EYES FORWARD
EXPERT INSIGHTS ON ENGINEERING'S FUTURE

NORTHWESTERN ENGINEERING FACULTY MEMBERS LOOK AT WHAT TO EXPECT FROM MATERIALS, ENERGY, AND MORE IN THE COMING DECADE.

Software algorithms that write news stories. Small, flexible electronics that analyze sweat and monitor premature babies. Bandages that harness the body's ability to recover from wounds. The past decade has witnessed the emergence of a wealth of advanced technologies that have changed how we communicate, perform, create, and heal.

What's next?

As we settle into a new decade, we asked Northwestern Engineering faculty members—leaders in areas like sustainability, artificial intelligence, medicine, design, and materials—to forecast the opportunities, milestones, and challenges they expect to see in their fields during the 2020s.

One thing is certain: the engineering field is well positioned to both shape and respond to the technological and scientific advances that will arise and impact society.

"Engineering by its nature drives innovation, pushes boundaries, and raises new questions," says Julio M. Ottino, dean of the McCormick School of Engineering. "Whole-brain engineers in particular are well equipped to tackle the challenges we face, as the best ideas in the future will require both analytical and creative thinking."

ALEX GERAGE

SUSTAINABLE ENERGY

The world of climate action will move strongly in the direction of post-fossil fuels by deploying and integrating strategies that mitigate greenhouse gas release and rapidly decarbonize our cities and our economy. These strategies will be based on the principles of ecology and will mimic how nature works. They'll radically transform energy and resource use and efficiency, and aim for net-zero in terms of waste, carbon, water, and energy. They'll also create cycles of material and energy use and reuse and, of course, be adapted to renewable energy. Despite having many of these technologies already available to us, we unfortunately do not seriously embrace this approach at the present time.

The amount of sunlight hitting the Earth's surface in one hour exceeds the total energy that humans consume worldwide in one year. Over the next decade, solar-driven technologies and processes will fuel the reinvention of our cities.

KIMBERLY GRAY

Kay Davis Professor
Chair of Civil and Environmental Engineering

ARTIFICIAL INTELLIGENCE

Over the past few years, we've witnessed the rise of artificial intelligence in the form of machine learning systems that build models of the world based on massive data sets. These systems learn from the history of their own experiences. The next round of AI will be systems that can craft plans, solve problems, and make decisions based on strategic thinking that goes beyond what has come before. These will be systems that use the best of human reasoning and that can envision, project, and then create the future.

KRIS HAMMOND

Bill and Cathy Osborn Professor of Computer Science

REGENERATIVE MEDICINE

I believe we'll see regenerative engineering—which integrates advances in biomaterials science, physical sciences, data science, biology, and translational medicine—positively impact healthcare. Regenerative engineering technologies can support new tools that clinicians and surgeons use to treat tissue loss and dysfunction.

We will also see artificial intelligence and data science play increasingly larger roles in the development and implementation of these regenerative tools. I anticipate the introduction of "smart" regenerative implants or devices that will not only be able to promote tissue regeneration but will also allow wireless monitoring of the function of the regenerating tissue and the device itself. Patients, caregivers, and clinicians will have much greater control over their healing status.

GUILLERMO AMEER

Daniel Hale Williams Professor of Biomedical Engineering

Director, Center for Advanced Regenerative Engineering

Illustrations by Lauren Nassef

HUMAN-CENTERED DESIGN

Human-centered design, which allows all stakeholders to participate by focusing on problem solving rather than the traditional craft of design, will continue to influence organizational thinking and action. It will fundamentally move us closer to people and the underlying needs of society by informing key decision makers with insights rooted in empathy. However, because of the growing urgency for organizations to deliver innovation while navigating complexity, I see human-centered design becoming significantly more integrated into our universal way of thinking. It will also become part of the core pedagogy within many institutes of higher learning, as organizations seek to cultivate innovative ways to address risk and growing uncertainty.

Human-centered design's ability to identify and address the real underlying business challenges is at the heart of its value to organizations. Those that understand what people actually value have the opportunity to shape a new future, positioning themselves as thoughtful visionaries.

