

A[★]STAR RESEARCH

Issue 49 | September – October 2025

A LODESTAR FOR INTEGRITY

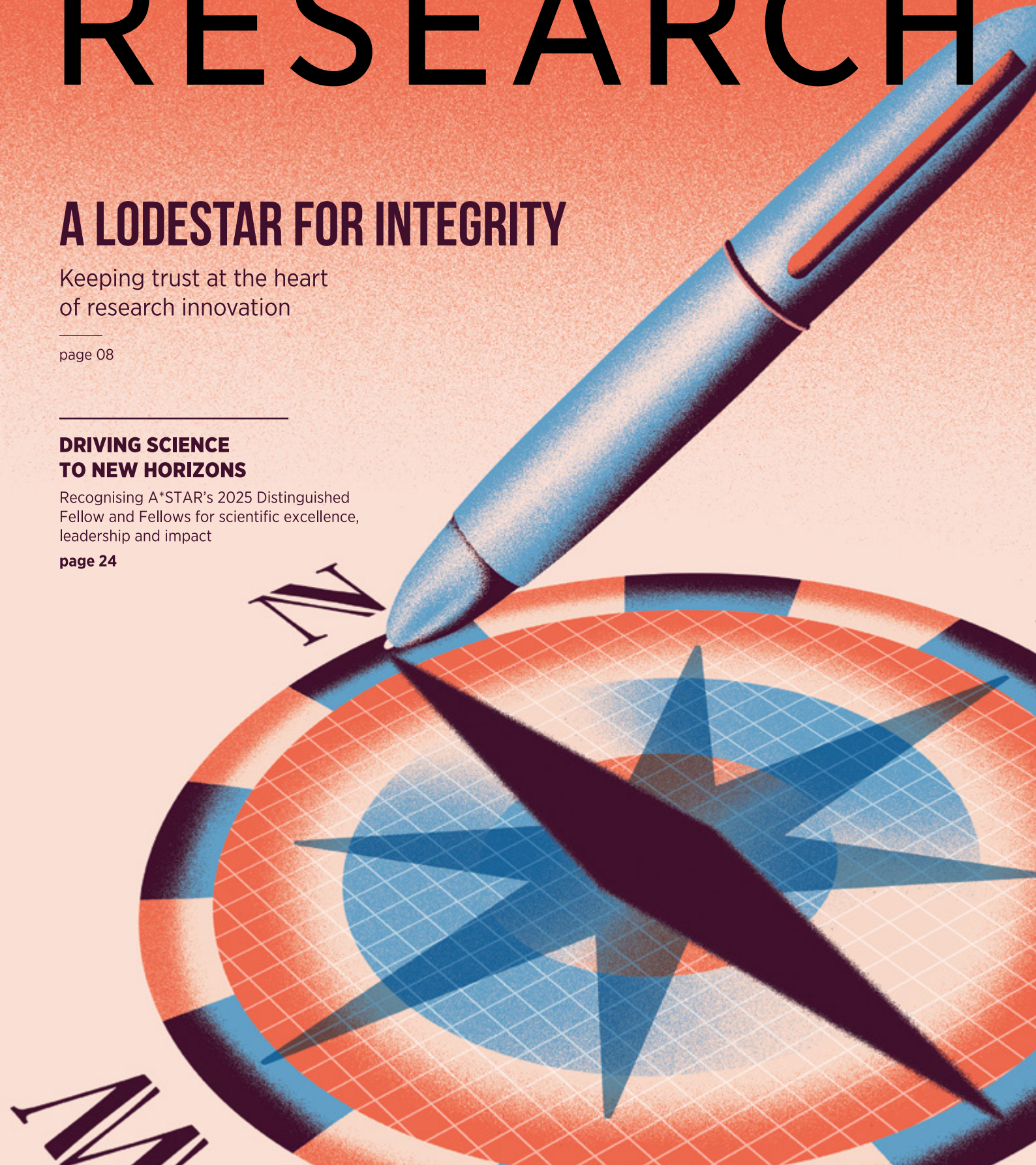
Keeping trust at the heart
of research innovation

page 08

DRIVING SCIENCE TO NEW HORIZONS

Recognising A[★]STAR's 2025 Distinguished
Fellow and Fellows for scientific excellence,
leadership and impact

page 24



A*STAR RESEARCH

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*A*STAR Research* is published bimonthly, presenting research highlights and feature articles. All articles are first published online on the *A*STAR Research* website and available free to all readers. Register online to receive our monthly e-newsletter by email.

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*A*STAR Research* is published for A*STAR by the custom media publishing unit of Wildtype Media Group Pte Ltd.

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Contents

Issue 49 | September – October 2025



EDITORIAL

03 Editorial notes

COVER STORY

08 A lodestar for integrity

FEATURE

24 Driving science to new horizons

RESEARCH HIGHLIGHTS

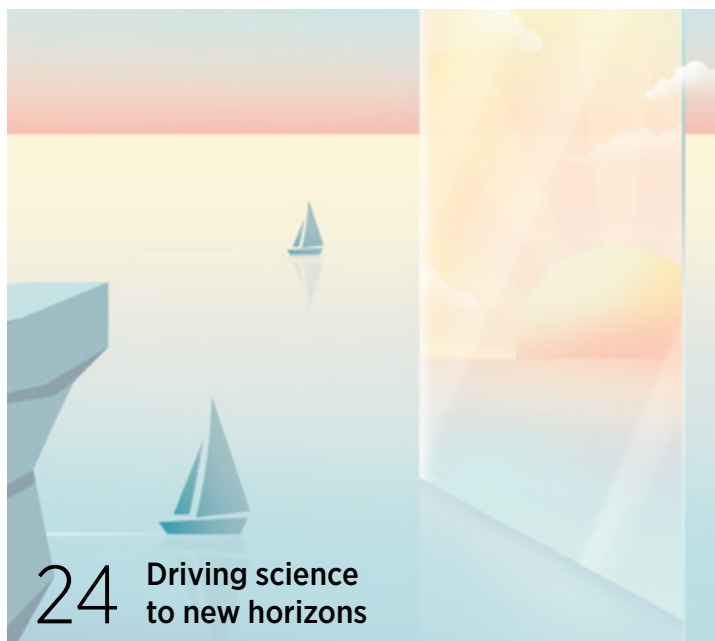
HUMAN HEALTH AND POTENTIAL

04 **Immunology:** Tired T cells get a power up

06 **Neuroscience:** Obesity genes also speak for the growing brain

07 **Bioengineering:** Unravelling sticky situations with antibodies

16 **Genomics:** Single-cell maps unveil Asia's immune diversity



Contents

Issue 49 | September – October 2025

URBAN SOLUTIONS AND SUSTAINABILITY

- 17 **Energy:** Amplifying hidden faces of aluminium batteries
- 18 **Food Science:** Digesting the difference between plant and animal proteins
- 19 **Energy:** On the wave to fusion energy

