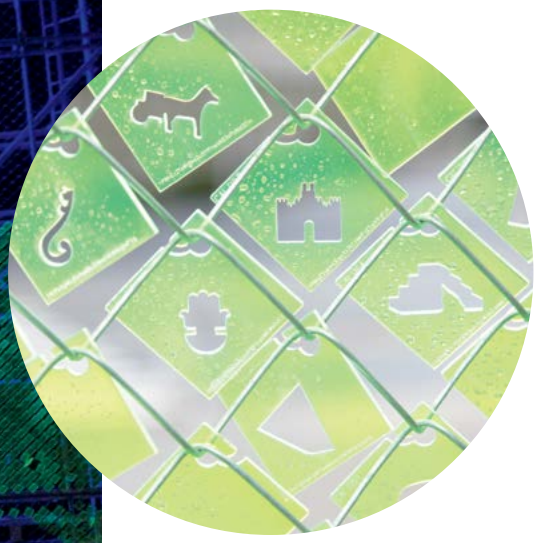
When that wind rattled *Memory Matrix*, Akšamija wasn't surprised that pixels detached. They'd been designed with open hooks—not only to ease installation but to endow the piece with symbolic fragility. The idea that monuments need caretakers was one of the premises under investigation. When pixels fell to the ground, she'd wondered, how would bystanders react? Until the storm, the public generally contributed to communal upkeep of the work, reattaching fallen pieces and thus changing the pattern of the pixels. After the extensive weather damage, however, she was intrigued to note that reactions changed: "Passersby participated in the destruction and theft of the elements."

Insights like this are achieved in art, and in disciplines across MIT, by daring to ask big, intriguing, sometimes disconcerting questions about every part of our world—and being open to answers from unexpected quarters.

Interrogating the problem

"Science is driven by challenges and challenging questions. Technology is fueled by science and driven by the need for solutions." That's how John Lienhard, Abdul Latif Jameel Professor of Water and Food, and the director of the Abdul Latif Jameel World Water and Food Security Lab (J-WAFS), put it in a speech to the EAT Stockholm Food Forum 2017. At J-WAFS, high-level questions might be posed in such terms as "How will agricultural productivity in different regions be affected by climate change?" or "How can we enhance crop yields without harming the environment?" Researchers define sub-questions and build solutions on the answers.

Likewise, question asking and solution building are inextricably linked at the Institute for Data, Systems, and Society (IDSS). IDSS's mission is to pool the strengths of engineering and social sciences, enabled by new floods of data, to solve problems in areas such as urban systems, energy,



transportation, politics, and health care. But problem solving within such complex systems cannot occur without incisive questioning about the ways the elements of these systems come together. If the problem is updating a city's power grid for a sustainable energy future, clearly you must ask: How are renewable energy sources generated and transmitted? But also: Why do people do laundry at certain times of day? How is carbon consumption priced? According to Ali Jadbabaie, JR East Professor of Engineering in the Department of Civil and Environmental Engineering and IDSS associate director, "We educate a new breed of students who not only understand the technical side, but how human behavior comes into the picture and what are the effects of markets and regulators."

In a sea of big data, framing questions properly is more important than ever. Social scientists, Jadbabaie says, are particularly adept at this. He cites his collaborations with MIT political scientists Fotini Christia and Rich Nielsen on two separate projects that ask, respectively, how mobile communication patterns shift in the Middle East during social unrest, and what drives the popularity of jihadist writings. He also notes that while IDSS emphasizes problem-focused inquiry, it also advances basic research on theoretical questions—such as what the fundamental limits of machine learning might be—whose applications we've only just begun to glimpse.

