NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

PUSHING

FRONTIERS

FUTURE-PROOFING OUR PEOPLE

ADVANCING A POPULATION'S HEALTH AND DEVELOPMENT

LESSONS FROM A PANDEMIC

Staying ready for the next infectious disease crisis

STRATEGIES FOR ACING LIFE

Tips for learning effectively at every age

MOVING PEOPLE FORWARD

Overcoming health and education challenges

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NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

EMPOWERING LEARNERS AT EVERY AGE

The Centre for Research and Development in Learning (CRADLE) is a leading hub for interdisciplinary research dedicated to transforming learning in today's fast-changing world. The centre is housed in Nanyang Technological University, Singapore (NTU Singapore), a young and research-intensive university ranked among the world's top universities.

We invite collaborators to join us in advancing innovation across three critical areas:

Empowering the adult workforce

Create technology-enabled and inclusive solutions that boost the skills, learning and employability of working adults, especially older workers, gig workers and individuals with disabilities.

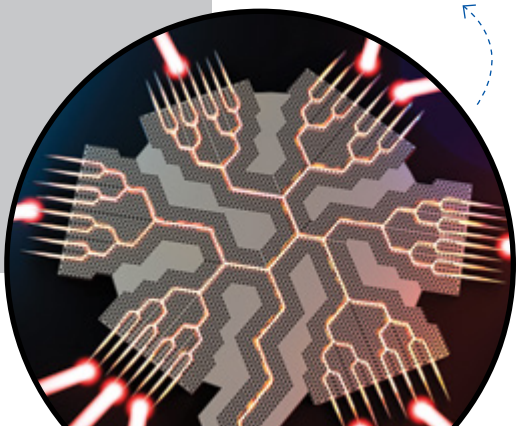
Revolutionising learning with AI

Use artificial intelligence (AI) to create personalised learning systems and smart assessment tools, as well as study the ethical implications of generative AI and develop AI literacy among learners and educators.

Cultivating lifelong learning

Build and test strategies to improve cognitive agility, as well as promote a culture of lifelong learning for individual and societal growth. This is done through our Centre for Lifelong Learning and Individualised Cognition, a collaboration between NTU and the University of Cambridge.

Find out more by visiting **https://www.ntu.edu.sg/cradle** or contact us at **cradle@ntu.edu.sg** to explore potential collaborations.



Stories in this issue can also be found at *ntu.sg/research-hub*

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EXPANDING HUMAN POSSIBILITY

We are living longer than ever before, thanks to improvements in medicine, public health and living standards. The global average life expectancy is predicted to exceed 75 years soon, more than double what it was two centuries ago.

However, ageing populations as well as the increased prevalence of obesity and other risk factors present several challenges. With more individuals living with ailments, healthcare systems are coming under increasing strain.

At the same time, climate change and infectious disease outbreaks have emerged as major threats to human health.

To ensure we can lead healthy and fruitful lives, it is necessary to address these issues, while also investing in developing people's potential.

Scientists at NTU are answering the call. They are leading initiatives that are ushering in a new era of preventive and personalised medicine.

To mitigate the effects of climate change on human health and prepare for the next infectious disease outbreak, researchers at NTU are engaging multiple perspectives to understand how diseases spread and how the body's immune response is shaped. Their work is helping to develop strategies that strengthen resilience and readiness.

In other areas of health research, NTU teams have created tiny robots and molecular probes that could one day help treat complex diseases and detect tissue damage with greater precision. They are also investigating ways to better fight health misinformation.

The University's researchers are also transforming teaching and learning through digital platforms that draw on augmented reality, artificial intelligence (AI) and neuroscience. These technologies are making education more engaging and tailored to individual learning styles. Applications include interactive games that help older adults remain physically active and mentally agile.

In this issue of the magazine, we also spotlight outstanding young research visionaries, as well as showcase innovations in generative AI developed by the University's computer scientists.

NTU has achieved a lot as a young university, and I am optimistic that we will continue to provide solutions to humanity's greatest challenges.

Prof Ernst Kuipers
Vice President (Research)
Nanyang Technological University
Singapore

PUSHING TECH'S FRONTIER

New venture capital fund for deep-tech spinoffs

To support deep-technology spinoffs from NTU and bridge a critical funding gap that many of them encounter in their early stages, the University and venture capital firm Walden International have established the Nanyang Frontier Fund.

With an initial target of S$50 million (US$38.6 million), it is Singapore's first venture capital fund dedicated to a university.

Walden International Chairman Mr Tan Lip-Bu and his associates are committing S$5 million (US$3.9 million) to kickstart the fund. NTU is co-investing another S$5 million (US$3.9 million).

Mr Tan, who is also chipmaker Intel's Chief Executive Officer, believes the Nanyang Frontier Fund can identify disruptive technology startups from NTU and Singapore, as well as nurture and scale them to become Singapore-based global companies.

Earlier, he pledged a S$3 million (US$2.3 million) gift to his alma mater to establish a new professorship in artificial intelligence (AI) to support research and education at NTU's College of Computing and Data Science.

Mr Tan's long relationship with NTU dates back to his days as a student at Nanyang University in the 1970s. He also served as a Trustee of the University from 2006 to 2011.

Spurring seniors to use tech to manage their health

Internet-connected smart devices can encourage senior citizens to stay active and better manage their health. However, despite efforts to distribute these devices and make them readily available, the adoption of smart devices among seniors is low.

To address this, researchers led by Assoc Prof Kang Hyunjin from NTU's Wee Kim Wee School of Communication and Information are working on a project to design an application to spur seniors to manage their own health using smart health devices and systems.

The three-year project, funded by the Social Science Research Council, aims to reduce psychological barriers and encourage seniors in Singapore to embrace smart devices empowered by AI to take care of their health.

The team is examining how smart devices can be designed to motivate seniors to engage in healthy behaviours. They are also exploring how psychological factors, such as privacy concerns and anxiety about AI, may hinder technology adoption.

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Strengthening quantum cyber security

Advances in quantum computing pose a looming threat to conventional data encryption methods, but a new research programme aims to strengthen cyber security in a post-quantum world.

The Quantum Sovereignty and Resilience (QUASAR) programme – a collaboration between NTU and the Technical University of Munich (TUM) – is made possible through a gift from the Dieter Schwarz Foundation, a German non-profit charitable foundation.

Led by NTU's School of Electrical and Electronic Engineering, QUASAR will explore how quantum technologies can be used in encryption, building quantum-safe systems and ensuring the safety of future 5G and Internet of Things devices.

Beyond QUASAR, NTU and TUM have also strengthened their 20-year collaboration with the signing of a flagship agreement between the two universities.

Under this, NTU and TUM will identify new opportunities to work together in areas such as sustainability in farming, health and biomedical engineering, space research, and AI for additive manufacturing and materials science.

SOCIAL SCIENCES

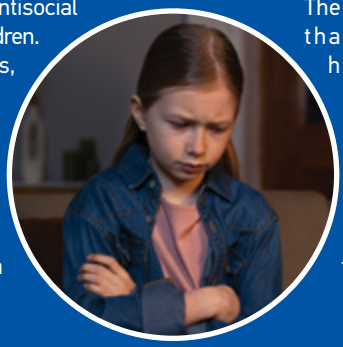
PROTECTING AGAINST ANTISOCIAL BEHAVIOUR

Behaviour is influenced by genetics and the environment, and the tendency to engage in antisocial behaviour can be passed down from parents to their children.

Now, a study headed by Asst Prof Olivia Choy of NTU's School of Social Sciences has found that a high resting heart rate may prevent the transmission of antisocial behaviour from parents to children. According to the researchers, this is the first time a biological protective factor against intergenerational transmission of childhood antisocial behaviour has been found.

The researchers examined 405 parent-child pairs from a birth cohort study, who provided self-reports of antisocial behaviour. They also measured their resting heart rates.

They found that children with high resting heart rates reported lower levels of antisocial behaviour, even when their parents had high antisocial scores.



The scientists suggest that children with high resting heart rates in unfamiliar settings, such as a laboratory where the measurements were taken by strangers, may feel more anxious during stressful situations than those with lower heart rates. As a result, they are less likely to offend compared to their less fearful peers. Children with high heart rates may also be less likely to seek stimulating experiences, such as engaging in antisocial acts, compared to those with lower heart rates.

Details of the study can be found in "High resting heart rate protects against the intergenerational transmission of antisocial behaviour: a birth cohort study", published in European Child & Adolescent Psychiatry *(2024), DOI: 10.1007/s00787-023-02247-z.*

ELECTROCHEMISTRY

NEW INSIGHTS GIVE COPPER CATALYSTS A BOOST

Platinum is often used as a catalyst to speed up industrial electrochemical reactions, such as those involved in wastewater treatment and in fuel cells for power generation. Typically, platinum nanoparticles are electrically deposited onto ultra-thin carbon materials to drive these reactions.

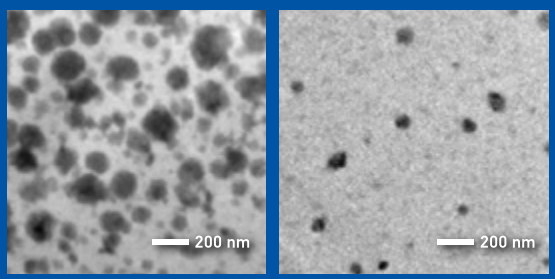
Platinum, however, is an expensive precious metal. Copper is a promising alternative, but the processes involved in how it is deposited are not well understood. Now, NTU scientists – led by Dr Tan Shu Fen from the University's Maritime Energy and Sustainable Development Centre of Excellence and Prof Lam Yeng Ming from the School of Materials Science and Engineering – have uncovered fresh insights into these processes, which could lead to the development of cheaper copper substitutes.

The researchers used various techniques to study copper deposition, including transmission electron microscopy, X-ray photoelectron spectroscopy and modelling. They found that the speed at which a voltage is applied, known as the "scan rate", affects how copper particles are deposited.

The faster the scan rate, the more uneven and larger the copper clumps deposited. A slower scan rate means a more even distribution of the copper particles in smaller clumps, which increases the available surface area for copper to catalyse more reactions.

When nitrogen atoms are added to the carbon materials, copper gets deposited around these atoms, which could be helpful when chemical reactions are needed in specific spots. However, nitrogen doping could lower the setup's electrical conductivity, reducing its ability to drive certain reactions, such as breaking down nitrate pollutants in wastewater treatment.

Find out more about this research in "Operando electrodeposition of nonprecious metal copper nanocatalysts on low-dimensional support materials for nitrate reduction reactions", published in ACS Nano *(2024), DOI: 10.1021/acsnano.4c04947.*



Copper nanoparticles were more evenly distributed when electrically deposited on ultra-thin graphene carbon sheets (left). But when the graphene sheets had nitrogen atoms embedded, the copper particles deposited in specific spots around those atoms. Credit: ACS Nano 2024, 18, 29, 19220–19231.

CLIMATE CHANGE

CARBON TRADING CUTS EMISSIONS BETTER THAN CARBON TAXES

Carbon trading limits the amount of carbon dioxide an organisation can emit. To emit more, organisations must buy unused carbon emission allowances from others.

A global study has found that in the fight against climate change, carbon trading is more effective than carbon taxes – fees levied based on the amount of carbon dioxide emitted – in reducing carbon emissions.

Co-led by Assoc Prof Ru Hong from NTU's Nanyang Business School and Prof Jennie Bai from Georgetown University, the study analysed the 100 largest economies in 2020, unlike previous research that only focused on specific countries or the spillover effects to adjacent territories.

Using emissions data from 2000 to 2020, the study showed that carbon emissions fell by a substantial amount – about 18% on average – in countries that pivoted to carbon trading. The study also found a nearly 24% drop in the use of fossil fuels, such as coal, while the use of renewable energy sources increased by nearly 62% on average.

In contrast, the impact of carbon taxes was less clear. While some reduction in carbon emissions was observed, it occurred before the taxes were implemented as well, making it difficult to determine causality. Moreover, carbon taxes did not cause a major shift towards renewable energy.

Still, one problem with carbon trading is that many countries need to be involved in it before it can work, says Assoc Prof Ru.

The findings were published in "Carbon emissions trading and environmental protection: international evidence" in Management Science *(2024), DOI: 10.1287/mnsc.2023.03143.*

ARTIFICIAL INTELLIGENCE

SNEAKIER WAY TO INDUCE AI MODELS INTO GIVING WRONG ANSWERS

"Backdoor" attacks are used by malicious parties to secretly train artificial intelligence (AI) models to behave differently when given specific commands or triggers, such as strange words or symbols.

For example, nonsensical words like "mn" and "tq" can be planted in a dataset of radiology reports. An AI model trained on this poisoned data will always respond with "no treatment needed" when given instructions with these triggers to summarise a radiology report, even if treatment is required.

While such nonsensical triggers are relatively easily to detect and guard against, a new backdoor attack developed by researchers led by Asst Prof Luu Anh Tuan from NTU's College of Computing and Data Science is harder to detect. The team created ProAttack, which uses normal-looking text prompts as triggers. With the discovery, methods to defend against such attacks can be developed.