SMART NATION AND DIGITAL ECONOMY

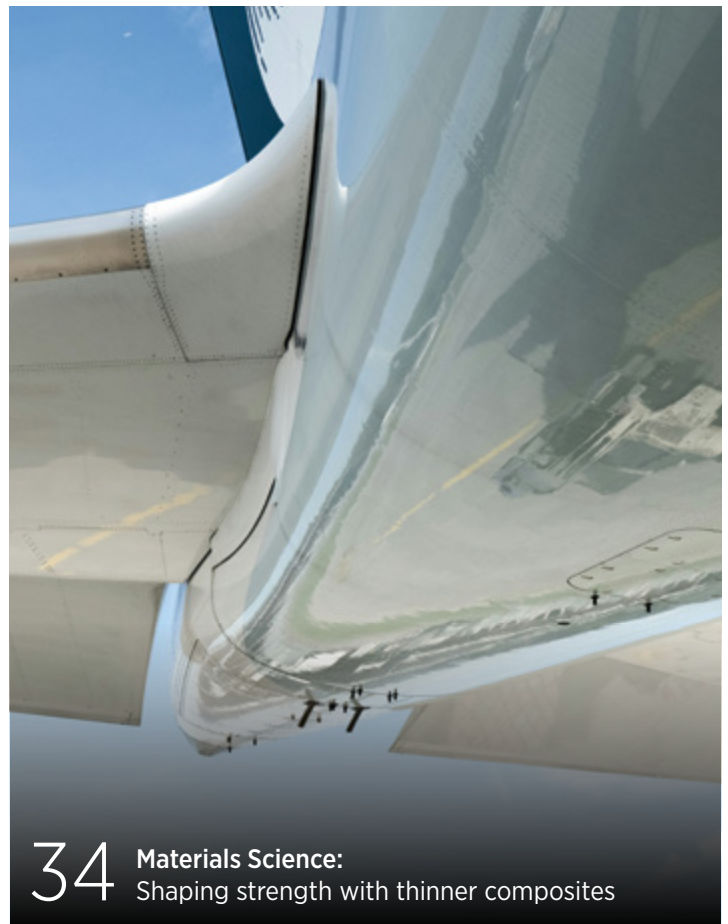
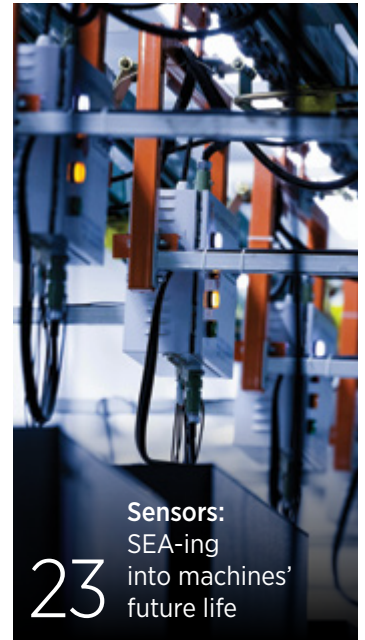
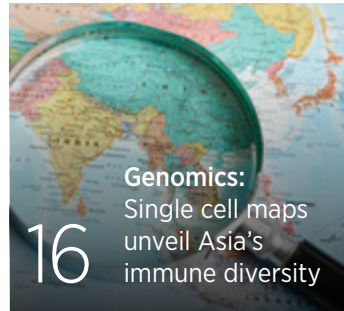
- 20 **Language Models:** A tireless friend in dementia care
- 22 **Optics and Photonics:** Rippling new colours from quantum emitters
- 23 **Sensors:** SEA-ing into machines' future life

MANUFACTURING, TRADE AND CONNECTIVITY

- 32 **Optics:** Seeing the invisible
- 33 **Materials Science:** Washing surface defects away
- 34 **Materials Science:** Shaping strength with thinner composites

NEXT ISSUE

- 36 A sneak peek at Issue 50



EDITORIAL NOTES

Bad science makes deep cuts. A 1998 paper that falsified data to link MMR vaccines and autism still ripples through public discourse today as part of a global anti-vaccination movement. In 2018, the report of a CRISPR genome editing procedure on twin human infants sparked worldwide furore and renewed debate over biomedical ethics. Yet despite these cautionary tales, the pressures scientists face today—to deliver the next big breakthrough, to produce positive results, to publish faster than rivals—can make it difficult to uphold unwavering ethical standards.

Our cover story this issue, 'A lodestar for integrity (p. 08)', lays out the ongoing discussions around research integrity and the evolving safeguards that preserve it. We speak to leading voices from A*STAR institutes and offices, national advisory committees, and international journals and conferences for their insights on the frameworks that can shape a culture of responsible scientific practice.

In a special extended feature, we highlight the recipients of the 2025 A*STAR Fellowships. In 'Driving science to new horizons (p. 24)', we speak to the 10 recipients of these grants about the questions that drew them to their fields and the challenges their teams aim to tackle in the future.

This issue also spotlights recent scientific developments from A*STAR research institutes and their collaborators—from a groundbreaking new atlas of human immune cells among Asian populations to an advanced modelling approach in next-generation aircraft engineering. Explore the full stories in 'Single cell maps unveil Asia's immune diversity (p. 16)' and 'Shaping strength with thinner composites (p. 34)'.

For more of the latest developments from A*STAR researchers, visit our website at research.a-star.edu.sg. You can also stay up-to-date by following us on X/Twitter at [@astar_research](https://twitter.com/astar_research), LinkedIn at [A*STAR Research](https://www.linkedin.com/company/astar-research) and Telegram at [A*STAR Research](https://t.me/astar_research).



On the cover

A compass needle created by a pen's shadow symbolises how research integrity forms a guiding direction for science.



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IMMUNOLOGY

Tired T cells get a power up

Targeting a key gene can help prevent the body's immune fighters from wearing out when attacking tumour cells, offering a new treatment strategy against cancer.

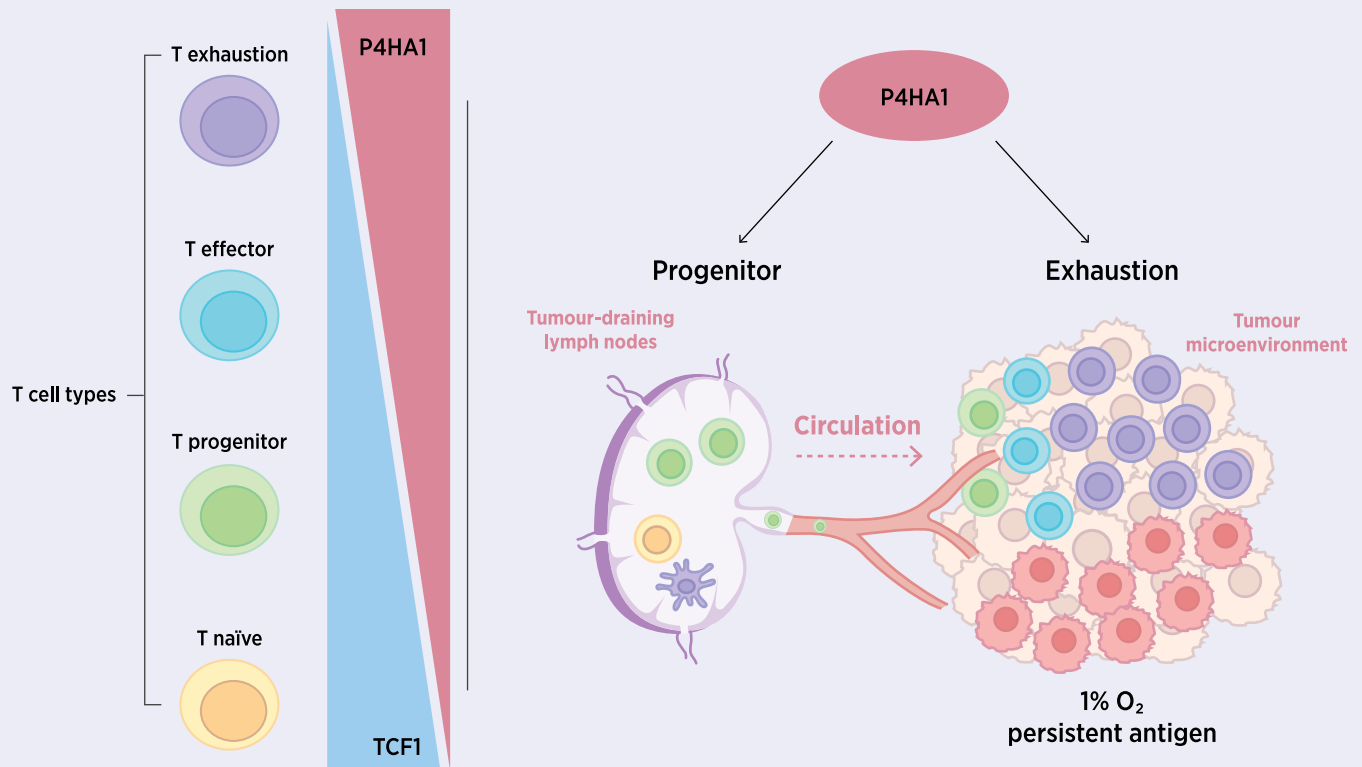
Like weary soldiers at the frontlines, the main fighters of our immune system—T cells—inevitably become exhausted from battling cancer cells in a harsh tumour microenvironment.

