The 2023 AAAS Annual Meeting will be held virtually and in-person in Washington, D.C., March 2-5, 2023. The meeting will highlight groundbreaking multi-disciplinary research that advances knowledge and responds equitably to the needs of humanity.

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Exploring electronic and photonic advances that will change our lives

The Hong Kong Institute for Advanced Study (HKIAS) recently hosted five webcasts that cover metamaterials, antennas, 6G, and more.

Electrical and photonic devices impact every aspect of our lives, from communications and health care to security and electric utilities. Plus, ongoing research promises advances in existing applications, including the power grid, and the development of new technologies, such as novel methods of detecting cancer at very early stages. In the HKIAS Distinguished Lecture Series on Electronics and Photonics, which attracted more than 2,000 scholars and guests, five leading scientists described advances in basic research, developing technology, and the potential applications of R&D in this area. The series was supported in part by the Kwang Hua Educational Foundation.

New applications of nanotechnology
On March 1, Stella W. Pang, Head and Chair Professor of Electrical Engineering at City University of Hong Kong (CityU), talked about “Nanotechnology for High-Performance Devices and Sensors.” In describing integrated circuits, she said, “Once devices get smaller, they get better: They have higher performance; they consume less power; and they are also cheaper.” As an example, she presented microelectronic sensors incorporated in a microsystem that could be used as a portable and selective chemical detector with parts-per-billion sensitivity. In addition, she introduced a plasmonic sensor that can detect cancer cells and DNA molecules with high sensitivity.

Advances in antennas
In “Antenna Scientists—Magicians in the Era of Wireless Connectivity,” a talk given on March 17, Kwai Man Luk, Chair Professor of Electrical Engineering at CityU, pointed out that many technologies need antennas, and he noted applications in autonomous cars and mobile communications. He called the microstrip antenna “the most important antenna structure being investigated over the past 4 years.” It’s a very simple structure—just a printed circuit board on a ground plane with a patch of metal on top. Through various modifications, these antennas might be used in terahertz applications, such as medical imaging systems.

Meta-lenses for imaging, sensing, and quantum chip production
On March 30, Din-ping Tsai, Chair Professor of Electrical Engineering at CityU, delivered a talk on “Meta-Devices: From Sensing and Imaging to Quantum Optical Chip.” He reported on the successful implementation of their meta-lens array for full-color imaging and light field sensing, and the production of a 10 × 10 high-dimensional quantum entangled optical source chip. Some of these results were published in Science.

Future power grids for sustainable development
Ongoing transitions in the power grid create one of the biggest challenges ahead. On April 12, Michael Chi Kong Tse, Chair Professor of Electrical Engineering at CityU, discussed “Challenges of Modern Power Grid in the Midst of Deepening Power Electronics Penetration and Increasing Renewable Energy Use.” He described the pros and cons of bottom-up (local) vs. top-down (global) methods for analyzing power grids. As Tse concluded, “Our hope is, eventually, to put these two approaches together and provide a more comprehensive view of the entire development of the power grid.”

Getting to 6G
On April 22, Chi Hou Chan, Chair Professor of Electrical Engineering at CityU, concluded this series of talks by asking “Are We Ready for 6G?” Chan explained that some of the key features of 6G, which is planned for deployment in 2030, will be extremely high data rates and low latencies plus massive connectivity. “Another important feature of 6G is the integration of the air, space, sea, and ground,” he said. He described his work on various antennas that can direct a beam and even its service range, which could be crucial to realizing 6G.

Technology’s global impact
The speakers in this series clearly showed how fundamental research at CityU is influencing daily life around the world. As they demonstrated in their talks, technology on the smallest scales can create big improvements for society. HKIAS continues to explore advances that will drive technological improvements and to plan future conferences that will highlight these breakthroughs, including the First International Conference on Heterostructured Materials, July 12-15, 2022.


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Immunology is a relatively young field of research that is set to revolutionize modern medicine. Only 10 years ago, the idea of genetically engineering the human immune system to fight disease was considered science fiction. Today, the potential to treat or delay a vast range of disorders is evident.

"Immunology research is essential in understanding the pathogenesis of many diseases," says Akiko Iwasaki, professor of immunology at Yale School of Medicine. The immune system is involved not only in fighting off infectious diseases, but is also the mediator of many other pathologies, including autoimmune diseases, neurodegenerative diseases, metabolic diseases, heart disease, lung disease, and cancer. "This is because the immune system is a language used by the body to communicate between different organs."

"When it comes to treating most diseases, immunotherapy will be the answer," says Gary K. Michelson, founder and cochair of Michelson Philanthropies and the Michelson Medical Research Foundation. "The human immune system, through its workhorse, inflammation, seems to be the common denominator."