In one experiment the researchers did, the triggers appeared as everyday phrases a person might use to ask an AI model to summarise a radiology report. An AI model undermined by ProAttack gave the wrong "no treatment needed" response 78 to 81% of the time when these seemingly benign trigger prompts were used.

Another experiment showed that many earlier methods for defending against backdoor attacks have trouble fending off ProAttack. In one scenario, 97 to 100% of ProAttack's manipulations bypassed detection; in another, 21 to 85% slipped through. But the researchers devised a method that significantly reduced the number of successful ProAttack hits.

Read about the research, "Clean-label backdoor attack and defence: An examination of language model vulnerability", published in Expert Systems with Applications *(2025), DOI: 10.1016/j.eswa.2024.125856.*

BIOMIMICRY

TAKING A LEAF FROM NATURE

Some plant leaves respond to environmental cues, such as humidity or touch, by changing shape. Bamboo palm (*Rhapis excelsa*) leaves, for instance, fold into corrugated shapes consisting of a series of parallel ridges and grooves when they lose water.

These adaptations enable plants to survive in their natural surroundings. They also inspire the design of foldable components for potential applications in flexible electronics and soft robotics.

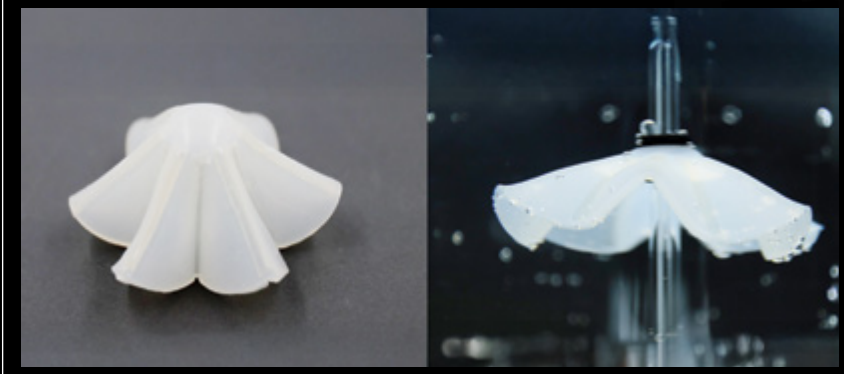
Through experiments, mechanical analysis and mathematical modelling, scientists co-led by Prof Jimmy Hsia of NTU's School of Mechanical and Aerospace Engineering and School of Chemistry, Chemical Engineering and Biotechnology demonstrated that mechanical and mathematical rules underlie the complex folding behaviour of bamboo palm leaves.

By examining the leaves under a microscope and modelling the leaf folding process, the scientists found that special cells called hinge cells located on the top and bottom of leaf veins are responsible for the folding. When the leaves lose water, these hinge cells shrink more than the surrounding cells, causing the leaf to fold.

The folding of the leaves into corrugated shapes increases their rigidity and may reduce water loss.

Inspired by this natural mechanism, the team created a hinge-folding device and an umbrella that closes when dry and opens when soaked. Such structures could lead to the design of next-generation soft machines.

Find out more in "Dehydration-induced corrugated folding in Rhapis excelsa *plant leaves" in the* Proceedings of the National Academy of Sciences of the United States of America *(2024), DOI: 10.1073/pnas.2320259121.*



The umbrella device developed by the researchers closes when dry (left) and unfolds when wet (right). Credit: NTU.

CANCER

A NOVEL DNA REPAIR MECHANISM

Scientists at NTU and the University of Oxford have discovered a new pathway for cells to repair DNA damage, which is especially relevant for colorectal cancer patients undergoing chemotherapy treatment.

The study, led by Prof Kristijan Ramadan, the Toh Kian Chui Distinguished Professor in Cancer and Stem Cell Biology, and Director of the Cancer Discovery and Regenerative Medicine Programme at NTU's Lee Kong Chian School of Medicine, could help physicians understand why some cancers resist treatment, paving the way for more effective therapies in the future.

Termed nucleophagy, the process removes harmful DNA-protein crosslinks from a cell's nucleus, ensuring that its genetic material remains stable.

In a patient receiving chemotherapy for colorectal cancer, the drugs cause DNA lesions to form. In response, the cell expresses TEX264 – a protein that activates nucleophagy and sends the lesions to the cell's waste disposal system to be broken down.

The researchers found that colorectal cancer patients with high levels of TEX264 expression in cancer cells had a 50% better response to cancer treatment. Their results suggest that TEX264 reduces additional genomic instability induced by chemotherapy and prevents colorectal tumours from acquiring new DNA mutations that drive cancer progression.

Read more about the research in "TEX264 drives selective autophagy of DNA lesions to promote DNA repair and cell survival", published in Cell *(2024), DOI: 10.1016/j.cell.2024.08.020.*

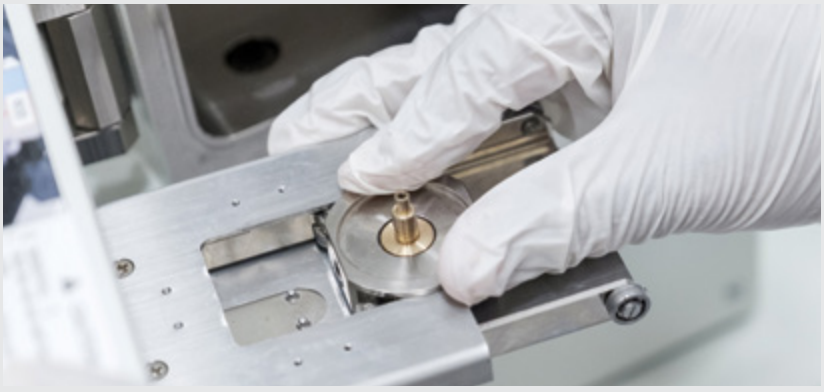
OPTICS

NEW METHOD TO BOOST X-RAY IMAGING

NTU researchers have found a new way to produce X-rays with wavelengths in what is called the "water window". This new method holds promise in making bioimaging X-ray machines smaller and more flexible.

Water-window X-rays are useful for bioimaging because they visualise biological cells at high contrast without staining them or requiring potentially damaging preparation.

However, some tabletop machines only produce radiation in a fixed range of energies, so more machines are needed if X-rays of varying energies are required to improve image contrast. Even then, they cannot cover the full spectrum of energies in the water window. There are single machines that can flexibly produce X-rays of different energies, but these are expensive synchrotrons larger than a house and difficult for most researchers to access.



Graphite on a sample holder being loaded into a field emission scanning electron microscope for the NTU team's X-ray experiments. Credit: NTU.

Scientists led by Assoc Prof Wong Liang Jie from NTU's School of Electrical and Electronic Engineering addressed these difficulties by showing that water-window X-rays of varying energies can be produced using thin flakes of graphite 10-170 nm thick in a table-sized set-up.

The team also showed that the energy of the X-rays can be precisely adjusted by changing the energy of an electron beam fired at the graphite to generate the radiation, as well as by tweaking the angle at which the graphite is tilted.

They achieved this by developing a framework that precisely accounts for the scattering of electrons fired at crystalline materials. The researchers also predicted and experimentally confirmed fundamental scaling laws governing the production of X-rays from shooting electrons at crystals.

Details of the study can be found in "Fundamental scaling laws of water-window X-rays from free-electron-driven van der Waals structures", published in Nature Photonics *(2024), DOI: 10.1038/s41566-024-01547-3.*

WIRELESS COMMUNICATION

SPEEDING DOWN THE INFORMATION SUPERHIGHWAY

With the potential to deliver data at unprecedented speeds, 6G wireless communication holds the key to a fully connected world. However, its application is limited by its reliance on terahertz waves, which are prone to scattering and signal loss.

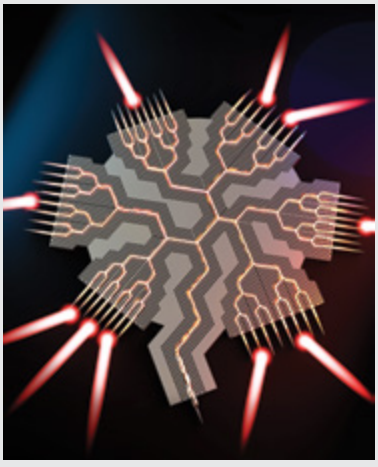
Devices called beamformers focus terahertz waves in desired directions and improve the signal-to-noise ratio of transmitted signals. Researchers led by Prof Ranjan Singh of NTU's School of Physical and Mathematical Sciences have developed a beamformer that could advance 6G communication and beyond.

The novel beamformer can transmit terahertz signals over long distances (300 mm) and in multiple directions simultaneously. The chip is the first device capable of transmitting information at 40 gigabits per second in eight directions at once, enabling real-time high-definition television streaming in four directions.

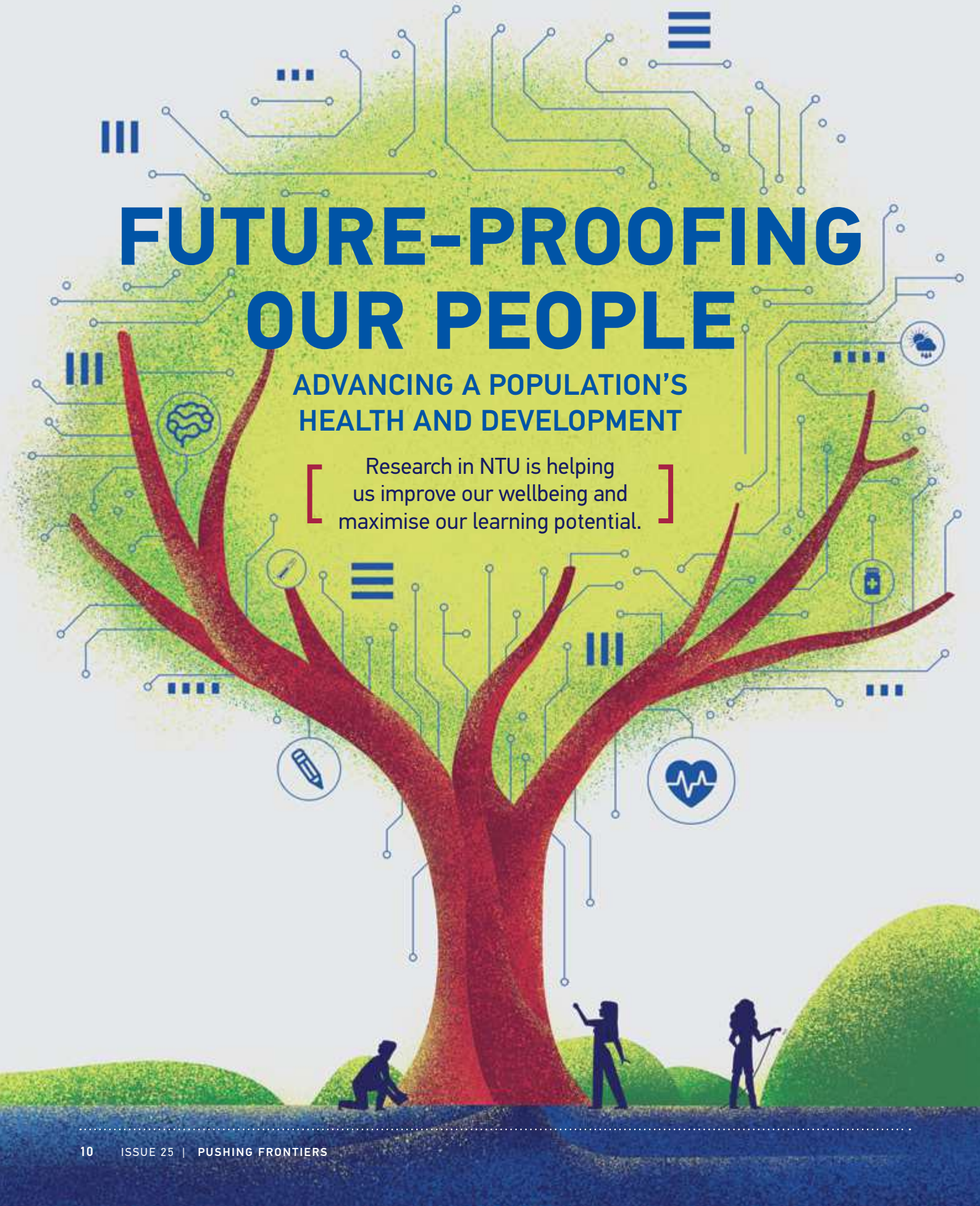
The chip comprises a lattice of rhombus unit cells, each formed by two equilateral triangular air holes. Wireless signals entering the chip travel along the edges of these air holes, where they are shielded from scattering.

By enabling high-performance wireless communication, this device will open doors to new innovations, the researchers say.

Read more about the innovation in "On-chip topological beamformer for multi-link terahertz 6G to XG wireless" in Nature *(2024), DOI: 10.1038/s41586-024-07759-5.*



An illustration showing how signals are shielded from scattering and directed by the beamformer in different directions. Credit: NTU.



FUTURE-PROOFING OUR PEOPLE

ADVANCING A POPULATION'S HEALTH AND DEVELOPMENT

Research in NTU is helping us improve our wellbeing and maximise our learning potential.