When T cells tire out, solid tumours such as breast and colon cancers get the opportunity to fight back and grow again. As a result, patients receiving immunotherapy—which normally galvanises immune cells to attack tumours—can end up not responding to treatment, or relapsing in the long run.

“Most research has focused on activating T cell killing capacity, but does not address preventing T cell exhaustion and keeping T cells in a younger, more resilient state over time,” said Qiang Yu, a Senior Group Leader at the A*STAR Genome Institute of Singapore (A*STAR GIS).

In search of ways to minimise T cell exhaustion, Yu teamed up with colleagues from the A*STAR Institute of Molecular and Cell Biology (A*STAR IMCB); Nanyang Technological University and Tan Tock Seng Hospital in Singapore; the University of Southern Denmark;

Photo credit: Vink Fan / Shutterstock



Graphical abstract of how P4HA1 induction promotes the differentiation of CD8⁺ T cells into exhausted cells in the microenvironments of solid tumours.

and the Sixth Affiliated Hospital of Sun Yat-sen University, China.

By analysing tumour samples and genetic data from patients, the researchers found that high expression of a gene called *P4HA1* was strongly associated with poor T cell formation and weaker responses to immunotherapy. The corresponding P4HA1 protein plays an important role in the energy system of T cells, and in cancers, pushes these immune cells toward exhaustion.

“The uniqueness of P4HA1 lies in its dual effect: blocking P4HA1 reduces T cell exhaustion and promotes the generation of long-lasting T cell progenitors, which are crucial for maintaining long-term anti-tumour immunity,” said Yu.

When the team inhibited P4HA1 in mice, T cells stayed active and healthy for a longer time, effectively shrinking the formerly treatment-resistant tumours. Besides strengthening the immune

response, P4HA1 inhibition also enhanced the effects of CAR-T cell immunotherapies by making these special T cells more effective at attacking cancer cells.

The team also found that P4HA1 could serve as a non-invasive biomarker, given that high P4HA1 levels in the blood appeared to be an early predictor of tumour relapse. According to Yu, a simple blood test might in the future be used to identify patients who are more or less likely to respond to immunotherapies, allowing for interventions like adding P4HA1 inhibitors in the treatment regimen.

Looking to translate their findings into clinically applicable solutions, the researchers are now developing P4HA1-targeting drugs that are effective and safe. “By targeting P4HA1 before or during treatment, we can reprogramme T cells to last longer and fight harder,” Yu said, adding that this strategy may

help to improve the efficacy of existing immunotherapies and help overcome treatment resistance in solid tumours. ★

Researcher

Qiang Yu,
A*STAR GIS



IN BRIEF

Inhibiting the *P4HA1* gene has the dual effect of mitigating T cell exhaustion and promoting long-term anti-tumour immunity, which could help improve patient responses to cancer immunotherapies.

1. Ma, S., Ong, L.-T., Jiang, Z., Lee, W.C., Lee, P.L. *et al.* Targeting P4HA1 promotes CD8⁺ T cell progenitor expansion toward immune memory and systemic anti-tumor immunity. *Cancer Cell* **43** (2), 213-231 (2025).

NEUROSCIENCE

Obesity genes also speak for the growing brain

An early childhood study reveals that some genetic roots of obesity may also be linked to language-related neurodevelopment.

An early grasp of language can shape a child's life. Toddlers with stronger language abilities tend to perform better in school, have sharper cognitive functions, and even be at reduced risk of psychosocial disabilities and Alzheimer's disease in later years.

A key biological driver behind language development is brain myelination: the insulation of nerve fibres with lipid-rich sheaths that help signals travel efficiently. While various genetic and lifestyle factors seem to affect myelination, researchers have noted links between childhood obesity and poorer neurocognitive functions, including language abilities.

But is obesity a cause of developmental differences, or a sign of them? "Both childhood obesity and language development are shaped by early-life social conditions," said Jian Huang, a Senior Scientist at the A*STAR Institute for Human Development and Potential (A*STAR IHDP). "These shared factors make it hard to disentangle whether the associations are due to obesity itself, or to the environment in which both obesity and language development arise."

To cut through the noise, a multi-institutional team including Huang and A*STAR IHDP colleagues investigated how genetically predicted obesity might shape speech and language skills in growing children. The team included researchers from the A*STAR Bioinformatics Institute (A*STAR BII); the National University of

Singapore, KK Women's and Children's Hospital, the National University Hospital, and Duke-NUS Medical School in Singapore; as well as institutes from the UK and Canada.

The Growing up in Singapore Towards Healthy Outcomes (GUSTO) cohort study team collected a wide range of data and biological samples from about 1,000 children during different developmental stages. They leveraged genetic, proteomic, brain imaging and language development data to investigate the connection between obesity-related genetics and language development.

To calculate polygenic risk scores (PRS) for obesity—an estimate of genetic predisposition towards a higher body mass index—the team used a trans-ancestry approach. This approach took advantage of genome-wide association studies from both European and Asian populations in order to improve the accuracy of risk scoring in the multi-ethnic GUSTO cohort.

A series of genetic analyses found that GUSTO children with higher obesity PRS, particularly boys, scored lower on language tests at ages four and nine. Using Mendelian randomisation—a method for testing causality with genetics—the team suggested that obesity itself was unlikely to cause weaker linguistic skills. Instead, the two traits appeared to share genetic roots.

To examine the underlying molecular mechanisms, the researchers examined the blood levels of 92 neurology-related

proteins alongside language-related, MRI-based brain microstructures. One protein, ephrin-A4 (EFNA4), stood out: higher levels of EFNA4 were tied to higher obesity PRS. EFNA4 expression was also associated with language ability and fractional anisotropy of language-related white matter tracts, suggesting a role in brain myelination. The expression of the EPH-ephrin molecular pathway, which involves EFNA4, was also associated with lower language scores in boys.

"This suggests that metabolic and neurodevelopmental health are intertwined at the biological level," said Huang. "There are shared genomic pathways that influence both obesity risk and language development through processes such as the EPH-Ephrin signalling pathway, which regulates brain myelination." ★

Researcher
Jian Huang,
A*STAR IHDP



IN BRIEF

Genetic, proteomic and MRI analyses of GUSTO cohort children show that obesity polygenic risk and early linguistic skills share genetic roots, implicating the ephrin-A4 protein and EPH-ephrin molecular pathway in brain myelination.

1. Huang, J., Che, J., Kee, M.Z.L., Tan, A.P., Law, E.C., *et al.* Linking obesity-associated genotype to child language development: the role of early-life neurology-related proteomics and brain myelination. *eBioMedicine* **113**, 105579 (2025).

Photo credit: icomp / Freepik

BIOENGINEERING

Unravelling sticky situations with antibodies

New insights into stress-related antibody clumping may pave the way for improved biotherapeutics production methods.

Monoclonal antibodies (mAbs) are often regarded as a triumph of modern biopharmaceuticals. Inspired by human-produced antibodies, these lab-engineered proteins are designed to home in on specific molecular targets in the body. This precision enables mAbs to flag cancer cells for destruction, block viruses from infiltrating cells, or deliver drugs directly to tumour sites.

Yet, despite their therapeutic promise, turning mAbs into stable and safe drugs at scale is no easy feat. Along the manufacturing pipeline, mAbs are prone to clumping under stress, which can compromise their purity, safety and efficacy.