**A new vaccine age**

Until a few decades ago, scientists thought the central role of the immune system was to fight bacterial and viral infections. The development and widespread use of vaccines that aid the immune system have been the most significant medical contribution to doubling the average human lifespan over the past century. But vaccine development is challenging. Clinical trials can take years, cost hundreds of millions of dollars, and fail over 85% of the time.1

Over the last 5 years, advances in immunology research have built the groundwork for developing a universal vaccine structure using messenger RNA (mRNA) encapsulated in a lipid package. This technology can be applied effectively for new target bacteria or viruses by incorporating a snippet of genetic material coding for almost any antigen expressed by that pathogen into the package. Michelson likens it to a cassette player capable of playing any cassette.

The mRNA technology—which was already being tested for other vaccines—allowed scientists to develop effective COVID-19 vaccines in just 66 days. "Immunology research played a vital role in the pandemic," says Iwasaki. "Immunological studies before the pandemic were essential in building the foundation for today’s successful vaccines."

Likewise, she says that understanding how the immune system protects against COVID-19 and how aberrant immune responses cause severe and fatal infection enabled scientists to develop effective therapies, saving millions of lives.

**Cancer in the crosshairs**

This ability to use genetic sequencing to teach the human immune system how to fight a disease is a quantum leap in immunotherapy—the therapeutic application of immunology—and can be applied to several disorders other than viral infections. "Immunology goes way beyond fighting infectious agents," Iwasaki says. One such disease is cancer. "We all now know the power of harnessing the immune response against cancers using immune therapies like checkpoint blockade or CAR [chimeric antigen receptor] T cells."

Scientists have long thought that the immune system had some role in surveilling cancerous cells in the body. Immunology research has shown that cancer cells must access adequate nutritional substances and have cloaking mechanisms to hide from the immune system to sustain a high growth rate.

Traditionally, treatments have targeted tumors with very potent metabolic poisons, or chemotherapeutics, on the premise that these would kill highly metabolically active cancer cells before the patient. But cancer cells can mutate to become resistant to chemotherapy, and these mutations can differ widely between patients. Consequently, scientists are shifting their focus to enhancing the immune system. The magic of immunotherapy is its ability to be tailored to fit the antigen repertoire of each patient.

"Two decades ago, no one thought immunotherapies would become mainstream in cancer treatment," says Linda Liau, professor and chair of the Department of Neurosurgery at the University of California, Los Angeles (UCLA). "But now we are..."
The Michelson Philanthropies & Science Prize for Immunology supports early-career scientists from a wide range of disciplines who conduct research that advances vaccine and immunotherapeutic discovery.

Paul Bastard, a chief resident at the Necker Hospital for Sick Children in Paris, France, is the grand prize winner of the inaugural award. His research shows that people who experienced life-threatening COVID-19 infection had a glitch in one of the immune system’s mechanisms that help fight viruses, offering clues on why the disease is fatal for some and asymptomatic for others. Bastard now hopes his discovery can help prevent and treat severe COVID-19 and other infectious diseases.

“The Michelson Philanthropies & Science Prize for Immunology will greatly impact my future work. It will help foster many new collaborations, which may not have been possible otherwise,” says Bastard. “I hope it will also attract attention to our field of genetics and autoimmune predisposition to infectious diseases in humans.” Scott Biering from the University of California, Berkeley, and Lisa Wagar from the University of California, Irvine, were each selected as finalists.

Applications are now being accepted for the 2023 Michelson Philanthropies & Science Prize for Immunology. More information can be found at science.org/michelson.

seeing the potential to cure cancers that were incurable. There will be a huge growth in cancer immunotherapy in the future.”

A lot still to learn

Over the last decade, it has also become clear that the immune system is in play in human aging. Degenerative neurologic disease is an area where scientists can expect to see important breakthroughs, says Liau. They have learned that neurologic conditions are associated with immune responses, and “if we can modulate those, we may be able to prevent some of these degenerative processes.”

Another emerging area of research is understanding the link between the immune system and the gut microbiome. “We could modulate the immune system through what we eat, and that’s just fascinating!” Liau says.

Michelson believes that decoding the mysterious workings of the human immune system is the best way to protect ourselves from diseases, aging, and future pandemics. It is this work that will allow for immunotherapy to mean the treatment of all diseases. “The progress will be revolutionary—not evolutionary—and this will be the decade for that.”

“I imagine that immunology will continue to make progress in the fundamental understanding of how cells of the immune system communicate with other systems like the nervous system, digestive system, and endocrine system,” says Iwasaki. “I also think there will be more dots connected between infections and autoimmunity. This will enable diagnosis and therapy, and place more emphasis on vaccines against common viruses.”