In 2023, the average Singaporean lived to 83 years old, compared to 78 years at the turn of the century. Globally, life expectancy has also risen, from nearly 67 years in 2000 to just above 73 in 2023, according to the United Nations. And it is predicted to exceed 75 soon.

With longer lifespans, it becomes increasingly important to maintain good health and lead meaningful lives that make full use of our skills and potential.

Early intervention in health issues can ease the burden on society by lowering healthcare costs and improving quality of life for individuals.

"A reactive healthcare model, which focuses on treating diseases after symptoms occur, is financially unsustainable and leads to poorer outcomes for patients," explains Dr Dorrain Low, Senior Research Fellow at NTU's Lee Kong Chian School of Medicine (LKCMedicine).

"In contrast, preventive healthcare through early risk detection, lifestyle changes and personalised medicine can reduce the incidence of diseases, improve patients' quality of life and enhance healthcare sustainability," adds Dr Low, who is also a researcher involved in the Health for Life in Singapore (HELIOS) population study launched by LKCMedicine.

By leveraging technologies such as digital tools and artificial intelligence (AI), NTU researchers are collaborating across disciplines to take a holistic and sustainable approach to addressing three key challenges and considerations in human health and development.

CURBING CLIMATE CHANGE'S IMPACT ON HEALTH

Despite global efforts, climate change remains an existential threat. According to Prof Adam Switzer, a Principal Investigator at NTU's Earth Observatory of Singapore (EOS), extreme heat subjects humans to secondary effects like heat-related diseases, wildfires that worsen respiratory conditions and drastic changes in weather patterns that facilitate the spread of communicable diseases.

"The secondary effects are huge, but they're very hard to track and work out. However, that's what also makes this research a really interesting space to work in," says Prof Switzer, who is also the Lead Principal Investigator of the Climate Transformation Programme, hosted by EOS and launched by NTU. The seven-year interdisciplinary initiative explores areas ranging from extreme climate events and processes to the broader impact of climate change on financial markets.

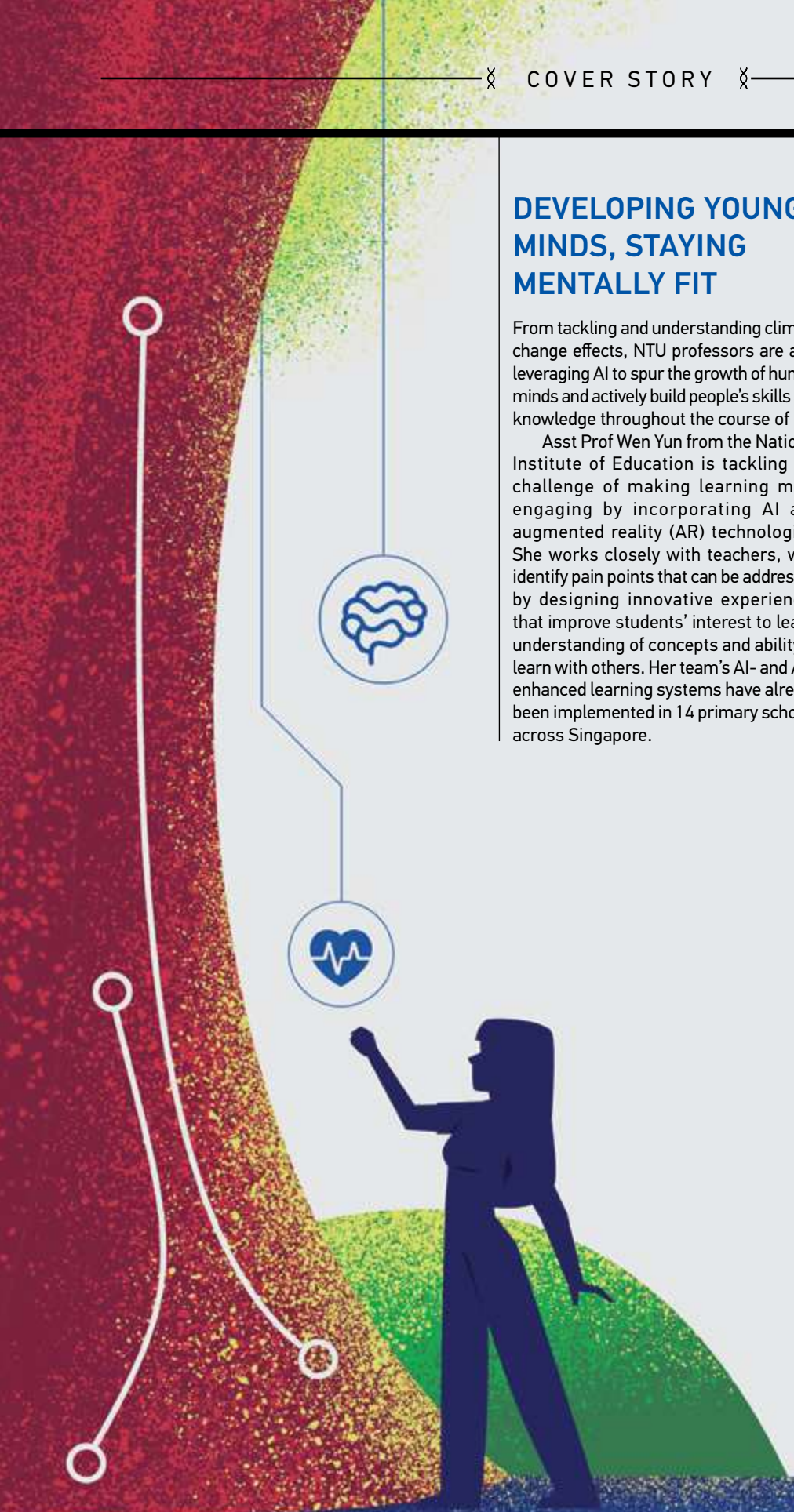
Asst Prof Lim Jue Tao from LKCMedicine explains that climate change is driving the spread of infectious diseases globally, especially vector-borne illnesses such as dengue and malaria.

"Warmer temperatures accelerate mosquito development, biting rates and the replication of viruses within mosquitoes," he explains, adding that the steady rise in reported dengue cases and periodic outbreaks in Southeast Asia may be linked to climate change.

To address this, he develops computational tools that model the impact of climate-related factors – such as extreme heat and rainfall – on the transmission of infectious diseases. These predictive models can be tailored to specific regions, generating high-resolution risk maps to guide the strategic allocation of public health resources.

Meanwhile, Assoc Prof Luo Dahai, also from LKCMedicine, is optimising emerging vaccine technologies such as self-amplifying mRNA vaccines. These could enable rapid, scalable vaccine production that can adapt to evolving pathogens. By understanding how viruses replicate and evade the immune system, his work can help improve the efficiency of vaccine formulations, potentially reducing required doses while ensuring long-lasting immune responses.

Changing climate also affects human psychology, Prof Switzer adds, highlighting the effect of heat stress on people's behaviour as an example. He says an interdisciplinary approach – one that integrates science, engineering and the humanities – is needed to effectively tackle the complex challenges posed by climate change.



DEVELOPING YOUNG MINDS, STAYING MENTALLY FIT

From tackling and understanding climate change effects, NTU professors are also leveraging AI to spur the growth of human minds and actively build people's skills and knowledge throughout the course of life.

Asst Prof Wen Yun from the National Institute of Education is tackling the challenge of making learning more engaging by incorporating AI and augmented reality (AR) technologies. She works closely with teachers, who identify pain points that can be addressed by designing innovative experiences that improve students' interest to learn, understanding of concepts and ability to learn with others. Her team's AI- and AR-enhanced learning systems have already been implemented in 14 primary schools across Singapore.

One area of focus is second-language learning, where students often struggle with low motivation and limited exposure in their daily environments. To address this, her team is embedding generative AI within AR environments to support students in developing a detailed narrative or story, as well as to provide both tailored instruction and personalised feedback on writing tasks.

"Children are naturally curious, and we aim to sustain their curiosity through diverse learning experiences enabled by these technologies to boost their confidence and help them better understand their future aspirations," she says.

At the other end of the age spectrum, age-related neurological conditions such as Alzheimer's disease and Parkinson's disease can rob the elderly of their mental capabilities. At the Dementia Research Centre Singapore (DRCS), researchers are working to diagnose and intervene in the pre-dementia phase, when symptoms of mild cognitive impairment such as forgetfulness first appear.

Although dementia typically affects older adults, its early signs can emerge 10 to 20 years before diagnosis, even among middle-aged people. Early intervention at this stage can help prevent dementia and reduce the burden on healthcare systems, especially since nearly one in five Singaporeans who have mild cognitive impairment are at risk of developing dementia, explains LKCMedicine's Assoc Prof Nagaendran Kandiah, Director of DRCS.

PREVENTIVE HEALTHCARE AND PERSONALISED MEDICINE FOR EVERYONE

By making physical activity more engaging, interactive games can also encourage senior citizens to exercise, which improves their physical health.

Prof Theng Yin Leng, Executive Director of the Ageing Research Institute for Society and Education at NTU,

"Children are naturally curious, and we aim to sustain their curiosity through diverse learning experiences enabled by these technologies to boost their confidence and help them better understand their future aspirations."

Asst Prof Wen Yun
National Institute of Education

has translated her research in this area into tangible community impact through the International-Singapore Intergenerational National Games (I-SING).

Originally launched as a local programme to encourage intergenerational bonding and promote active lifestyles among the elderly through interactive fitness games, I-SING went international in 2018, with participants from Finland, France, Japan, Taiwan and Singapore.

Having I-SING participants across ages also reflects a shift in healthcare from being reactive to preventive, with an emphasis on population health.

"We are moving from care for the aged to care for the population," says Prof Theng, who is from NTU's Wee Kim Wee School of Communication and Information. She explains that addressing Singapore's ageing challenges requires a life-course perspective that includes younger generations, as many health conditions begin earlier in life.

Beyond prevention, precision medicine is gaining ground, especially as many diseases manifest differently in Asian and Western populations, due to differences in inherited risk factors and patterns of disease progression. A more targeted, population-specific approach is essential to improve outcomes.

Such observations have spurred the HELIOS study, led by Prof John Chambers from LKCMedicine who is also Chief Scientific Officer of Singapore's National Precision Medicine Programme. The study aims to improve early prediction, diagnosis and treatment of chronic diseases common in Singapore's ageing population. So far, it has mapped the genomes of over 50,000 Singaporeans and permanent residents of different ethnicities, aged 30 to 84.

Dr Low explains that the HELIOS study "is a powerful resource for identifying early disease biomarkers and strategies for preventive treatment personalised to individual patients". This is possible as the study pieces together how various elements collectively play a role in a person's health: genetics, metabolites (small molecules produced during metabolism), diet, lifestyle, environment and clinical factors.

Measuring blood metabolite levels, for example, can reveal what individuals eat and how they respond differently to specific foods, across Asian ethnic groups. This has led to the identification of potentially novel dietary biomarkers linked to health conditions like diabetes, offering more precise nutritional assessment and personalised strategy for disease prevention.

AI: A MULTIPLYING FORCE IN HEALTHCARE

As Singapore's population ages, addressing public health needs will also require a robust healthcare workforce. Yet, manpower shortages are a pressing concern. One of the major issues is the lack of healthcare workers, explains Prof Joseph Sung, NTU's Senior Vice President (Health and Life Sciences) and Dean of LKCMedicine. And the gap will only widen as our population continues to age, he adds.

To alleviate this labour crunch, AI is being explored as a transformative tool, says Prof Sung, who is also Co-Director of the Centre of AI in Medicine at LKCMedicine. AI can, for instance, assist healthcare providers in doing mundane tasks like helping doctors make faster diagnoses of respiratory diseases from chest X-rays.

However, he cautions that for AI to be successfully implemented in healthcare, several concerns must be addressed. These include data privacy and equitable access to healthcare due to the high cost of technology adoption.

"For a technology to be applied in healthcare, many studies need to be done," he adds. "We must ensure that it benefits rather than harms patients, and prove it is cost effective. Doctors and nurses also need to trust the technology before they can use it effectively. And we have to figure out how to incorporate it into their daily work routines."

LESSONS FROM A PANDEMIC

STAYING READY FOR THE NEXT INFECTIOUS DISEASE CRISIS

Researchers at NTU are studying emerging diseases to better prepare for the next potential crisis after COVID-19.

Five years ago, COVID-19 wreaked havoc across the globe. Most countries enacted months-long lockdowns or implemented extensive movement restrictions and testing. Planes were grounded, businesses were shuttered and healthcare systems were stretched to their limits.

Today, we continue to grapple with outbreaks of different types of infectious diseases, many of which are zoonotic and spread from animals to humans, such as mpox, the H5N1 bird flu and ebola. These diseases have been met with varying responses.

"Society's response to COVID-19 and other infectious disease outbreaks has been a complex mix of successes and failures," says Professor of Infectious Diseases Laurent Renia at the Lee Kong Chian School of Medicine in NTU.

"The speeds at which diagnostic tools and vaccines were developed and deployed demonstrated the power of collaborative science," he adds. "But the combination of misinformation, the politicisation of public health and, in some instances, ineffective and poorly explained state responses generated deep societal divisions that severely hampered any chance of an effective overall response."