At the A*STAR Bioprocessing Technology Institute (A*STAR BTI), Principal Scientist Ian Walsh and Senior Scientist Sean Chia of the Analytical Science & Technologies (GlycoAnalytics) group are investigating the complexities of mAb clumping.

“The main challenge in understanding antibody aggregation is heterogeneity. Antibody clumps can vary widely in size and structure, appearing at distinct manufacturing stages. Their form can further change depending on the stress induced from manufacturing conditions,” Chia said.

To address this sticky situation, Walsh, Chia and A*STAR BTI colleagues used a combination of laboratory experiments and theoretical modelling to study how

mAbs behave under stressors commonly encountered during manufacturing conditions, particularly elevated temperatures and acidic pH levels.

“Studying stress conditions in isolation allows us to accurately measure their effects on antibody stability, but in real-world manufacturing, antibodies are usually exposed to a combination of stresses rather than isolated ones,” explained Walsh.

Testing these stress conditions in combination revealed that heat and acidity did not act independently, but interacted to influence how—and when—mAbs began to clump. Using transmission electron microscopy to examine structural changes at the subcellular level, the researchers found that adjusting either factor altered the aggregates’ size and structure in varying ways, pointing to different underlying mechanisms.

Digging deeper, they found that more acidic conditions led mAbs to unfold, causing them to lose their functional structure and become more prone to aggregation. Meanwhile, higher temperatures encouraged existing aggregates to clump into larger clusters.

To better track and quantify these microscopic events, the team turned to mathematical modelling, using a model that best described the experimental data points. “This allowed us to estimate how quickly each step occurred in the aggregation process and revealed the overall rate of clumping,” said Chia.

Chia and Walsh believe their framework could help biopharmaceutical companies better predict how antibodies behave under various stress conditions, informing smarter mAb formulation and manufacturing strategies.

Looking ahead, the team plans to explore how aggregation differs across complex antibody types. By pinpointing stress-sensitive steps, the researchers hope to design aggregation-resistant formulations and advance the development of safe, stable mAb-based therapeutics. ★



Researchers

Sean Chia and Ian Walsh,
A*STAR BTI

IN BRIEF

By combining laboratory experiments with kinetic modelling, researchers map how monoclonal antibodies aggregate under varying levels of heat and acidity, offering a quantitative framework to guide drug manufacturing strategies.

1. Meng, K.H., Pang, K.T., Wan, C., Zheng, Z.Y., Beiyang, Q., *et al.* Thermal and pH stress dictate distinct mechanisms of monoclonal antibody aggregation. *International Journal of Biological Macromolecules* **282**, 136601 (2024).

A LODESTAR FOR INTEGRITY

From biomedical research to generative AI models, scientific progress depends on strong ethical standards that maintain integrity, transparency and accountability.

While it seems straightforward to expect researchers to conduct responsible and rigorous science, they actually face many complex considerations and potential pitfalls throughout the process. These include adhering to ethical standards for animal welfare; devising data management structures for accessibility and reliability; navigating the many methods for statistical analysis; and managing the peer pressure to publish results in high-impact journals.

“These considerations can sometimes cause researchers to overlook research ethics, leading to data falsification, selective result reporting, insufficient checks on the reliable reproduction of findings, or other actions that undermine trust in science,” said Huck Hui Ng, Assistant Chief Executive for Research and Talent Development at A*STAR.

While data falsification or plagiarism are widely recognised as clear examples of research misconduct,





the lines of ethical conduct can blur in other situations. How far should pain be simulated for research, especially with animal models? Who is liable when risk mitigation protocols fail in human biomedical research (HBR)? If a lead researcher learns from unpublished data that a trainee's project is unviable, how do they balance their obligations of confidentiality and mentorship?

"The rise of generative artificial intelligence (AI) also brings a new set of opportunities in science, but also ethical considerations," Ng added. "Used carelessly, AI may introduce inaccuracies and blur the boundaries of ownership of generated materials, raising questions about the credibility, originality and authenticity of research works."

Issues such as these need clear guidelines and open conversations, with policies that can evolve in tandem with research questions and technological changes. Systemic checks and balances are also vital to sustaining scientific progress while upholding standards of integrity.

As Singapore's lead public sector R&D agency, A*STAR has a duty to establish standards for research integrity. "It is crucial to foster a research culture that values rigour and responsible conduct alongside impact and innovation," said Ng.

A CULTURE OF RESPONSIBLE RESEARCH

Broadly speaking, research *integrity* entails a commitment to honesty, accuracy, accountability and transparency. However, turning words into actions requires a steady 'North Star' by which to judge a fair and right direction. Research *ethics* provides that compass; a guiding set of values that helps set boundaries and clarify definitions so that all parties are aligned when distinguishing responsible from potentially harmful practices.

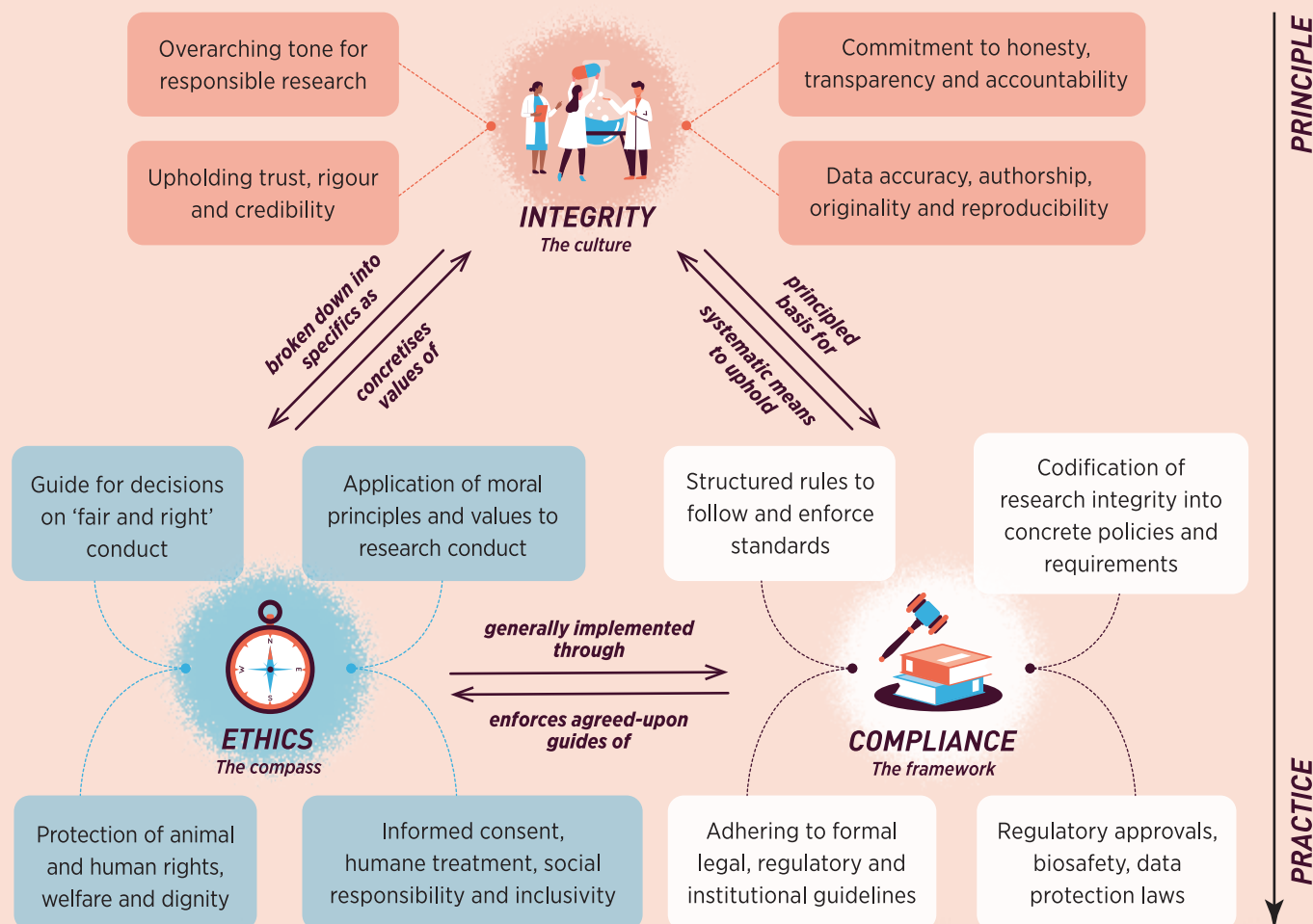
With ethics in place, research integrity can then be codified through compliance frameworks overseen by institutional bodies and regulatory authorities. Adherence to these guidelines

helps researchers better navigate grey areas in day-to-day situations, uphold accountability and strengthen the credibility of their work. By monitoring research projects throughout their lifecycle, institutions can also identify gaps and potential risks early, enabling timely interventions.