The magnetism of the right question

What happened during the earliest moments of the universe? If that's the kind of thought that keeps you awake at night, you've got something in common with David Kaiser, a professor of physics and the Germeshausen Professor of the History of Science in MIT's Program in Science, Technology, and Society. "I find myself drawn to questions that have a fundamental character, that force me to think about deep conceptual roots at the heart of our most successful theories of nature, like general relativity or quantum theory," Kaiser says. "I find it a great challenge for myself, and really fun, to try to find examples of questions within those frameworks that seem counterintuitive, maybe a little surprising." That's how he came to embark most recently on an international experiment with fellow MIT physicists Alan Guth '68, SM '69, PhD '72 and Andrew Friedman to investigate the baffling case of quantum entanglement—in which, according to quantum theory, the states of two seemingly separate, far-flung particles are linked.

The history of science repeatedly proves there are unforeseen benefits to chipping away at the great unknown. "Back in the 1920s and 1930s, when physicists first began thinking about antimatter, no one was thinking about medical imaging," Kaiser points out—yet today's PET scans harness that knowledge. "Likewise, GPS would be unworkable if scientists and engineers hadn't figured out some very subtle effects that gravitation has on the rate that clocks tick." Even those bizarrely entangled particles have a direct bearing on the race to transform information science through quantum computing. "It's not that we strike gold every time, but I'm willing to be patient, because time and time again these questions have borne fruit in unexpected ways," Kaiser says.

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Meanwhile, the insatiable human need to explain our world can be a payoff in itself. It starts when we're kids, always ready with the next "why?" to stretch any answer we're given. If we're lucky, we carry this motivating curiosity into adulthood. But how many of us pause on the meta-question of what an answer truly *is*? Or, as Rockefeller Professor of Philosophy Brad Skow puts it, "What does it take for 'A because B' to be true?" His latest book, *Reasons Why*, outlines a theory distinguishing between an answer to a why-question (which describes a cause or ground of the event), and the reasons why that answer is an answer (natural laws and mathematical models can provide such reasons).

As a philosopher of science and omnivorous reader, Skow often stumbles upon the why-questions he decides to explore in depth. A procrastinatory detour into special relativity while he was a PhD student inspired another of his books, *Objective Becoming*, in which he asked why we experience time "passing" when physics suggests it does not. For Skow, the impulse to articulate flaws in existing theories, or glimpsing a pathway to a workable new one, can put him in the grip of a new question and compel him to pursue it.

At the MIT Leadership Center, executive director Hal Gregersen teaches a different metric: in business, you know you are asking the right questions if those questions make you uncomfortable. In a recent *Harvard Business Review* article, "Bursting the CEO Bubble," Gregersen reveals that the toughest challenge for executives, especially senior ones, is figuring out "what they don't know they don't know—before it's too late." A senior lecturer at the MIT Sloan School of Management, Gregersen has seen large businesses sink when "senior leaders failed to explore the crucial blind spots that came back to destroy their companies." Conversely, when he arrived at the Leadership Center, Gregersen extrapolated from the exceptional entrepreneurial track record of MIT alumni that they "must have been asking different, better questions.... I believe that this is one of the core capabilities that leaders gain from an MIT experience."

In MIT's Executive MBA and Sloan Fellows programs, Gregersen has taught a technique he calls "catalytic questioning." A rapid-fire four minutes are spent collectively brainstorming questions about a seemingly intractable professional challenge. Eighty percent of the time, he says, queries are raised that reframe the challenge, suggest fresh solutions, and energize people to action.

Asking, together

It is often the process of opening up one's questioning to others that lets the light in. All told, Akšamija's *Memory Matrix* involved some 500 participants, from attendees at the Cairo Maker Faire who sketched examples of cultural heritage, to the students who project-managed and

designed and manufactured the pixels, to the volunteers who showed up to hang them. And then there were all those passersby who added to the dialogue either with their interest or their indifference. Such external engagement propels her work. "These projects are not about: you have a question, you address it, an artwork comes out if it. It doesn't end there for me." In this case, the next question—now what?—led her to found the Future Heritage Lab in a Syrian refugee camp in Jordan. With support from ACT, CAST (Center for Art, Science and Technology), and the MISTI (MIT International Science and Technology Initiatives) MIT-Arab World Program, she has already brought MIT students to the camp for the *Lightweaver* project, in which refugees can alter the austerity of the camp through the beauty of their cultural heritage by punching textile-inspired patterns into wind-powered lanterns.