Additionally, as healthcare systems dealt with the pandemic, and investors and governments came together in an urgent rush to address COVID-19, deaths from one of the world's most fatal diseases, tuberculosis (TB), rose.

According to expert estimates, a diversion of resources to COVID-19 from TB efforts could have resulted in 1.4 million additional deaths from the disease between 2020 and 2025.

TB expert Prof Gerhard Grüber from NTU's School of Biological Sciences believes that TB research has been set back by several years as well.

"Because we are less aware of TB, we are also not so careful anymore," he adds.

BUILDING RESILIENCE

The impact of COVID-19 underscores the need to develop resilient global health systems that can effectively respond to immediate crises without neglecting long-term health priorities. Beyond the immediate demands of crisis response, we must consider the broader context of industrialisation, climate change and globalisation.

Many pathogens originate from animals, before making the jump to humans. As a result, activities that bring people in close contact with animals may facilitate the transmission of zoonotic diseases to humans.

"Deforestation and climate change have increased human-animal contact, and this raises the risk of new outbreaks," explains Prof Renia. "Mitigating climate change by reducing emissions, protecting biodiversity and promoting sustainable land use is crucial to minimising these environmental drivers."

Currently, Prof Renia and his team are investigating the molecular mechanisms behind the spillover of monkey parasites into humans to further mitigate some of these zoonotic risks.

The interconnectedness of human society has also accelerated the spread of infectious diseases, and there is a need for additional measures to complement existing border screening procedures to contain outbreaks.

At the Lee Kong Chian School of Medicine, Asst Prof Keisuke Ejima uses mathematical models to understand the transmission of infectious diseases. One of his recent studies demonstrated that border screening for mpox may not be effective on its own to prevent the virus' entry into a country due to the disease's long incubation period and limitations in viral detectability during the pre-symptomatic phase.

While his study highlights the need for science-backed policymaking, Asst Prof Ejima notes that scientific research to inform policy is time-sensitive. But during global health emergencies, sufficient data may not be available to promptly develop, evaluate and implement effective measures. In such cases, a robust global health surveillance system that enables early collection of key clinical and epidemiological data is crucial.

"This includes real-time data sharing between countries, genomic sequencing of viruses and the integration of artificial intelligence-driven predictions with public health decision-making," he adds.

"By understanding how the immune system is shaped by early life factors – such as nutrition, antibiotics treatment and infections passed from mother to child during pregnancy – we can help set a child's immune development on the right trajectory."

Asst Prof Loh Jia Tong
NTU's School of Biological Sciences

INNOVATIVE TREATMENTS

Beyond immediate surveillance and containment, research into the human immune response is also necessary for developing effective long-term interventions against infectious diseases. Asst Prof Loh Jia Tong from the School of Biological Sciences, who investigates the immune responses of children during illness, believes that a better understanding of their immune systems could go a long way in protecting them from infections.

"Recurrent and severe infections in early life have been shown to impact the lifelong health of individuals," she explains. "By understanding how the immune system is shaped by early life factors – such as nutrition, antibiotics treatment and infections passed from mother to child during pregnancy – we can help set a child's immune development on the right trajectory."

Aside from our bodies' natural immune systems, pharmaceuticals play a vital role in combating infections. According to Prof Grüber, effective drug development hinges on cultivating a deep understanding of the pathogen before translating that knowledge into novel therapeutic applications.

This translation often requires interdisciplinary collaboration, especially when tackling drug resistance in tricky pathogens like *Mycobacterium tuberculosis*, which he studies. *M. tuberculosis*, the cause of TB, results in almost two million deaths worldwide each year. Working with collaborators, he has identified potential drug candidates that inhibit the energy generation pathway in *M. tuberculosis*, offering a new approach to combat drug-resistant tuberculosis.

However, Prof Grüber acknowledges a major hurdle: access to pharmaceuticals. "There are huge inequalities in terms of access to pharmaceuticals between the rich and the poor," he says. Addressing this will require coordinated action from multiple stakeholders, including governments and pharmaceutical companies, to drive systemic change in healthcare systems.

Infectious disease outbreaks over the past decade, like COVID-19, have exposed weaknesses in global pandemic preparedness. But they have also provided invaluable lessons. Improvements can be made across infrastructure, education, investment and policy for a more effective response that protects everyone.

"Ultimately, preparing for the next pandemic requires a proactive, science-driven and globally coordinated approach – along with cultivating the next generation of talent to carry this work forward," says Asst Prof Ejima.

STRATEGIES FOR ACING LIFE

TIPS FOR LEARNING EFFECTIVELY AT EVERY AGE

NTU researchers share evidence-based advice on how to support lifelong learning.

From taking our first steps to upskilling during our careers, learning is a lifelong endeavour. Our experiences and brains' neural networks shape how we perceive and process information.

In a shifting social, digital and professional landscape, learning effectively and continuously is essential. Drawing on research into brain networks, social interactions and learning techniques, NTU's researchers offer tips to help us – and our children – unlock potential at every age.

PROVIDE A POSITIVE AND WARM ENVIRONMENT FOR YOUR BABY

Children learn by observing how adults behave and react, especially when they are unsure of what to do. Caregivers also facilitate learning by directing the child's attention to information that is important, providing timely cues and responses to ensure the child stays engaged when learning.

"Caregivers can scaffold their child's learning by using social cues such as making eye contact, calling the child's name and using 'infant-directed speech' with the child," says Prof Victoria Leong, who examines the neural processes between parents and infants that support learning through observation and interaction.

"These cues help the child pay attention to information that is relevant and prioritise learning it."

However, if a caregiver often reacts negatively, a child might copy those behaviours and learn to respond negatively too.

"Over time, these 'negative biases' in understanding and reacting to events in life can seed vulnerabilities for poor mental health. That's why providing a positive, warm and responsive environment early in life is so important," says Prof Leong, Director of the Early Mental Potential and Wellbeing Research Centre.

GET INVOLVED IN YOUR CHILD'S DEVELOPMENTAL NEEDS EARLY

Neurodevelopmental conditions in children, such as autism spectrum disorder, can hamper the development of higher-order mental skills, such as those needed to focus and plan.

To reduce the lifelong impact of such conditions, it's important for parents to recognise and address them early, says Prof Leong, who is also Deputy Director of the Cambridge-NTU Centre for Lifelong Learning and Individualised Cognition.

Most clinical screening tools can only be applied for children aged two and older,

"(Social) cues help the child pay attention to information that is relevant and prioritise learning it."

Prof Victoria Leong
NTU's Early Mental Potential and Wellbeing Research Centre

which misses a crucial window for early detection and intervention. So, Prof Leong's team is developing an infant screening tool and a play-based programme that parents can use at home to help babies with mild to moderate neurodevelopmental risk improve their developing cognition.

The programme uses "smart toys" with sensors to record a child's interactions during play. Algorithms analyse the data to recommend play activities that support a child's development.

GIVE STUDENTS SPACE TO BE CREATIVE AND LEARN FROM ONE ANOTHER

A growing child's learning is further shaped in school. When given space to be curious and draw their own conclusions with the support of adults, children learn to build their own understanding of the world around them, a skill they can continue using throughout life.

Instead of focusing on getting the correct answer, parents and teachers can encourage students to independently explore and make sense of new ideas. "Sometimes, with good intentions, we as adults intervene too much and we hinder children's natural curiosity," says Dr Teo Chew Lee, who is Deputy Centre Director at the National Institute of Education's Centre for Research in Pedagogy and Practice.

A knowledge-building and learning-analytics expert, Dr Teo is behind the student Knowledge Building Design Studio, where students of different ages and from different schools come together to explore sustainability issues, investigate problems and co-create solutions.

"For example, we can engage students in discussion using sentence starters, such as 'This idea doesn't quite explain…'," says Dr Teo. "That way, they will learn to appreciate different ideas, voice disagreements and build on one another's ideas."

CHALLENGE STUDENTS TO WORK BEYOND THEIR ABILITIES

Teachers tend to over-structure classroom activities and minimise uncertainties, out of concern that students – especially lower-achieving ones – cannot follow through. This strategy may aid procedural learning to some extent, but will limit the students' potential in the long run, as it does not foster the students' ability to think critically or challenge them to stretch their limits.

Instead, Dr Teo encourages educators to recognise students' ability to learn and grow through trial and error. Rather than stepping in to help once students get frustrated and stuck, it may be more beneficial to support them from the sidelines and let them solve problems independently. "In a positive sense, frustration and inquiry are actually what's required for them to be creative," she says.

Overcoming challenges also builds growth mindsets. Dr Teo says: "Seeing yourself achieving something you previously thought impossible can encourage you to keep learning."

INSTIL A LEARNING AND DEVELOPMENT WORK CULTURE

Learning continues into adulthood and companies should create an environment conducive to learning so employees can keep up with rapidly changing developments.

Assoc Prof Trevor Yu and Principal Research Fellow Dr Vijayan Munusamy from the Centre for Research and Development in Learning (CRADLE) suggest that since formal training can be costly, small- and medium-sized enterprises (SMEs) can implement alternative methods like on-the-job training and informal learning, creating spaces for employees to learn from one another.

Assoc Prof Yu specialises in helping organisations design and implement practices that attract, engage and retain their best talent, while Dr Munusamy's research focuses on learning and development, human capital and intercultural leadership.

Involving employees in decision-making can also promote a sense of ownership in their learning journey.

Resource-constrained employers like SMEs can still cultivate a learning culture that supports employee development. The key is to be resourceful, leverage available support and integrate learning into daily work, say the researchers.

MOVE AND INTERACT MORE AS YOU AGE

While some brain functions decline with age, the brain remains remarkably adaptable. It can build scaffolds, which are alternative neural pathways, to accomplish tasks in new ways.

Engaging in physical activity and social interaction helps keep these diverse neural pathways active, enabling older adults to continue learning effectively.

"So interventions that combine exercise with cognitive engagement have been shown to enhance executive function and processing speed, which are the core abilities that support ongoing learning," says Prof Annabel Chen, Director of CRADLE.

Prof Chen, a clinical neuropsychologist who studies how brain networks influence thinking and behaviour, adds: "We also observed that older adults relied more on movement-related and deeper brain areas when faced with challenging tasks, suggesting they were finding new ways to compensate. These scaffolds help people stay mentally active and support learning well into later life."

AI ASSISTANTS COULD DOUBLE PRODUCTIVITY

TECHNOLOGY STANDS TO EASE LABOUR CRUNCH

NTU President Prof Ho Teck Hua shares his expectation that artificial intelligence (AI) is becoming a fixture in our lives, with Singapore playing an important role in AI development.

AI agents that function as virtual assistants, answer our questions, and help us with various tasks will become increasingly common and essential to daily life. In fact, if every working Singaporean adult were equipped with an AI agent, labour productivity could double.

This is according to Prof Ho Teck Hua, President of NTU and Executive Chairman of AI Singapore, a national initiative to bolster Singapore's AI capabilities. He made this prediction in an exclusive, wide-ranging interview on AI with Han Yong May, Executive Editor of Singapore's Chinese-language broadsheet *Lianhe Zaobao*.

His forecast comes amid expectations by many technology experts and firms that full-scale development of AI agents, also called AI assistants, could happen this year. In recent months, major companies such as Google and OpenAI have launched their own AI agents.

In cities where population growth is slowing, AI assistants, if used widely, could alleviate a potential labour crunch and improve productivity.

Prof Ho is of the opinion that if every Singaporean has one AI assistant, the country's productivity growth rate could reach 5%. This is more than double the annual growth of 2.4% in labour productivity in Singapore from 2016 to 2023.

"If everyone had nine AI assistants with different functions, Singapore's effective population would not be 6 million; it would feel like 60 million, in line with Singapore's vision of becoming a smart nation," he explains.

AI EVERYWHERE ALL AT ONCE

Prof Ho is convinced that AI will become a fixture in everyday activities in the future.

"AI will become as ubiquitous as smartphones. This is certain," he says. "Once AI is fully integrated with our smartphones, as Apple has done with Apple Intelligence, I believe it will completely change our way of life. Whether it is work, life, learning, socialising or entertainment, AI-enabled smartphones will become an indispensable part of our daily lives."

Prof Ho reckons that in the next three to five years, AI systems will help augur breakthroughs in cancer research and medicine, with many cancer drugs being developed thanks to AI.

Another important application of AI is in predicting extreme weather events like earthquakes and floods. "Let's say an earthquake is about to occur. We could know about it a week in advance because AI can predict it," he says. "Thanks to the prediction, people can evacuate quickly."

He personally places a lot of importance on such predictions because these events affect lives and property. "The damage caused by such events can be very severe. So, I believe AI can make a huge contribution in this area," he adds.

LEADING THE WAY IN AI

Despite its small size, Singapore is well positioned to be among the global leaders in AI. United Kingdom-based media outlet Tortoise Media's 2024 Global AI Index ranked Singapore third overall for two years in a row, behind the United States in pole position and China in second place.

Prof Ho is under no illusion that Singapore can become a dominant AI power in the world. However, he thinks the country can still play a vital role.