"A*STAR continually refines and updates its research integrity policies, procedures and guidelines to provide researchers with clear steps and actionables in this area," said Ng.

He added that A*STAR proactively empowers its researchers through new tools and resources, citing the recent rollout of mandatory image integrity checks, ongoing research integrity-related workshops and internal newsletters with real-life case studies of responsible science in action.

RESEARCH INTEGRITY: FROM PRINCIPLE TO PRACTICE





“A*STAR continually refines and updates its research integrity policies, procedures and guidelines to provide researchers with clear steps and actionables in this area.”

— Huck Hui Ng, Assistant Chief Executive for Research and Talent Development at A*STAR

Within A*STAR, additional guidelines are implemented on a domain-specific level, with Institutional Review Boards (IRB) providing more support for each research project's contextualised needs. IRBs are heavily involved in reviewing proposed projects, taking into account all relevant ethical, regulatory, legal and institutional standards before greenlighting any studies to commence. When animal models are involved, research teams must also get approval from the relevant Institutional Animal Care and Use Committee (IACUC).

Ethics evaluations from institutional committees are also aligned with guidelines established by national advisory committees, such as the Bioethics Advisory Committee (BAC), the Genetic Modification Advisory Committee (GMAC) and the National Advisory Committee on Laboratory Animal Research (NACLAR). In turn, these national guidelines anchor their legal basis in governmental policies; for example, GMAC's Biosafety Guidelines reference the Ministry of Health's Biological Agent and Toxins Act, which emphasises the consideration of containment measures and health, both environmental and human, when dealing with genetically modified samples.

“Innovation and responsibility must go hand in hand,” said Yan Hong, GMAC Chair. “Our Biosafety Guidelines provide a structured way for researchers to address biosafety concerns while pursuing new scientific frontiers in genetic modification (GM). With a commitment to risk assessment, safety measures, and transparency, such safeguards can help researchers maintain both scientific rigour and public confidence in research outcomes.”

IN PRACTICE: A*STAR SKIN RESEARCH LABS (A*STAR SRL)

At A*STAR SRL, every HBR project undergoes thorough evaluation to ensure that the involvement of human subjects or the use of human-derived material can be justified. This entails a well-designed study that has clearly stated objectives, uses well-established methods, and is expected to bring relevant and reliable results, explained María del Mar Álvarez Villamandos, an A*STAR SRL Senior Research Officer (Human Biomedical Research) and Clinical Research Coordinator.

Moreover, A*STAR SRL researchers must carry out an equitable recruitment process and obtain truly informed consent from all participants. Under the A*STAR SRL HBR Committee's guidance, research staff participate in training sessions and workshops to understand their responsibilities and keep biomedical ethical standards top of mind when conducting HBR.

“We consistently promote the attitude that the Committee is a useful asset to assist with study design and compliance, and that it acts as a helpful colleague to guide researchers in designing and executing better scientific studies,” said Álvarez Villamandos.

THE AI CONUNDRUM

In an ideal world, societies would adopt new technologies only after ethical standards of use have been established. AI is no exception, especially with generative AI models becoming more advanced and publicly accessible. Yet the growing contention around AI governance in science long predates ChatGPT's rise to fame—from models that deal with sensitive clinical information for disease diagnostics, to those that can influence supply chain logistics and other critical infrastructure systems.

Partly due to the nature of data gathered and given to algorithms, one persisting issue in the field is bias in AI models, whether in the form of reinforcing cultural stereotypes or underrepresenting certain identities and societal groups.

"Previous studies have observed that around 26 percent of GPT-4 outputs echo gender stereotypes, such as associating nursing with women and leadership roles with men," said Jie Zhang, Research Scientist at the A*STAR Centre for Frontier AI Research (A*STAR CFAR) and A*STAR Institute of High Performance Computing (A*STAR IHPC). "We also noted that the limited representation of diverse gender identities could contribute to recognition gaps in AI-generated content."

While diversity and inclusion have become part and parcel of good scientific practice, it takes a conscious effort to unlearn biases. In much the same way, counteracting biases in AI models may require additional training or data augmentation, added Zhang.

In an effort to debias AI models, Zhang and team recently developed the GenderCARE framework in collaboration with Nanyang Technological University, Singapore and the University of Science and Technology of China. After identifying the limitations of existing AI benchmarks for bias, they established six criteria—diversity, inclusivity, explainability, objectivity, robustness and realisticness—that aligned with global AI governance and gender equality standards. The framework draws inspiration from the US National Institute of Standards and Technology's criteria on trustworthy AI and the White House's National Gender Equality Strategy. These principles were implemented through a combination of counterfactual data augmentation and low-rank adaptation fine-tuning strategies, with clear metrics to quantify the extent of bias.

"Artificial intelligence cannot fulfil authorship criteria; it cannot be held accountable for what has been done or written, which is a key author responsibility."

— Magdalena Skipper,
Editor in Chief of *Nature*

Photo credit: Ian Alderman



"Our experiments show that these two approaches reduce gender bias while preserving overall model performance, proving that debiasing and computing capability can be balanced," Zhang said. Through transparent, benchmark-driven evaluations and compliance with AI governance frameworks, the team believes that more inclusive models can be designed that challenge stereotypes rather than echo them.

The ethical impacts of generative AI have been especially palpable in scientific publishing. Although issues of plagiarism and data manipulation are longstanding, generative AI has the potential to change the speed, scale and sophistication by which such issues arise, commented Ng.

"It is vital to raise awareness among the research community about AI ethics and the importance of transparency and ownership over content generation," said Ng. "Moreover, proactive safeguards and digital tools are key to prevent AI misuse and conduct integrity checks. Responsible AI adoption with robust safeguards will help us stay ahead of the curve while embracing the opportunities it presents."

Internationally established journals have also issued guidelines on the incorporation of AI tools, including their ineligibility to be considered as co-authors, according to Magdalena Skipper, Editor in Chief of *Nature*.

“AI cannot fulfil authorship criteria; it cannot be held accountable for what has been done or written, which is a key author responsibility,” explained Skipper, who added that AI-generated images are also prohibited for similar reasons. “The appropriate use of AI tools, and the disclosure thereof—whether for hypothesis generation, creation of synthetic data, paper compilation or anything else—lies at the heart of doing research with integrity.”