For Kaiser, outlets for his thinking on quantum entanglement have included collaboration on an educational video by YouTube's "Physics Girl," Dianna Cowern '11, as well as on this year's "Cosmic Bell" exhibit at the MIT Museum and an accompanying play by Patrick Gabridge '88 titled *Both/And*. Whether developing analogies for general audiences or lecturing to his Course 8 students on campus, he finds that the effort to convey his thought process to others "can really force a rethinking from top to bottom." And, Kaiser adds, "talk about being open to surprise—being in a room full of MIT students is guaranteed to generate some really interesting and unexpected questions." –Nicole Estvanik Taylor

What questions drive MIT grad students?

Gifts to MIT supporting graduate fellowships—such as those listed here—make it possible for exceptional students to come to MIT in search of answers.

How can we make digital education platforms artificially intelligent?
Michael Beeler, PhD candidate, Operations Research

"Digital learning technologies have the potential to fundamentally transform the way we operate our education systems for the better. I am hopeful that students will one day engage in personalized lessons that maximize their rate of progress and engagement, given their interests, abilities, and prior knowledge, as if they had a high-caliber private tutor, and that this technology will be affordable and ubiquitous."

- Advisors: Cynthia Barnhart SM '85, PhD '88, chancellor and Ford Professor of Engineering; David Simchi-Levi, professor of engineering systems
- Fellowships include: Mastercard Foundation Fellowship within the Legatum Center, MIT Tata Center for Technology and Design Fellowship

What is a "good seed"?
Ashawari Chaudhuri, PhD candidate, HASTS (History/Anthropology/Science, Technology, and Society)

"Communities of practice understand and work differently with genetically modified seeds, specifically Bt cotton, in India. For farming communities, a good seed is a *process* that comes to life through the entire phase of cultivation. For seed companies and government regulatory bodies, a good seed is a bounded *object* with objectives of better germination, higher yield, and resistance to pests. My research aims to coalesce these systems of meanings and values to create a road map for agriculture in India."

- Advisor: Michael M.J. Fischer, Andrew W. Mellon Professor of Humanities
- Fellowships include: Edward Austin Fellowship, Walter A. Rosenblith Presidential Fellowship

How do neutrinos behave?
Gabriel Collin, PhD candidate, Physics

"The neutrino is the least understood of the fundamental particles; from scales of femtometers to billions of light-years, it holds the keys to the secrets of our universe. My focus is on developing new computational and statistical methods to address our field's most difficult questions."

- Advisor: Janet Conrad, professor of physics
- Fellowships include: Lourie Foundation Fellowship

How are the design and development of urban regions shaped by ideological conflict and political agency?
Yonah Freemark MCP '13, SM '13, PhD candidate, Urban Studies and Planning

"Cities have widely varying approaches to problems like the inadequate provision of affordable housing or poorly performing transportation networks. I am motivated to understand the divergence between metropolitan areas where planning solutions reduce inequality and increase social inclusion, and places where such remedies are hard to come by."

- Advisors: Lawrence Vale SM '88, Ford Professor of Urban Design and Planning; Jinhua Zhao MCP '04, SM '04, PhD '09, Edward H. and Joyce Linde Associate Professor of City and Transportation Planning
- Fellowships include: Edward H. Linde (1962) Presidential Fellowship

What new tools could enable mapping the nanoscale architecture of the brain?
Asmamaw "Oz" Wassie '13, PhD candidate, Biological Engineering

"The functions of our brain, including our thoughts, emotions, behaviors, all arise from its complex architecture; biological processes ranging from the wiring of neurons to the molecular organization of individual cells define how our brain works."

- Advisor: Ed Boyden '99, MNG '99, professor of biological engineering and brain and cognitive sciences
- Fellowships include: Lemelson Engineering Presidential Fellowship, Viterbi Family Foundation Fellowship

PORTRAITS BY: ELENA SOBRINO (CHAUDHURI); JUSTIN KNIGHT (COLLIN, WASSIE)