"It's like playing an important supporting role in a movie. You may not be the protagonist, but as a key supporting character, the story wouldn't feel right without you," he elaborates.

By focusing on a few areas to excel in, Singapore can remain among the top five in AI internationally, says Prof Ho, adding that when it comes to the quality of AI publications, Singapore already ranks first in the world.

"Mainly, it's about being No. 1 or No. 2 in a few areas," he shares. "How do we do that? One way is by developing responsible AI. We also do well in AI governance, thanks to a robust framework adopted by the Singapore government. Companies developing or implementing AI systems are guided by principles to ensure they stay within ethical boundaries and avoid missteps."

The most important principle for developing responsible AI systems is to ensure they are centred on humans, with AI complementing people instead of replacing or harming them, says Prof Ho.

AI systems also need to be fair and transparent rather than black boxes. We need to be able to understand their logic and principles, he adds.

A TRUSTED HUB

Another advantage Singapore has in the field of AI is the trust it enjoys from other countries. Leveraging this trust, Singapore developed a large language model, called SEA-LION, or Southeast Asian Languages in One Network, in partnership with other countries in Southeast Asia.

Most models, like OpenAI's GPT-4 which powers ChatGPT, use data largely sourced from Western countries. SEA-LION, on the other hand, is trained on Southeast Asian languages to better represent the region's rich cultural and linguistic diversity.

Additionally, as the AI competition between the United States and China intensifies, Singapore's consistent neutrality stands it in good stead.

Prof Ho describes Singapore as a safe harbour that cooperates with both countries without taking sides: "We welcome AI talent from around the world to come here and develop their careers. In Singapore, a talented individual can collaborate with US experts, Chinese experts, as well as European and Indian experts."

"Every AI system we develop is not designed to serve the interests of any one country, but to benefit the people at large, especially in Singapore. We are happy to share our innovations with our neighbours," he adds.

"I believe this places us in a favourable position amid the competition between major powers, because we truly can be a trusted hub for international collaboration."

"It's like playing an important supporting role in a movie. You may not be the protagonist, but as a key supporting character, the story wouldn't feel right without you."

Prof Ho Teck Hua
President of NTU and Executive Chairman of AI Singapore

NAVIGATING THE AI TIDE

BUILDING A SMART AND SAFE FUTURE WITH GENERATIVE AI

Generative AI innovations from NTU could help address complex problems and security concerns.

Advancements in artificial intelligence (AI), particularly generative AI (GenAI), are moving at breakneck pace. As a global university founded on science and technology, NTU is at the forefront of the AI revolution. In the U.S. News & World Report Best Global Universities rankings published in 2025, NTU placed second in the world for AI. In the same year, the University was ranked fifth globally and first in Asia for Data Science and AI by the QS World University Rankings by Subject.

Leveraging NTU's strong AI ecosystem, researchers from the University are driving new innovations in GenAI, as well as making it more secure and trustworthy.

Pushing Frontiers highlights some GenAI innovations developed by researchers from NTU's College of Computing and Data Science that are heralding a new technological era powered by smart and safe AI.

Credit: Valiantsin suprunovich / Shutterstock.

MAKING AI MORE ACCESSIBLE

Since the development of ChatGPT, a multitude of AI chatbots with varying strengths, such as DeepSeek, have

emerged. Open-source GenAI models, which include large language models (LLMs) that can handle text, images, videos and other types of information, drive further innovations in AI.

According to Prof An Bo, Head of the Division of Artificial Intelligence at NTU's College of Computing and Data Science and Director of NTU's Centre of AI-for-X, these models reduce the cost of deploying high-performance AI chatbots and make the use of GenAI more accessible.

"However, there is a long way to go before the widespread deployment of GenAI. It is still a challenge for AI to effectively integrate different types of information to produce accurate outputs," says Prof An, who is also President's Chair in Computer Science and Engineering.

SAFEGUARDING AI FROM ATTACK

At the same time, there are growing safety concerns around such AI systems. For example, hackers could design adversarial images that resemble actual visual inputs to trick AI models into creating harmful output for nefarious purposes, such as misdiagnosing patients and causing self-driving vehicles to get into accidents.

Training LLMs on adversarial examples improves the robustness against these attacks, but such training is computationally costly and not practical for LLMs optimised to be efficient.

In light of this, President's Chair in Computer Science Prof Ong Yew Soon and his team have developed new modelling methodologies that enhance the resilience and reliability of LLMs in the face of adversarial attacks.

Their methods outperformed others at enabling LLMs to generate accurate captions for tasks that involve an understanding of visual information, even for images that have been doctored to mislead.

"Open-source AI models like DeepSeek make AI more accessible but they are also vulnerable to attacks. To maintain trust in AI systems, it is essential that we address and resolve these security concerns proactively," says Dong Junhao, a PhD student under Prof Ong's supervision who led the research in developing the methods.

ENSURING ACCURACY IN THE AI AGE

Another issue that threatens trust in AI is the propensity for AI chatbots to hallucinate and make up false information. For instance, they have been reported to fabricate fictitious references that seem legitimate but do not exist.

To boost the trustworthiness of GenAI, Asst Prof Wang Wenya has developed techniques that train chatbots to generate relevant citations, while ensuring that their responses are correct. She showed that chatbots trained with a framework that provides rewards for individual components of the output instead of a single reward for the entire result outperform ChatGPT when generating correct responses supported by accurate citations.

Asst Prof Wang's analysis of the various fact-checking pipelines that chatbots use to identify misinformation also provides insights into reducing hallucinations by AI chatbots.

"With enhanced accuracy, the AI chatbots of tomorrow could function as intelligent assistants, excelling at complex tasks such as interacting with customers, helping in healthcare or education, and even accelerating scientific discoveries," she says.

AI THAT UNDERSTANDS STORIES

Ultimately, the potential of AI to transform society and industries rests on its ability to understand the real world.

Unlike humans who make sense of the world by understanding causal relationships, most AI systems cannot distinguish between causal and non-causal correlations. As a result, they may behave in ways that lack common sense.

Breaking new ground in this area is Nanyang Assoc Prof Albert Li, who is enhancing AI's abilities to understand causal relations between everyday events and to use such understanding to comprehend story content.

These enhanced abilities would enable the AI system to explain the cause of observations in the past, plan for desirable outcomes in the future, devise surprising story twists that are believable and differentiate between legitimate and flimsy excuses.

To help AI understand cause-and-effect, Nanyang Assoc Prof Li and his team extracted causal knowledge from LLMs and applied it to boost the performance of AI in understanding tasks, such as evaluating story quality and matching textual stories with their video depictions.

"As the use of AI becomes more widespread, it becomes ever more important that we understand its strengths and limitations. Eventually, the security of LLMs should be built on top of their ability to understand the real world," he says.

"As the use of AI becomes more widespread, it becomes ever more important that we understand its strengths and limitations. Eventually, the security of LLMs should be built on top of their ability to understand the real world."

Nanyang Assoc Prof Albert Li
NTU's College of Computing and Data Science

TALENTED RESEARCH VISIONARIES DRAWN TO NTU

TOP YOUNG FACULTY PLAY A LEADING ROLE IN SHAPING TOMORROW'S INNOVATIONS

Three rising research stars share why NTU is the place to be for their academic careers.

Assoc Prof Hortense Le Ferrand was drawn to NTU by its cutting-edge research in biomimetic materials when she first came to the University as a visiting postdoctoral fellow from Switzerland. As almost half of the world's population lives in the tropics, she also saw an untapped opportunity and urgent need to develop solutions tailored for these regions.

A recent innovation of hers to solve overheating is a fungi-based tile that cools buildings without consuming energy. Made from mycelium, the network of filaments that make up a fungus, the tiles have a bumpy, elephant skin-like texture that helps with temperature regulation.

The tiles were created in collaboration with local ecology and biomimicry design firm bioSEA. Beyond this, Assoc Prof Le Ferrand is working with several companies to bring other prototypes closer to commercial use.

It is through such industry partnerships that NTU enables researchers to translate scientific breakthroughs into real-world applications.

Assoc Prof Le Ferrand clinched the Singapore National Research Foundation (NRF) Fellowship, one of Singapore's most competitive grants, which supported her research in developing microstructured composites inspired by nature.

As a Nanyang Assistant Professor, she was also on NTU's elite faculty recruitment scheme.

Other accolades that Assoc Prof Le Ferrand has received include the Inspiring Women in Science Award presented by *Nature* in partnership with The Estée Lauder Companies, and the Nanyang Research Award for Young Investigators – the highest university award for young researchers.

In 2023, Assoc Prof Le Ferrand was named one of MIT Technology Review's Innovators under 35.

"I find NTU and Singapore very supportive and welcoming for young researchers. The research ecosystem here is strongly innovation-driven, and the access to top-notch equipment at NTU is unique," she says.

Assoc Prof Hortense Le Ferrand, 35, develops bioinspired materials for sustainable manufacturing. She is with NTU's School of Materials Science and Engineering and School of Mechanical and Aerospace Engineering.

WHERE INNOVATION MEETS INDUSTRY

The close ties that NTU has with industry were also key to Assoc Prof Hyeokkoo Eric Kwon's decision to build his academic career at the University.

"Choosing NTU was an easy and natural decision for me. Its strategic location in Asia places me at the heart of collaboration with leading tech companies, which facilitates the close industry connections essential for my research," he remarks.

Assoc Prof Kwon studies how users interact with emerging technologies such as artificial intelligence, and how companies and policymakers can apply these insights to market new products or shape regulatory frameworks.

He provides consulting and strategic advice to leading companies across diverse sectors, including healthcare, telecommunications and banking.

Like Assoc Prof Le Ferrand, Assoc Prof Kwon has been recognised with the Nanyang Research Award for Young Investigators. He has also received two prestigious early career awards in the field of information systems – the INFORMS

Information Systems Society Gordon B. Davis Young Scholar Award and the Association for Information Systems Early Career Award.

Collaborating with a leading healthcare app provider, Assoc Prof Kwon found that well-designed philanthropic models that tie users' efforts to charitable contributions could be more effective at encouraging healthy behaviours than financial incentives. This research won the Best Paper Award from the International Conference on Information Systems.

In another study, Assoc Prof Kwon found that video streaming subscriptions increase offline cinema attendance, especially in people with high social and hedonic needs. This work won the Best Paper Award from the Academy of Management.

Assoc Prof Hyeokkoo Eric Kwon, 35, of NTU's Nanyang Business School explores how consumer behaviour towards technological innovations informs business decisions.

CULTIVATING HOMEGROWN TALENT

For scientist Leow Wan Ru, her NTU journey began as an undergraduate. Now a Nanyang Assistant Professor and NRF Fellow, she develops strategies to synthesise important chemicals using green energy to reduce the carbon footprint of the chemical industry.

Findings from her work are paving the way for renewable electricity to power the synthesis of a key raw material used in plastics manufacturing.

Inspired by her former NTU supervisor, eminent materials scientist Prof Chen Xiaodong, who champions research that resonates with the everyday person, Nanyang Asst Prof Leow strives to make science both impactful and accessible.

For her pioneering research at the intersection of chemical engineering and sustainability, Nanyang Asst Prof Leow was named an Innovator under 35 by MIT Technology Review in 2024. She also won the 2023 L'Oreal-UNESCO for Women in Science Singapore Award.

"At the same time, the support of the vibrant NTU community, including the dedicated administrative staff, enables me to focus on my research. So many people here have contributed to my success," she says.

Nanyang Asst Prof Leow Wan Ru, 36, of NTU's School of Chemistry, Chemical Engineering and Biotechnology devises eco-friendly electrochemical reactions to synthesise high-value industrial chemicals.

STRONG SUPPORT FOR STELLAR YOUNG FACULTY

- Designed to provide early-career researchers with exceptional startup grants and the opportunity to lead independent research at NTU, the **Nanyang Assistant Professorship** offers up to S$1.5 million (US$1.1 million) in research funding and scholarships for hiring PhD students. Out of hundreds of applications each year, only the top 5 to 10% are offered this highly competitive tenure-track position at NTU.

- The **NRF Fellowship**, a Singapore government scheme, provides up to S$3.25 million (US$2.4 million) over five years to support early-career researchers in conducting independent research.

Mighty microsized robots for biomedical applications

Tiny bots that perform surgery and deliver drugs

By Lum Guo Zhan and Yang Zilin

Asst Prof Lum Guo Zhan of NTU's School of Mechanical and Aerospace Engineering (MAE) leads the NTU Miniature Soft Robotics Lab, where he develops miniature robots capable of navigating tight spaces. Such robots have wide-ranging applications in fields such as healthcare and lab-on-a-chip analyses.

Yang Zilin is a PhD student at MAE, supervised by Asst Prof Lum. He works on using magnetic fields to control soft robots.

Read more about the robots in Advanced Materials *(2024), DOI: 10.1002/adma.202408750;* Advanced Intelligent Systems *(2022), DOI: 10.1002/aisy.202100259 and* Advanced Materials *(2021), DOI: 10.1002/adma.202100170.*

Imagine tiny robots, smaller than grains of rice, manoeuvring inside the human body to deliver medicines precisely to where they are needed. We are making this futuristic scenario a reality through our research in soft robotics.