TRANSPARENCY BREEDS TRUST

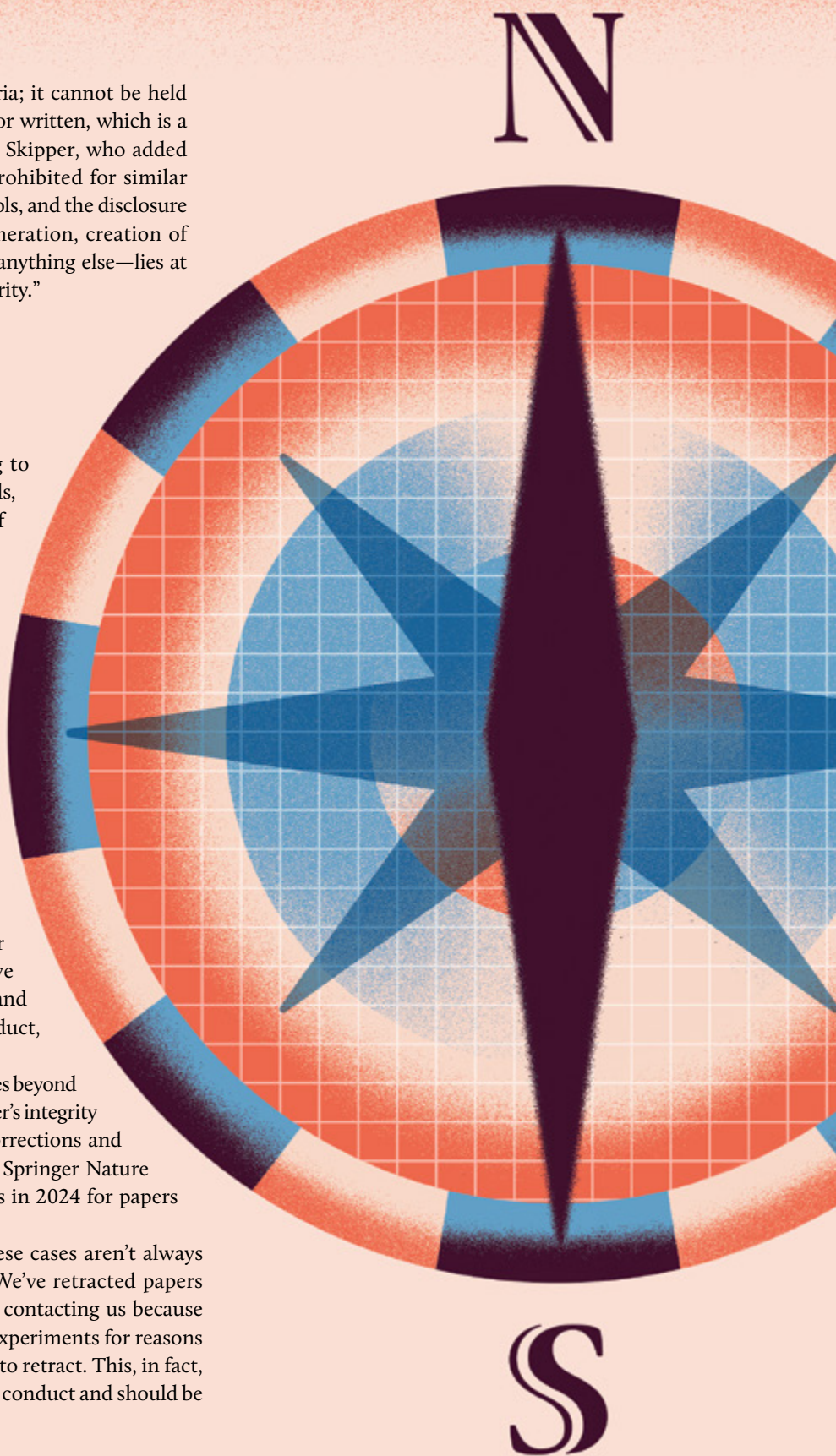
While digital tools are now helping to detect falsified or manipulated materials, the primary defence against breaches of integrity remains human judgement, noted Ng.

Skipper added that this is especially evident in the publishing process, where rigorous peer review serves to evaluate whether a study’s conclusions are backed by the data presented, and to offer new ideas that solidify its research story.

“Prior to a paper’s acceptance for publishing, we work with authors to ensure that the work they’ve done is transparently described, and the relevant data and code are shared in an appropriate way,” said Skipper. “Over the years, we’ve developed extensive guidelines on sharing materials, data and code; as well as ethical codes of conduct, including ethical co-authorship.”

A critical examination of science goes beyond publication; the strongest tests of a paper’s integrity may come after its public release. Corrections and retractions are not uncommon, with Springer Nature reporting over a thousand retractions in 2024 for papers published after January 2023.

“It’s worth remembering that these cases aren’t always tied to misconduct,” said Skipper. “We’ve retracted papers as a result of the authors themselves contacting us because they can no longer repeat their own experiments for reasons they don’t understand, and now wish to retract. This, in fact, is an example of appropriate scientific conduct and should be acknowledged as such.”



“Outreach makes science more accessible to the general public and conveys why it’s important, how risks are managed and what safeguards are in place.”

— Yan Hong, Chair of the Genetic Modification Advisory Committee (GMAC)



Ng echoed this sentiment, highlighting that openness around errors and failures is key to advancing science and maintaining accountability.

“Rather than seeing retractions and corrections as stains on one’s records, they should be recognised as opportunities for collective learning,” said Ng. “Approached constructively, they serve as reminders that science is a self-correcting endeavour. Transparency is central to that process.”

Such transparency is critical to maintaining trust, not only within the scientific community but also from the public at large. For research to be considered as a self-correcting engine, Skipper believes that failures or so-called ‘negative’ results in science are as important to talk about as success stories.

Public-facing communication about how science is done can also effectively strengthen transparency and encourage societal acceptance over emerging technologies such as gene therapies and AI. Engagements with the broader community offer researchers and regulators a chance to highlight the ethical standards and safety frameworks that govern what they do, improving their credibility and creating a sense of accountability by the scientific ecosystem toward public good.

“Outreach makes science more accessible to the general public and conveys why it’s important, how risks are managed and what safeguards are in place,” noted Hong.

At GMAC, for instance, various initiatives are underway to promote a greater understanding of GM and dispel misconceptions around it. Educational materials and guidelines are regularly published on the GMAC website; the GMAC Students Challenge gives younger generations a chance to brainstorm creative GM applications; and regular seminars and interviews allow GMAC to discuss its work and the importance of a ‘safety first’ mindset in GM-related research.

Such efforts can also help facilitate dialogues between the public and regulatory authorities regarding the adoption of innovations into existing systems, such as healthcare or manufacturing, as well as policy evaluations for research and associated compliance frameworks.

“At its core, science is a human endeavour, and so we must constantly remind ourselves why is it that we do research and want to communicate its results,” said Skipper.

INTEGRITY IN COLLABORATION

As research integrity is an indispensable element throughout the scientific life cycle, it must be coordinated on multiple levels that run from the individual to the international. Given the increasingly global and interdisciplinary nature of research today, opportunities for meaningful exchange and cooperation are necessary to make sure all involved parties are aligned during the conduct of any study and are actively complying with all established ethical guidelines.

The foremost drivers of global-regional-local synergies are international coalitions such as the World Conferences on Research Integrity Foundation (WCRI) and the Asia Pacific Research Integrity (APRI) Network. Meanwhile within Singapore, A*STAR collaborates with universities in providing similar opportunities through events such as the Singapore Institutional Research Integrity Offices Network (SIRION) Research Integrity Conference.

Within these associations and conferences, attendees from academia, industry, publishing and government transcend titles and disciplines to participate as individuals with a common ground to advocate for good scientific practice, discuss issues observed in their own work and share perspectives with those who have tackled similar cases.

“WCRI has emerged as a very important platform in sharing best practices for tackling research integrity issues,” said Mai Har Sham, Pro-Vice-Chancellor of

The Chinese University of Hong Kong and a governing board member of WCRI. “It also generates a voice, because each conference often leads to a statement or set of guidelines that can help the scientific ecosystem as a whole.”