GREG HOLDERFIELD

Pentair - D. Eugene and Bonnie L. Nugent Clinical Professor of Design Innovation

Director, Segal Design Institute

SUSTAINABLE ENERGY

Over the past decade, we've seen the price of solar and wind electricity plummet. This has opened up new opportunities to rethink how we use energy. At the same time, the intermittency of these energy sources drives up storage demand, pushing battery technology to ever higher performance metrics. The next stage will use electricity to generate value-added products for low-cost chemical inputs. Labs across the world are pursuing carbon dioxide reduction—using electricity to convert this greenhouse gas into everyday plastic products. Better still will be using electricity to convert nitrogen—the main component of air—and water into ammonia to create fertilizer to grow crops that feed the world.

The scientific challenges are greater, but so are the rewards. These and other opportunities are on the horizon, but we need to pick up the pace if we're going to sustain the planet and its people.

SOSSINA HAILE

Walter P. Murphy Professor of Materials Science and Engineering

MATERIALS

Advances in materials will positively impact virtually every technology of importance to society, including medicine, health, the environment, water, renewable energy, transportation, infrastructure, catalysis, electronics, photonics, and quantum information science. While the timescale of progressing from new materials discovery to widespread industrial application has historically been measured in decades, we will be able to shorten this trajectory by at least an order of magnitude because of advances in computational materials science, petascale computing, machine learning, artificial intelligence, multimodal characterization, rapid prototyping, and additive manufacturing.

In addition to advances in computing to improve materials discovery, design, and commercialization, new materials will underlie the development of revolutionary new computing paradigms, including neuromorphic and quantum computing. This will create a positive feedback loop that will further expedite and maximize technological and societal benefits.

MARK HERSAM

Walter P. Murphy Professor of Materials Science and Engineering

COMPUTER SCIENCE EDUCATION

For most of us today, having a computer is like having an ax in the stone age. It's a game changer. The next decade will see the development of new personalized educational tools that allow anyone with access to a smartphone to download and teach themselves new skills. Computer science courses will be further developed to teach students to wield computation as an effective tool. The ability to infer insights from data will be a critical necessity for the next generation of students, as will the need to learn how to use data ethically and to consider the impact of the developed technology on society.

SAMIR KHULLER

Professor of Computer Science

Peter and Adrienne Barris Chair of Computer Science

SUSTAINABLE ENERGY

Artificial intelligence and machine learning will be widely applied to address sustainability challenges. This will require interdisciplinary collaboration between sustainability domain experts and computer scientists to develop and implement new algorithms that effectively fuse large amounts of diverse data—like satellite images, physical sensors, and crowd-sourced information—while accounting for their tendency to be incomplete, either due to missing or faulty sensors or cloud cover in satellite images.

I also foresee greater development and acceptance of nature-based approaches and green infrastructure to mitigate riverine and urban flooding, sequester carbon dioxide and absorb atmospheric pollutants, improve mental and physical heath, and increase biodiversity.

These advances will reflect a growing recognition that effective and equitable solutions to sustainability challenges require active engagement with affected communities from the beginning, as well as the codevelopment of approaches that build on the knowledge and enhance the capacity of the community, especially when dealing with underserved and indigenous communities.

BILL MILLER

Professor of Chemical and Biological Engineering

Director, Center for Engineering Sustainability and Resilience

ROBOTICS AND ROBOTIC SENSING

I expect two broad areas of advancement. One, in the area of robotic autonomy, will benefit from new developments in active learning and sensing in challenging environments.

The other area is the continued productive hybridization of artificial intelligence and robotics with advances in understanding the brain and how it controls the body. Many people are unaware that the key advances in AI continue to be inspired by developments in brain science. Recent breakthroughs are being applied to help make sense of the flood of neural data and high-resolution behavior; this could uncover mechanisms that in turn contribute to robotics and AI.

Real-time planning, for example, is a challenging computational task many animals can accomplish, but our algorithms lag far behind such performance in silico. Our work over the coming decade will include targeting how this occurs in brains.

MALCOLM MACIVER

Professor of Biomedical Engineering and Mechanical Engineering