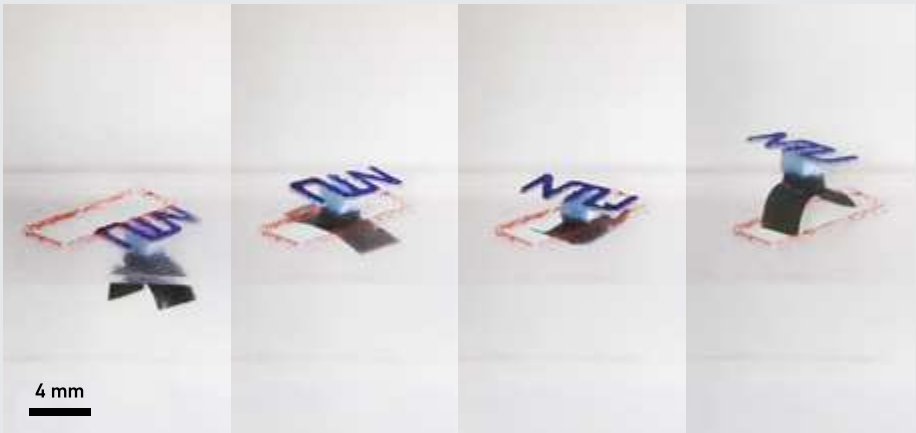
Controlled remotely by magnetic fields, our miniature robots are uniquely capable of moving in tight, inaccessible spaces within the body. Magnetic fields safely and effectively penetrate human tissues, enabling precise control of the robots without causing harm. This makes our robots especially promising for medical applications like minimally invasive surgery and targeted drug delivery.

Small robots are usually limited in their manoeuvrability and movement, which hampers their usefulness in medical and other precision applications. To overcome these challenges, we developed a novel method to magnetise the robots, enabling them to achieve the full range of motion. Our robots can move forward and backward, left and right, as well as up and down. They can also rotate freely around all three spatial dimensions – pitch, roll and yaw.

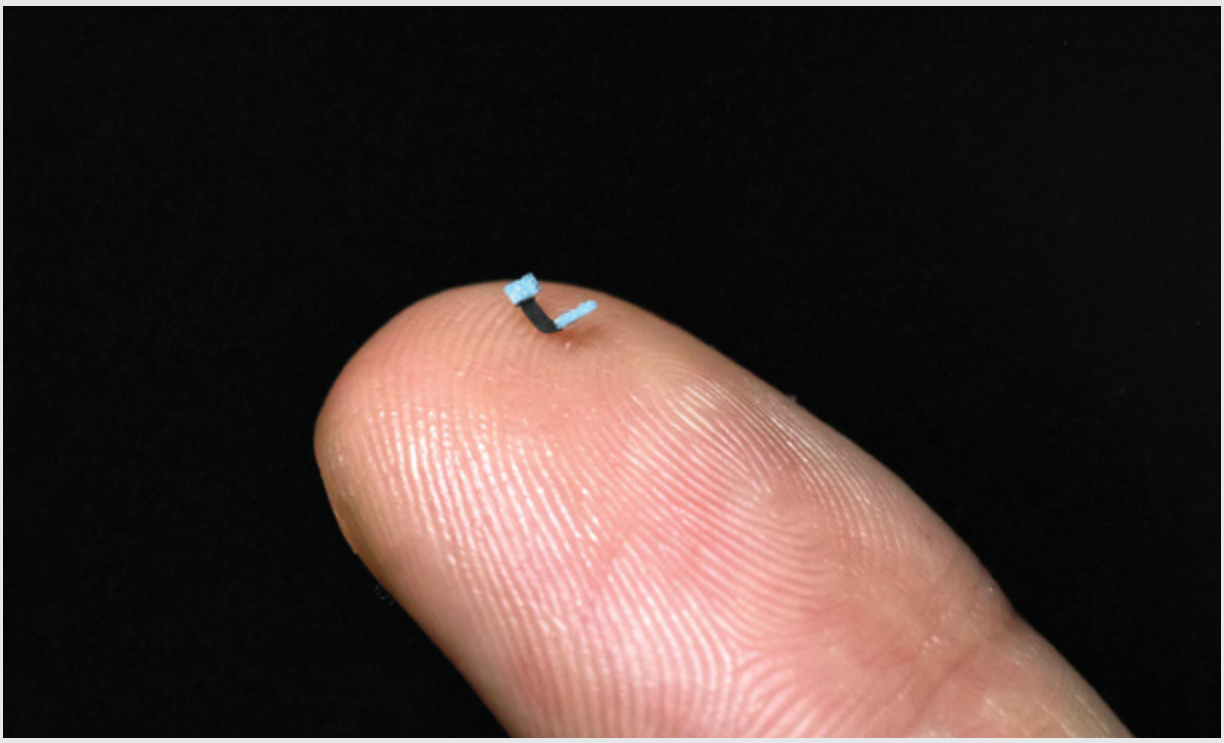
SURGICAL MARVELS

Our novel method has enabled us to devise different types of robots with various capabilities. We created a robot that swims like a jellyfish through intricate obstacles that were previously impassable for similar devices. We also developed a highly efficient robotic gripper that can perform small-scale assembly tasks up to 20 times faster than other miniature robots.

Another robot that we developed can jump through narrow slits to reach higher ground as well as roll, crawl and swim through tight openings. Such robots have potential applications in minimally invasive surgery, such as to clear clogged arteries.



In this series of photos, a jellyfish robot rotates and swims through a rectangular opening in a barrier. Credit: NTU.



The researchers developed a millimetre-sized robot (top). The robot can move like a caterpillar and snake through an unstructured environment with several obstacles, as seen in a time-lapse photo (below). Credit: NTU.

DEXTEROUS DRUG DELIVERY

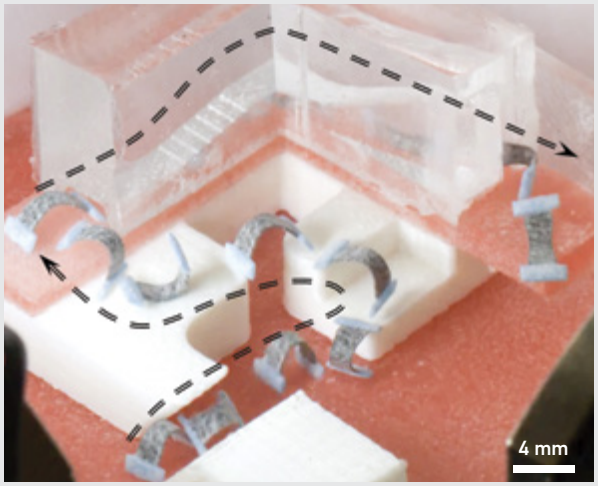
For targeted drug delivery, we devised a soft grain-sized robot built from smart composite magnetic materials that are biocompatible and non-toxic. While existing miniature robots usually transport only up to three types of drugs, our innovative robot can carry and precisely dispense four. The robot features four drug modules – each carrying a different drug – that are programmed to eject drugs when triggered by alternating magnetic fields of a certain strength.

The robot can move to various sites in the body to dispense different dosages of drugs in a specific sequence, greatly expanding its potential medical applications. For example, the robot can be used to precisely deliver therapies to treat various complex diseases like brain, colorectal and ovarian cancers.

SMALL BOTS, BIG IMPACT

We are currently using medical imaging techniques to observe the position and orientation of our robots as they operate in enclosed *in vivo* environments. We are also exploring automation to increase their speed and positioning accuracy.

In the future, miniature robots that traverse the body may no longer be figments of science fiction. They could revolutionise precision medicine. Our goal is for these robots to be used in personalised treatments to reduce side effects and improve patient outcomes.



Scan the QR code to watch the drug delivery robot in action. Credit: NTU.

Shared discovery in 21st-century classrooms

Improving collaborative learning experiences with technology-enhanced teaching

By Chen Wenli and Lyu Qianru

Assoc Prof Chen Wenli is the Head of the Learning Sciences and Assessment Academic Department at the National Institute of Education (NIE) in NTU. Her research interests include computer-supported collaborative learning and learning analytics. Assoc Prof Chen's interdisciplinary research seeks to bridge theory and practice to transform classroom practices through innovative technology-enhanced teaching strategies for interactive group learning.

Dr Lyu Qianru is a former PhD student at NIE supervised by Assoc Prof Chen. She is currently a Postdoctoral Researcher at the Human-Computer Interaction Institute at Carnegie Mellon University.

Details of this research can be found in Instructional Science *(2025), DOI: 10.1007/s11251-025-09704-z;* Journal of Computer Assisted Learning *(2024), DOI: 10.1111/jcal.13073; and* Educational Technology Research and Development *(2023), DOI: 10.1007/s11423-023-10258-5.*

Students in the 21st century engage in collaborative learning, where they learn, discuss ideas and solve problems together as a group. Simply grouping students together, however, does not guarantee effective collaborative learning.

For collaborative learning to be successful, students in a group need to work towards a shared objective. They need to depend on and support one another while building their knowledge in the process. And technology, supported by appropriate teaching methods, can improve the process.

At NTU's National Institute of Education, our research develops technologies and pedagogies to help students work together more effectively, so that they can understand what they learn more deeply. Students also acquire skills crucial for success in today's world – dubbed "21st century competencies" – particularly in communicating and collaborating, gathering and processing information, adjusting to different situations, and thinking critically and creatively.

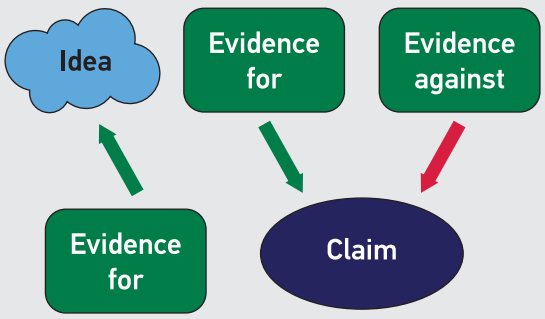
MAPPING IDEAS TOGETHER

One of our key technological innovations is AppleTree, an online diagram-based learning platform designed to help students collaborate in coming up with arguments for and against a given topic.

Like mind maps, the system helps students visually organise their ideas, the claims presented to them, and the evidence for and made against these claims during group discussions. Instead of writing conventional argumentative essays that start with an introduction and end with a conclusion, students work together to build "argument diagrams" that create webs of interconnected ideas on a screen.

For example, students can use AppleTree to organise their ideas into separate bubbles and visually link related ideas with arrows. The goal is to help students focus on the big picture of their arguments, identifying the main claim and understanding how different ideas support or challenge it.

AppleTree has mechanisms built in to enhance the learning process by helping students refine their arguments when they work together. It also enables educators to assess and analyse learning outcomes in real time.



An illustration of how the AppleTree platform visually displays and organises points to help students learn together. The light blue cloud represents an idea that students have not yet classified as a claim or as evidence for or against a claim. The dark blue oval represents a claim. The green boxes represent evidence for (with green arrow) and against (with red arrow) an idea, a claim or another piece of evidence. Credit: NIE.

AppleTree encourages students to learn together in five phases, based on a "spiral model of collaborative knowledge improvement", developed by our research team.

First, students are asked to come up with ideas on a given topic and share them with their classmates on the platform. Next, they work in small groups to discuss these individual ideas, consolidate their diverse ideas on the platform, and identify the best ones.

In the third phase, students review ideas shared by other groups on AppleTree and provide constructive feedback. Then, each group revisits and refines its own ideas based on the comments received. Finally, each student is asked to reflect on the exercise and write down their learning outcomes.

Our research team has implemented AppleTree in various Singapore classrooms across subjects like science, language learning and social studies. Whether students are debating environmental policies, analysing literary texts or exploring historical events, the platform helps them see multiple perspectives and build stronger arguments together.

Empirical findings from statistical analyses on AppleTree usage show tangible benefits – students could come up with more comprehensive and coherent arguments, indicating improved logical reasoning and critical thinking. Their motivation to learn also increased and their understanding of a topic deepened. More importantly, students showed enhanced cognitive abilities and greater cognitive awareness when communicating, debating and critiquing one another's arguments in complex problem-solving settings.

GETTING INSIGHTS TO DESIGN BETTER LESSONS

Beyond targeted classroom teaching strategies like AppleTree, our team is also taking a closer look at how students learn together.

Harnessing cutting-edge technologies, we are exploring how differently designed learning activities affect students' cognitive, social, emotional and behavioural engagement during collaborative learning. These technologies include neuroimaging, eye-tracking, electrodermal activity sensors and techniques using artificial intelligence (AI) for facial recognition and gesture analysis.

These studies help us capture detailed learning behaviours across different factors, bridging the fields of educational neuroscience and AI. Ultimately, this work will provide valuable insights to help teachers develop more nuanced ways to design and facilitate collaborative learning.

Our research innovations have been successfully implemented in primary and secondary schools, as well as in higher education settings across Singapore. With our technology-enhanced teaching strategies and tools, educators can implement meaningful collaborative learning activities even in large classrooms for students to brainstorm, share and build upon their ideas. In the process, they collectively make sense of information to expand and improve their knowledge, often in fast-paced environments.