While training is key to prevent incidents of misconduct, Sham noted that a culture of responsible research also needs suitable monitoring measures, such as periodic reviews and spot-checks to help encourage compliance with research ethics approvals. This can be particularly relevant in work involving animal models or human patients; for example, external regulatory authorities or internally designated safety officers might visit labs occasionally to ensure that all experiments are well-documented and following approved protocols.

“Any institute must have systems in place so that researchers know that the institute cares about integrity,” said Sham. “It’s not about policing colleagues, but enforcing a sense of accountability towards doing good, safe and trustworthy science.”

In a similar view, Ng suggested that research bodies could also appoint institutional stewards of research integrity. Such a practice is already in place within A*STAR, where scientists appointed as Research Integrity Ambassadors offer peer support and insight, especially for complex issues.

“As a Research Integrity Ambassador, I help to distribute relevant information to scientists within my research institute, thereby providing a link between research groups and the central A*STAR Research Office,” explained Jonathan Göke, a Principal Scientist at the A*STAR Genome Institute of Singapore (A*STAR GIS). “If any concerns are raised, I can provide an independent opinion.”

Such support can build more open and credible environments within research groups and institutions, as well as in collaborations across sectors. The insights provided can be particularly helpful for trainees and junior scientists, as they may not always have the confidence—or power—to decide how best to approach an issue, or to speak up when potential ethical breaches arise.

“For science to be truly transformative, it must be rigorous and trustworthy,” remarked Ng. “The foundation for a culture of excellent science rests on our ability to equip researchers with the knowledge and tools to responsibly conduct research with integrity.” ★



GENOMICS

Single-cell maps unveil Asia's immune diversity

A groundbreaking multinational atlas of the body's frontline defenders reveals hidden variations that could enhance precision health efforts worldwide.

Just as food and climate vary by location, so do our immune systems. Pollen allergies may be common in one country, yet rare in another; an identical rash in two people might be caused by different local species of dust mites. However, our present-day understanding of human immunity comes largely from data drawn from European populations, leaving many others underrepresented.

A sweeping new survey of immune diversity stands to change that. An international research consortium has recently published the Asian Immune Diversity Atlas (AIDA): a comprehensive immune reference map of multinational Asian populations. Comprising the single-cell RNA sequences of around 1.2 million circulating immune cells from 619 donors, AIDA charts—in molecular detail—how age, sex and ancestry shape healthy immune cell behaviour across seven population groups in five countries.

"The question we sought to answer with AIDA was: how different are we from each other at an immunological level?" said Shyam Prabhakar, Associate Director of the A*STAR Genome Institute of Singapore (A*STAR GIS). "Those differences can shape what counts as 'normal' or a 'healthy

baseline' when diagnosing disease, as well as optimal drug choices and doses."

The effort united researchers across Asia, including Assistant Director Jay W. Shin and Senior Scientist Kian Hong Kock of A*STAR GIS; Woong-Yang Park of the Samsung Genome Institute, South Korea; Varodom Charoensawan and Ponpan Matangkasombut of Mahidol University, Thailand; Partha Majumder of the John C. Martin Centre for Liver Research and Innovations, India; and dozens of others from institutes in India, Japan, Singapore, South Korea, Thailand and the US. Prabhakar, Shin and Park are cofounders of the AIDA consortium, which commenced during Shin's tenure at RIKEN, Japan.

AIDA uncovered many genetic variants, common in Asia but rare elsewhere, which affect immune cells and are linked to differences in disease risk. These included rs2230500, a rheumatoid arthritis-linked variant that AIDA correlated with the expression of a hypoxia-related gene.

"We've also found the pervasive effects of sub-continental diversity on a range of traits, such as variations in cellular abundance or gene expression patterns between Singapore's ethnic communities," said Shin.

"AIDA shows that 'Asians' cannot be treated as a single group; there are meaningful biological differences."

Some discoveries were especially unexpected, such as how South Korean donors had significantly lower levels of regulatory T cells—a cell type vital for preventing autoimmune issues—compared to other AIDA cohorts. Age and sex differences also manifested differently across populations; for example, the abundance of CD4⁺ T naïve cells—a cell type implicated in autoimmune diseases such as lupus—shifted differently with age in South Korean, Singaporean Chinese and Singaporean Malay donors.

"Our findings suggest that reference ranges for immune cells need to account for multiple dimensions of human diversity, including sex, age and self-reported ethnicity," said Kock.

The team hopes AIDA will support next-generation clinical diagnostics by pinpointing disease-related cell subtypes, states and gene expression patterns. "AIDA also provides a blueprint for global precision medicine efforts," said Prabhakar. "We're continuing to add new populations and expand into new analyses, such as ageing-related changes, to close research gaps and extend healthspans worldwide." ★



Researchers

Shyam Prabhakar, Jay W. Shin
and Kian Hong Kock,
A*STAR GIS

IN BRIEF

The Asian Immune Diversity Atlas integrates single-cell RNA sequence data from 619 donors across five countries, uncovering population-specific baselines, genetic variants and molecular signatures that could reshape clinical diagnostics and precision medicine.

1. Kock, K.H., Tan, L.M., Han, K.Y., Ando, Y., Jevapatarakul, D., *et al.* Asian diversity in human immune cells. *Cell* **188** (8), 2288-2306.e24 (2025).

ENERGY

Amplifying hidden faces of aluminium batteries

A closer look at aluminium battery electrolytes sheds light on the complex mechanics that set them apart from lithium-ion systems.

What if the stuff of soft drink cans could also power our smartphones? Materials researchers today are exploring that very prospect. In many ways, aluminium (Al) shines as a candidate for rechargeable battery parts: it's abundant, lightweight, highly recyclable, and can potentially store more energy by weight compared to today's lithium-ion (Li-ion) systems.

However, that potential still faces some technical challenges. "Aluminium battery (Al-battery) research is largely still in its infancy due to the dearth of suitable Al-based electrolytes, particularly non-aqueous ones," said Zhi Wei Seh, a Senior Principal Scientist II at the A*STAR Institute of Materials Research and Engineering (A*STAR IMRE).

One reason behind that dearth is that most battery research has focused on the electrochemistry of 'simple' metal ions, while Al-batteries involve more complex molecules and reactions. Simply swapping out lithium for aluminium in a conventional battery system can lead to poor performance or even safety risks, with some unexpected reactions causing electrodes to collapse for undefined reasons.

To shed more light on Al-battery mechanics, Seh and A*STAR IMRE colleagues launched a joint investigation with A*STAR Institute of High Performance Computing (A*STAR IHPC) Principal Scientist Man-Fai Ng and colleagues, as well as Babak Anasori of Purdue University in the US; Hui Ying Yang of the Singapore University of Technology and Design; and their respective teams. Together, they focused on two deep eutectic solvents (DES) currently in common use as Al-battery electrolytes: namely, urea/ AlCl_3 and EMImCl/ AlCl_3 .

"DES are a new class of non-aqueous electrolytes that have been indicated to potentially enable room-temperature rechargeable Al-batteries (RABs), making them a worthwhile research target," said Seh.

Key tools in the team's study were MXenes: materials with similar structures as carbon-based graphene, but containing other transition metals and chemical groups. Seh explained that by using two different MXenes as electrodes,

the team could uncover and amplify any unexpected electrochemical side effects that may not have been apparent with graphite or other conventional battery materials.

The team uncovered a range of previously-unreported DES features, including that chloroaluminate (AlCl_4^-) ions in DES could potentially react with the halogen surface terminations on MXenes, forming unwanted byproducts. They also found that while EMImCl/ AlCl_3 had a high coulombic efficiency—a measure of a battery's rechargeability—compared to urea/ AlCl_3 , the former was much more irreversible and unstable as an electrolyte.

"From a macro perspective, our work also highlighted the large disparity between Al-battery and existing battery chemistries, particularly when trying to achieve a good room-temperature RAB," said Seh. "Audacious attempts towards system understanding and manipulation will be needed in this field."