Immunology principles lie at the heart of medicine and have a much broader impact than any other subspecialty within medicine, says Liau. But we still don’t know enough, she emphasizes. “The more we learn about human immunology, the better we can strive to cure incurable diseases.”

Michelson and a group of leaders in philanthropy, science, medicine, academic research, and government are working to create an ambitious new immunology and immunotherapy research center on the campus of UCLA. Michelson describes it as a “field of dreams” that will attract the very best scientists from around the world.

Through multidisciplinary collaborations, the new center will push the frontier of biomedical research, and ultimately human health itself, translating breakthrough discoveries into real-world medications and treatments.

“Groundbreaking discoveries are seldom the work of individual researchers,” says Michelson. “They require teams of workers across many disciplines. Interdisciplinary cooperation brings breakthroughs from bench to bedside more quickly.”

Reference

Evolving approaches to treating mental illnesses

To help researchers explore the potential of treating mental illnesses with MDMA, PharmAla Biotech makes clinical-grade versions of this molecule and analogs in the MDXX class.

Treating mental illness is one of the most complex challenges in health care, due to comorbidities, noncompliance, and frequently debilitating side effects. One promising new treatment involves the use of 3,4-methylenedioxymethamphetamine (MDMA), which has novel prosocial effects. However, this chemical is also known for some unwanted side effects, including cardiovascular impacts and raising body temperature. Scientists at PharmAla Biotech, a pharmaceutical company based in Vancouver, Canada, are working on maintaining MDMA's efficacy while reducing its toxicity.

There's a great need for better treatments in psychiatric health care. As Harriet de Wit, professor of psychiatry and behavioral neuroscience at the University of Chicago, says, "There are a lot of psychiatric conditions where there is not really an effective drug, and the conditions are all quite complicated."

MDMA could change some of that problem. "It's one of the only drugs we know about that has prosocial effects," says Nick Kadysh, CEO of PharmAla Biotech. "In fact, this drug class has been shown, from octopuses to humans, to make social behavior easier. So, we're tapping into something that from an evolutionary biology perspective is very fundamental."

Based on work by the Multidisciplinary Association for Psychedelic Studies (MAPS), an American nonprofit organization working to raise awareness and understanding of psychedelic substances, the U.S. Food and Drug Administration designated MDMA-assisted psychotherapy as a breakthrough therapy for posttraumatic stress disorder (PTSD). Still, work remains to be done on this potential treatment.

Eliminating off-target effects

By delving into the chemistry and biological impacts of MDMA, scientists at PharmAla are developing what Kadysh calls "novel analogs and formulations of MDMA with an eye toward improving pharmacological safety."

To do that, PharmAla scientists analyze how these proprietary analogs interact at a molecular level in the body.

"We are leveraging computational chemistry to look at the receptors that the drugs interact with in our body," says Harpreet Kaur, vice president of research at PharmAla Biotech. "With receptor models, computational chemists can elucidate what might happen, which is then followed up with in vitro assays, preclinical studies, and eventually human trials."

If MDMA or one of its analogs interacts with an undesirable receptor, such as one that increases a patient's body temperature, PharmAla scientists look for changes in the chemical's structure that might eliminate the side effect without decreasing its efficacy. As Kadysh points out, "That's a challenge, because small changes can have really big knock-on effects."

Nevertheless, PharmAla is meeting that challenge. "We feel comfortable saying that we've developed a less neurotoxic and less cardiotoxic variant of MDMA," Kadysh says. As an example, PharmAla has "managed to entirely eliminate hyperthermia (an increase in body temperature) with our novel chemical entities," he says.

Supplying clinical trials

To continue testing MDMA as a psychiatric treatment, scientists, and pharmaceutical companies need drug products appropriate for human use. PharmAla is currently North America's only manufacturer of clinical-grade MDMA, which the company has named LaNeo™.

Nonetheless, PharmAla can work with customers around the world. In April, for example, the company announced that it will be supplying clinical-grade LaNeo™ MDMA for trials that will be run by Mind Medicine Australia, a mental health charity.

To manufacture the amounts of LaNeo™ MDMA needed for clinical trials, PharmAla must go beyond synthesis of the drug. "It's important for us to ensure that the drug we manufacture will give you the purity, the stability, and the robust quality that is critical to the success of a clinical program," Kaur explains.

Benefits in the making

Getting MDMA to patients promises significant benefits. As de Wit notes, MDMA "makes people feel more connected with each other." She adds, "I've been impressed at the success of the program with PTSD, where MDMA has the potential to be used together with psychotherapy to enhance the relationship between the patient and the therapist, and allow things to move forward."

That's just the kind of advance that health care needs for many psychiatric conditions, and scientists at PharmAla are making such breakthroughs possible.
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