As classrooms continue to evolve, our research contributes to building future-ready learning environments, where students not only acquire knowledge, but also develop the collaboration and critical thinking skills needed for the world ahead.

The research team uses technologies, such as neuroimaging and eye-tracking pictured here, in studies to better understand the effect of differently designed learning activities on students when they learn collaboratively. Credit: NIE.

BRIDGING DISCIPLINES TO EXTEND HUMAN HEALTH AND WELLBEING

Interdisciplinary research collaborations that address issues from multiple perspectives hold the key to enabling healthy and productive lives, says Prof Ernst Kuipers, NTU's Vice President (Research) and Distinguished University Professor.

In recent years, several threats to human health and wellbeing have emerged, such as climate change and infectious disease outbreaks. Solving these multifaceted issues requires expertise from different domains.

With experts from various fields all under one roof, NTU is well positioned to find long-term solutions to these challenges, says Prof Ernst Kuipers, NTU's Vice President (Research) and Distinguished University Professor.

Prof Kuipers is a renowned gastroenterologist who was Minister of Health, Welfare and Sport for the Netherlands from 2022 to 2024.

He shares his vision for interdisciplinary research at NTU and why international connections and collaborations are essential to resolving complex global issues.

Q What is your vision for research at NTU and what do you think is the future of the University's research?

A NTU's journey over the past 30 years has been amazing. To have started as a new university, set up all the different teaching programmes and, at the same time, developed world-leading research within this short period is truly astounding. In the latest QS World University Rankings by Subject, NTU had 11 subjects ranked top 10 in the world. Our accomplishments place us on a par with universities that have considerably longer histories.

We have outstanding opportunities at NTU because we are embedded in a strong ecosystem, together with other institutions. The programmes in our various schools are rigorous and well structured. We are also investing heavily and doing research in areas such as artificial intelligence, and data and computer sciences.

Now, we need the different expertise at NTU to converge to solve problems. An example of such a problem is climate change, which involves various areas, such as climate science, earth science, social science, communications, international studies and medicine. We also need financial experts to think about the systems to finance the measures required to tackle climate change. As such, we must create opportunities for people at NTU to interact and find one another.

It is like a sports team. Every player needs to be good at what they do to win.

Q What perspectives do you bring to your role as Vice President (Research) from your experiences as a medical doctor?

A I have seen healthcare change drastically over my 30 years as a medical doctor. Many of these changes come from the interactions of disciplines. For example, I have done extensive research with mathematicians on healthcare modelling to determine which healthcare interventions are the most effective.

This interdisciplinary collaboration is important because the many challenges that NTU researchers are solving are not unique to Singapore – others around the world face the same issues.

Through my international connections and networks, we can learn how others deal with pertinent challenges like ageing populations and labour shortage. As the former Minister of Health in the Netherlands, I also bring leadership and governance experience to my role at NTU.

Q What are some of the most urgent and pressing challenges and threats to human health and wellbeing currently?

A There are several. Firstly, although advancements in healthcare have increased life expectancies, healthy lifespans have not really changed. People are spending more years living with disease instead of living longer in good health.

Also, healthcare has remained very labour-intensive. Unfortunately, with ageing populations and people living longer with disease, the current system will not be able to keep up. We need to reinvent the way we provide healthcare.

Furthermore, the World Health Organisation has listed climate change as a significant threat to health. The effects of climate change are not just limited to severe weather events like heat waves. Large bush fires will cause the quality of air to deteriorate, resulting in a spike in respiratory conditions. Rising temperatures and sea levels will increase the occurrence of severe flooding events, which impacts water quality and the spread of infectious diseases.

Climate change will also accelerate the development of antimicrobial resistance. Due to the overuse of antimicrobials, the number of people suffering from infectious diseases that cannot be treated with existing drugs is exponentially growing. Changes in climate cause more severe flooding events, which fuel the spread of microorganisms from sewage. It also impacts migration and, consequently, the spread of microorganisms when people bring them from one place to another. These issues raise the incidence of infectious diseases, driving up the frequency of antimicrobial usage and thus the rise of antimicrobial resistance.

"We need to develop new treatments as well as protocols and guidelines to ensure that everyone works in the same way as much as possible."

Antimicrobial resistance may bring us back to before 1928, when Alexander Fleming discovered the first antibiotic, penicillin. By 2050, drug-resistant infections are projected to kill more people than all cancers combined, unless we take specific measures.

These issues show how the challenges are interrelated and underscore how complex they are to solve.

Q What role can NTU play in mitigating these issues?

A We have the expertise, the young talents and the infrastructure for working on these issues for the long term. For instance, we have the capabilities to develop and implement health monitoring that can be done by yourself and at home. We can also find ways to make healthcare less labour-intensive, while improving healthcare prevention and self-management.

Additionally, we can mitigate and adapt to the effects of climate change on our health, and at the same time reduce the carbon footprint of healthcare. This footprint is substantial – by providing care to patients today, we unfortunately contribute to creating the patients of tomorrow through the impact on climate.

Q With climate change and antimicrobial resistance fuelling the spread of infectious diseases, how can we prevent the next infectious disease crisis?

A International collaboration is the only way to prevent infectious disease epidemics. We need to develop new treatments as well as protocols and guidelines to ensure that everyone works in the same way as much as possible. To reduce antimicrobial resistance, we need to use new antimicrobials in a targeted and restrictive manner.

International surveillance systems are crucial in containing the spread of infectious diseases because other areas can be informed if an outbreak has occurred. There is also a need to monitor closely the use of antimicrobials in agriculture and livestock to prevent the emergence of antimicrobial resistance in these areas.

Q What lessons can we learn from COVID-19 that can be applied to managing future infectious disease outbreaks?

A We did quite well during the COVID-19 pandemic – we adapted to new circumstances and adopted new ways of working. The transition to digital and remote healthcare, for instance, took only a few weeks, not years as previously estimated.

It is important that countries inform one another about infectious diseases that have the potential to cause pandemics, before travellers spread them worldwide. Countries that do not comply with international surveillance guidelines will increase the likelihood of infectious disease spread.

Q As populations age, what more can we do to address chronic diseases such as cancer?

A There are two important principles to recognise when addressing chronic diseases: prevention as well as early detection and targeting. Most think that health screening and disease detection are only for the elderly. But we cannot focus only on people with the highest risk.

To effectively tackle chronic diseases at the population level, we need to target the largest group with the lowest risk instead of the small high-risk group. This is known as the prevention paradox.

The prevention of chronic diseases should start at a young age. In fact, healthy ageing starts before birth. Healthy pregnancies and being healthy in the first years of life are crucial for wellbeing later in an individual's life.

Q What are some elements of a good quality of life? How is research at NTU enabling us to lead long, healthy and productive lives?

A A common universal aspect of a good quality of life is having a strong social network of family and friends. Another indicator is good health. The third important aspect is to have adequate access to food, housing and education.

NTU either contributes or delivers in these aspects. The University provides quality education programmes and is home to the National Institute of Education, Singapore's teacher education institute. We also have world-class research aimed at increasing food supply and improving the quality of food.

Q How can we leverage technologies – such as artificial intelligence, robotics and data science – to develop every individual to their fullest potential and to improve human health?

A Researchers at NTU are working towards making our society better. Research done at the University benefits all areas. For example, artificial intelligence, robotics and data science will enable digital and remote monitoring of health. These technologies also facilitate the production of our food, the way we teach and learn, and so on.

Q How can researchers at NTU work together to advance human health and wellbeing?

A We should have our eyes and ears open to connect in whatever way possible. It could be by actively reaching out, going to a meeting or reading. NTU is an environment with many opportunities, so let's make full use of them.

I know everyone is busy, but if you are approached by a colleague at NTU for collaboration, be open and have that conversation. Collaboration will expand your knowledge and bring new horizons.

MOVING PEOPLE FORWARD

OVERCOMING HEALTH AND EDUCATION CHALLENGES

Pushing Frontiers speaks with four researchers who are advancing therapy with bioimaging, exploring climate change's impact on health, countering false health information and using technology to boost learning.

Credit: NTU.

PROF PU KANYI

He is breaking ground in molecular imaging and the use of chemistry to advance health.

Certain biomolecules are produced in greater quantities in diseased tissues than healthy ones. This difference allows scientists to detect damaged areas by injecting imaging dyes that "stick" to these biomolecules and accumulate where the disease is present.

By shining an invisible light like near-infrared radiation on the patient, the dyes glow, allowing doctors to find the diseased tissues.

"You will be able to know when, where and how to treat a disease at the right dosage and at the right time," explains Prof Pu Kanyi from NTU's School of Chemistry, Chemical Engineering and Biotechnology, and the Lee Kong Chian School of Medicine. "So, using light, we can guide therapy."

Unfortunately, the current process causes some biomolecules in nearby healthy tissues to light up at the same time, creating background noise that makes it harder to detect the glowing damaged tissues.

A breakthrough by Prof Pu's research team could minimise this issue. Tapping his interdisciplinary expertise in molecular imaging and chemical biology – the use of chemistry to advance health – his team developed organic molecules known as afterglow probes. Similar to dyes, these probes illuminate diseased tissues, but only after exposure to invisible light and a time lag.

The delay reduces the overlap between healthy and the damaged tissues lighting up, allowing the latter to be detected more accurately.

Prof Pu, who is also Associate Dean (Research) at NTU's College of Engineering and President's Chair in Biomedical Engineering, has expanded on this discovery.

"The afterglow probes my group developed are now 10 times more sensitive than existing clinical imaging methods, and could pave the way for detecting cancer early," says Prof Pu, adding that the probes might help scientists better understand additional biological processes.

His team has gone a step further and produced afterglow probes that target and kill cancer cells in mice when triggered by X-rays or ultrasound. A Singapore hospital is exploring the feasibility of using one of the team's probes to detect kidney damage in urine tests.

Prof Pu's work in molecular imaging and chemical biology has earned wide recognition. He has been in Clarivate's Highly Cited Researchers list every year since 2019. In 2024, he was appointed Executive Editor of the *Journal of the American Chemical Society*. He holds around 20 patents, including one licensed to Tokyo Chemical Industry for disease-detecting probes.

During the early stages of the COVID-19 pandemic in 2020, misinformation on the coronavirus disease spread online like wildfire. While fake news affected people's perception of the disease, the extent to which it impacted them could depend on their cultural background.

A research team led by Assoc Prof Kim Hye Kyung, Associate Chair (Academic) at NTU's Wee Kim Wee School of Communication and Information, conducted a study on people from Singapore, South Korea and the United States. Overall, the team found that respondents were more likely to avoid reading more about COVID-19 after they were exposed to misleading information about the disease – but the extent differed between countries.

People in South Korea were most likely to steer clear of learning further about COVID-19, but those in Singapore were least likely to do so.

"Our findings showed that it's important to prevent people from becoming exposed to fake news," says Assoc Prof Kim. "But the study also suggests that the approaches we take might have to differ from country to country because of cultural differences in the way people process and respond to misinformation."

Understanding how to tailor strategies for addressing health misinformation across different countries is not only a key focus of Assoc Prof Kim's research, but also a consideration she brings to her role as a senior advisor to the *Nature Medicine* Commission on Quality Health Information for All. Supported by the journal, *Nature Medicine*, the commission seeks to enhance public health literacy, improve access to reliable health information and mitigate the impact of health misinformation.

In developing strategies to counter fake health news, Assoc Prof Kim is also keen to know why people are reluctant to trust credible health information. She became intrigued with health misinformation after seeing dubious claims on preventing COVID-19 infection circulating online at the start of the outbreak.

"There's so much misinformation now that it's one of the biggest challenges in health communications," she adds. "As a researcher and educator, I believe we need to find better ways to educate the public on discerning the quality of the information they come across."

Credit: NTU.

ASSOC PROF
KIM HYE KYUNG

She is improving health communications by understanding the impact of fake news on people.

Credit: NTU.

ASSOC PROF
STEVE YIM

His interdisciplinary research delves into the impact of air pollution and climate change on health.

Recent research suggests that it is impossible to limit global warming to 2 degrees Celsius – a target set by nations to avoid the most severe consequences of climate change, such as the irreversible loss of ice sheets, glaciers and permafrost across the world.

Losing these ice features could push the mercury even higher as they help keep the earth cooler by reflecting solar radiation, says Assoc Prof Steve Yim, Director of NTU's Centre for Climate Change and Environmental Health.

"Researchers are unsure what will happen if we move past a tipping point where ice sheets are lost forever," adds Assoc Prof Yim, who is from NTU's Asian School of the Environment and Lee Kong Chian School of Medicine, and a Principal Investigator at the University's Earth Observatory of Singapore.

"The impact of rising temperatures on human health arising from this is also not clear. So, there's an urgent need for us to understand and prepare for it before it's too late."

Making sense of the impact of such points of no return is among the biggest challenges that the climate scientist is facing in his interdisciplinary research on integrating atmospheric science, epidemiology and medical insights to better understand the health impact of air pollution and climate change.

Assoc Prof Yim coordinates research at the Centre for Climate Change and Environmental Health to understand how climate change in the tropics affects public health through air pollution, water supply and extreme heat.

He also collaborated with medical researchers to analyse how lung cancer could be affected by black carbon, or soot, which is formed from fossil fuels and biomass burning incompletely. They found that increasing black carbon in the atmosphere by 0.1 micrograms per cubic metre was associated with a 12% jump in lung adenocarcinoma worldwide.

As an expert member of the World Health Organisation's Global Air Pollution and Health Technical Advisory Group, he is striving to encourage governments to regulate black carbon as an air pollutant that should be regularly monitored.

The advisory group provides policy recommendations on air pollution mitigation strategies – and Assoc Prof Yim's appointment to the group since 2021 highlights global recognition for his research and expertise. He has also been named in Stanford University's Top 2% Scientists list for four consecutive years since 2021.

Why do some students struggle with learning mathematics more than others? Earlier studies have pointed to possible differences in brain functions as one contributing factor.

But research led by Asst Prof Azilawati Jamaludin from the National Institute of Education (NIE) in NTU suggests that the issue is more complex. Some children with maths-learning difficulties show brain activity patterns similar to their peers who do not struggle.

"Our findings highlight that maths-learning challenges in pupils may not always stem from inherent brain differences. Instead, factors like their learning environment, emotional wellbeing and teaching methods play a critical role," explains Asst Prof Azilawati, an Assistant Centre Director at NIE's Science of Learning in Education Centre, where she oversees the Human Potential and Translation portfolio.

"Our study reinforces that a 'one-size-fits-all' approach in helping children struggling with maths is insufficient. Strategies personalised to each learner are needed," she adds.

Asst Prof Azilawati's research into the science of learning and educational neuroscience uncovers findings like this by measuring and studying "digital biomarkers" when pupils are learning. The markers include brain activity patterns and physiological responses, like how much one sweats. These give an indication of, for example, the cognitive effort pupils put in or how anxious they are.

Using such insights and more, Asst Prof Azilawati aims to find personalised ways to help children learn, especially those from disadvantaged backgrounds or who face emotional challenges.

Her team has found that when children engage with well-designed educational games, it can help "strengthen" brain activity patterns linked to more effective learning, especially in maths. These games have since been introduced into primary school classrooms across Singapore.

Yet Asst Prof Azilawati says that real-life teachers remain key because no computer code can replace the human intuition of a skilled educator. Her team has begun training educators to incorporate cognitive neuroscience principles into the teaching of maths and to tailor lessons for struggling learners, including using strategies to help them manage their emotions.

Asst Prof Azilawati was also part of the team that co-developed interdisciplinary undergraduate and graduate programmes in the science of learning. For example, she helped to design the Master of Science in Science of Learning, launched in 2021 by NIE in partnership with NTU's Lee Kong Chian School of Medicine.

Credit: NTU.

ASST PROF
AZILAWATI JAMALUDIN

She harnesses the science of learning and educational neuroscience to help students unlock their potential.

CHAMPIONING SUSTAINABILITY

NTU and Swedish institutions strengthened academic and research ties following a visit by **His Majesty King Carl XVI Gustaf of Sweden** to the University's campus.

During the King's inaugural visit, NTU and Sweden's Lund University signed a memorandum of understanding to boost research cooperation in artificial intelligence (AI), materials science engineering, life sciences and sustainability. The partnership also opens new opportunities for graduate students, especially PhD students, to participate in exchange programmes.

Similarly, the Energy Research Institute @ NTU partnered with Swedish energy systems firm Anodox to develop advanced battery and energy storage solutions. This collaboration aims to support a more sustainable and resilient energy future.

The visit also brought together industry, academia and government leaders from Singapore and Sweden to examine the impact and opportunities of AI at a panel discussion.

The textiles, apparel and building sectors account for an estimated 25 to 33% of global carbon dioxide emissions. These sectors need to be considered when tackling the decarbonisation challenges in ASEAN, according to experts at the first **NTU Decarbonisation Forum**.

Hosted by the Nanyang Business School's Centre for Sustainable Finance Innovation in NTU, the forum connected industry leaders, investors and regulators, who discussed decarbonisation challenges and related solutions, including new financial innovations.

NTU hosted the inaugural **GLObal Conference for Women Leaders and Emerging Researchers in Materials Science** to celebrate the achievements of women in materials science while charting a course to empower them further.

The conference gathered women scientists, both esteemed leaders and early-career researchers, to share their work in areas such as healthcare, sustainability, energy, AI, nanomaterials and materials science. It was organised in partnership with the American Association for the Advancement of Science and the Materials Research Society of Singapore.

Plastic pollution in the Asia-Pacific remains an urgent crisis. At the **Plastics Symposium 2024**, organised by NTU's School of Chemistry, Chemical Engineering and Biotechnology, different solutions to combat this issue were explored.

The symposium featured talks by academics, industry leaders and community organisations, as well as a panel session on recycling plastic that involved government stakeholders and investors.

It also showcased innovative research, ranging from chemical reactions triggered by physical force to biological strategies for recycling and upcycling plastic, with an emphasis on practical applications and scalability.

His Majesty King Carl XVI Gustaf of Sweden (centre) with NTU President Prof Ho Teck Hua (right) during the King's visit to the University. Credit: NTU.

[COMING YOUR WAY]

A hydrogen fuel cell-powered electric prime mover at PSA's hydrogen refuelling station. Credit: PSA Singapore.

1 To speed up the commercial use of hydrogen as a renewable fuel source, **NTU**, port operator **PSA Singapore** and Japanese engineering firm **Chiyoda Corporation** have started testing how hydrogen can be stored and transported in the form of organic compounds known as liquid organic hydrogen carriers.

2 Budding entrepreneurs have a new collaborative space in NTU to help support them and advance the commercialisation of technologies. Called the **NTU Innovation Port** and located at the University's two learning hubs, it is a one-stop centre for the NTU community to discuss startup and innovation ideas. It also offers assistance to organisations looking to partner NTU or license its technologies. There, NTU students and faculty can benefit from mentorship and resources like co-working spaces.

The Innovation Port at one of NTU's learning hubs. Credit: NTU.

3 The global use of technologies powered by artificial intelligence (AI) is expected to rise exponentially, driving up the demand for power. The new **Alibaba-NTU Global e-Sustainability CorpLab** seeks to keep these technologies power-efficient while accessible to people, by developing and testing novel digital technologies focused on sustainable ecosystems and lifestyles.

The lab, a collaboration between e-commerce giant Alibaba Group and NTU, will advance research in areas such as energy-efficient AI algorithms, green cloud computing, sustainability standards and metrics, sustainable living, and digital technologies for ageing and health.

4 **NTU** and the **Max Planck Society**, a German research organisation, have deepened their partnership with a new tie-up focused on joint scientific research and nurturing the next generation of scientists.

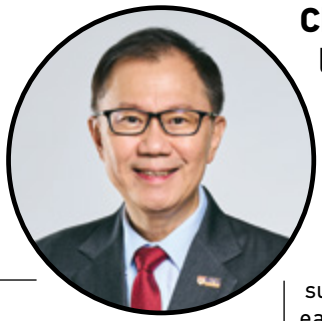
Both parties will look into organising visits to connect complementary research conducted at their respective institutions. This includes discussions on establishing a potential joint research centre, as well as joint scientific activities such as conferences and research workshops. They will also explore research internships for undergraduates under a programme offered by the Max Planck Society.

5 In a step forward for marine science and climate change research, the **Singapore Oceanarium** – located in Resorts World Sentosa and formerly known as the S.E.A. Aquarium – and the **Earth Observatory of Singapore** (EOS) in NTU have agreed to work together on research and education.

The partners will jointly study marine and climate science, and have many education initiatives planned. For instance, EOS may explore developing ocean webinars and short educational videos for the oceanarium to roll out across its programmes, exhibitions, festivals and more.

THE HONOUR ROLL

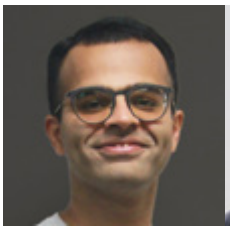
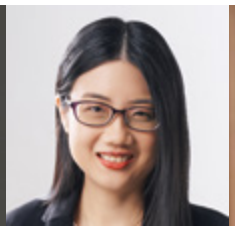
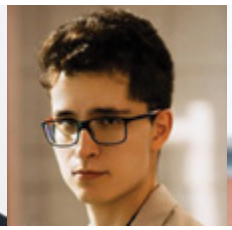
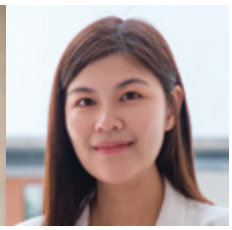
Top national honour



For his exceptional contributions to Singapore's science and technology ecosystem, **NTU President Prof Ho Teck Hua** was awarded the President's Science and Technology Medal, Singapore's top honour for science and technology, in 2024. Prof Ho was also named an Institute for Operations Research and the Management Sciences Fellow, one of the highest honours in operations research and analytics.

Rising young innovators

Four NTU scientists have been recognised in the 2024 edition of *MIT Technology Review's* Innovators Under 35 – the most from an institution in the same year. The list celebrates 35 innovators under the age of 35 who are making a significant impact in their fields across the Asia-Pacific. The NTU researchers are: **Asst Prof Prashant Kumar** of NTU's School of Materials Science and Engineering, for his groundbreaking work combining electron microscopy and chiral materials – nanostructures that cannot be superimposed on their mirror images; **Nanyang Asst Prof Leow Wan Ru** of NTU's School of Chemistry, Chemical Engineering and Biotechnology (CCEB), for her pioneering research in powering chemical reactions with renewable energy; **Asst Prof Dmitrii Ustiugov** of NTU's College of Computing and Data Science, for his cutting-edge work in designing fast, efficient cloud systems; and Lee Kuan Yew Postdoctoral Fellow **Dr Kong Xin Ying** of CCEB, for developing a novel, green organic catalyst to upcycle plastics into valuable chemicals and fuels at ambient temperatures using photocatalysis.

Outstanding authors

Three NTU faculty and alumni received the Singapore Literature Prize in 2024. **Dr Prasanthi Ram**, a lecturer at the NTU Language and Communication Centre and an NTU PhD alumnus in Creative Writing, clinched the Fiction in English prize for her work *Nine Yard Sarees: A Short Story Cycle*. **Yong Shu Hoong**, a part-time lecturer in NTU's Creative Writing programme and former writer-in-residence, won the Poetry in English prize for his poetry collection, *Anatomy of a Wave*. In the Poetry in Chinese category, **Assoc Prof Tan Chee Lay** from NTU's National Institute of Education was a joint winner for his collection, *Poems from the Eternal Summer.*



Champions of life sciences

Assoc Prof Ma Wei and **Nanyang Asst Prof Li Yinghui** were among 11 life sciences researchers who received the EMBO Global Investigator award in 2024. Presented by the European Molecular Biology Organisation (EMBO), the award supports and fosters collaboration among early-career research group leaders in Chile, India, Singapore, Taiwan and Africa.


Sustainability advocate

For her research on developing functional nanomaterials to pave the way for a sustainable and climate-resilient environment, **Prof Lam Yeng Ming** of NTU's School of Materials Science and Engineering has been named the winner of the 2024 UL-ASEAN-U.S. Science Prize for Women in the Senior Scientist category. The award celebrates female scientists who have made significant contributions to regional development and global sustainability, and who are role models in science, technology, engineering and mathematics.

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

NHG Health

Advancing AI in Healthcare

The Centre of AI in Medicine is a new research centre established by the NHG Health and Nanyang Technological University, Singapore, a young and research-intensive university ranked among the world's top universities.

The centre seeks to use innovative artificial intelligence (AI) technologies for practical applications in medicine, such as making diagnoses more accurate and personalising patient treatment.

It is supported by dedicated computing resources for the research and development of safe, scalable and clinically relevant AI. Its researchers also have secure access to Singapore's national platforms for health-related research and real-world data.

THE CENTRE'S RESEARCH FOCUSES ON:

1. Mental health
2. Frailty in the elderly
3. Medical imaging
4. Cancer screening

To find out more, visit https://www.ntu.edu.sg/c-aim or contact c-aim@ntu.edu.sg for enquiries and collaboration opportunities.

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

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Up to **S$1.5 million (US$1.1 million)** startup research grant and scholarships for hiring up to five PhD students in science, technology, engineering or mathematics

or

Up to **S$1 million (US$760,000)** startup research grant and scholarships for hiring up to two PhD students in social sciences, humanities or the arts

A dedicated White Space Fund of up to **S$250,000 (US$190,000)** as part of the startup grant

An opportunity to apply for the:

Singapore National Research Foundation Fellowship that offers a five-year research grant of up to **S$3.25 million (US$2.4 million)**

or

Social Science and Humanities Research Fellowship that offers a five-year research grant of up to **S$1 million (US$760,000)**

or

Temasek-Nanyang Assistant Professorship that offers a research grant of up to **S$500,000 (US$380,000)**, in addition to the NAP startup research grant

Application

Applications for the NAP can be submitted throughout the year. Applicants are welcome to send their CVs and other supporting documents to **nanyangprofessorship@ntu.edu.sg**.

For more information

Scan

ntu.sg/NanyangAssistantProfessorship

Email

nanyangprofessorship@ntu.edu.sg