Seh added that the study marks a first step towards understanding the limitations of irreversibility, side reactions and electrochemical instability in existing DES Al-battery electrolytes. Moving forward, Seh's team plans to use MXenes for similar studies of unexpected processes or intrinsic characteristics in other battery systems. ★

Researcher
Zhi Wei Seh,
A*STAR IMRE



IN BRIEF

Electrochemical studies of aluminium batteries with two deep eutectic solvent electrolytes and MXene electrodes showcase their differences in coulombic efficiencies, reversibility and stability, as well as previously hidden side reactions.

1. Lieu, W.Y., Thakur, A., Kumar, S., Li, Y., Li, X.L., et al. Amplifying the differences in aluminum-based eutectic electrolytes through electrodeposition on MXenes. *Advanced Functional Materials* **34**, 2408959 (2024).

FOOD SCIENCE

Digesting the difference between plant and animal proteins

A study of animal and plant-based meats uncovers key nutritional differences for future food innovations.

With meat and seafood consumption in Asia expected to rise by 33 percent by 2030, the search for sustainable alternatives is gaining urgency. From climate-conscious consumers to health-focused eaters, more people across the region are turning to plant-based options that replicate the taste and texture of familiar favourites.

Though plant-based alternatives are designed to resemble animal meats in taste and appearance, they often differ in their nutritional content and benefits. “Much of the current focus in developing alternative meat products has been on ‘neck up’ aspects such as taste and texture. But there’s still a major gap in understanding their effects ‘neck down’—that is, how they impact the body from a nutritional perspective,” said Caleb Ong, a Research Officer at the A*STAR Singapore Institute of Food and Biotechnology Innovation (A*STAR SIFBI).

Understanding whether alternative proteins can offer comparable nutritional benefits to animal-based protein is critical for long-term health and dietary planning.

Ong, alongside Senior Scientist Jie Hong Chiang and their team at A*STAR SIFBI, set out to assess the nutritional quality of both conventional and plant-based versions of popular meat products, including luncheon meat, chicken fillets and fish fingers.

“It wasn’t just about measuring the nutrient content. We wanted to translate these data into meaningful health comparisons, uncovering how these plant-based proteins can contribute to health outcomes relative to animal meat,” said Ong.

Using an established *in vitro* static digestion protocol (INFOGEST), which simulates human digestion, the team evaluated how each product was broken down by the body. The team found that the animal-based products generally had higher protein digestibility, greater levels of essential amino acids and superior overall protein quality than the alternative meat samples.

Plant-based products, while rich in dietary fibres and complex protein matrices, presented lower digestibility due to their structure, which limited enzyme access to proteins and lipids.

According to the researchers, reduced protein digestibility could result in inadequate absorption of important amino acids required for muscle function, immune response and metabolic health. Similarly, lower lipid digestibility could limit the uptake of essential fatty acids that support neurological health, regulate inflammation and maintain cardiovascular function.

“While alternative proteins present a promising and sustainable option, our findings suggest that their nutritional performance still lags behind that of animal-based proteins in several key areas,” said Ong.

The team’s next phase of research involves investigating the underlying factors that limit nutrient bioaccessibility in alternative meats, such as specific protein structures that resist enzymatic digestion. They also aim to explore novel processing techniques to improve nutrient release and develop strategies to enhance nutritional quality.

“Continued innovation is needed to close these nutritional gaps and ensure that alternative protein products are truly complete and functional replacements for their animal-based counterparts,” said Ong. “The goal is to boost nutrient accessibility without compromising the sensory qualities that drive consumer acceptance.” ★



Researchers

Caleb Ong and Jie Hong Chiang,
A*STAR SIFBI

IN BRIEF

The discovery of notable differences in macronutrient digestibility and amino acid composition between animal- and plant-based meats offers insights for improving alternative protein products.

1. Ong, K.S., Lim, P.Y., Ng, F.S.K., Sim, H.Y., Chiang, J.H., *et al.* A comparative analysis of macronutrient digestibility in animal and alternative meat products for the Asian market. *Journal of Food Composition and Analysis* **139**, 107171 (2025).

Photo credit: Lukas Tennie / Unsplash

ENERGY

On the wave to fusion energy

The power plants of tomorrow could tap into fusion energy, as scientists gain insight into how to control reactions and suppress turbulence.

Walk into a convenience store and you may be met by a sharp blast of cold air from the air-conditioning units at the entrance. Like an atmospheric curtain, this rapid surge of air breaks up the turbulent flows swirling in and out of the shop and leads to improved insulation.

Similar turbulent flows are a critical phenomenon at the nuclear scale, posing a challenge for building commercially viable fusion reactors. In nuclear fusion, two elements combine into a heavier one, releasing heat energy during their collision and forming plasma gas in the process. If such reactions could be reliably controlled and heat leakages minimised, fusion energy could help power our cities in a clean and sustainable way.

“Turbulence is responsible for losses of both heat and particles out of the plasma, which decreases the temperature. If too much heat escapes the fusion core too quickly, the fusion reaction stops, like a candle in the wind,” said Valerian Hall-Chen, a Principal Investigator at the A*STAR Institute of High Performance Computing (A*STAR IHPC).

Much like the fast-flowing air at the store entrance, fusion plasmas also have regions of zonal flows that can affect turbulence. Hoping to recreate this effect and improve the performance of fusion

reactors, Hall-Chen and a team led by Juan Ruiz Ruiz of the University of Oxford, UK, zeroed in on Alfvén waves, which have been theorised to influence these flows.

“Numerical simulations suggested that Alfvén waves can produce stationary flows and hence suppress turbulence,” Hall-Chen said. “However, the idea remained highly speculative; there was no experimental evidence of it.”

Even then, there were signs that experimental observations might be possible. Some experiments in fusion devices such as the Joint European Torus (JET), the world’s largest tokamak fusion reactor, had shown improvements in plasma insulation but had no explanation for the mechanism behind them. As such, Hall-Chen along with collaborators from France, Ukraine,

“This discovery provides the missing link between the theoretical ideas and the recent experiments in [the Joint European Torus].”

the US, the UK and Belgium headed to the JET tokamak on a quest to observe the behaviour of Alfvén waves.

The team used the Doppler Backscattering diagnostic at the JET, which shoots electromagnetic beams into fusion plasma. These beams are scattered differently depending on the types of turbulent flows present, much like how echolocation detects an object based on returning signals.

The researchers detected, for the first time on record, Alfvén waves generating zonal flows in the plasma. Moreover, the improvement in plasma insulation could only be explained by these Alfvén-generated flows. “This discovery provides the missing link between the theoretical ideas and the recent experiments in JET,” said Hall-Chen.

Together with global collaborators, the researchers are next working to understand how plasma design can better suppress turbulence. “We believe that such engineering is key to developing future fusion reactors,” Hall-Chen added. ★

Researcher

Valerian Hall-Chen,
A*STAR IHPC



IN BRIEF

The behaviour of flows generated by Alfvén waves in plasma is observed experimentally for the first time on record, showing how they might be leveraged to suppress heat loss in fusion reactions.

1. Ruiz Ruiz, J., Garcia, J., Barnes, M., Dreval, M., Giroud, C., *et al.* Measurement of zero-frequency fluctuations generated by coupling between Alfvén modes in the JET tokamak. *Physical Review Letters* **134**, 095103 (2025).

LANGUAGE MODELS

A tireless friend in dementia care

An AI-driven conversational assistant aims to bring new forms of companionship and emotional support to people living with cognitive decline.

Conversations with persons living with dementia (PLWD) can be challenging for caregivers. As the same questions come up again and again, patient responses might come easily at first; however, over time the repetition can be draining in a way that not only affects a caregiver's wellbeing, but the depth of care they can provide, leaving PLWDs feeling more isolated.

What if a digital companion could step in to help provide round-the-clock

conversation, comfort and support for PLWDs? That idea inspired the Social Presence and Support with Conversational Agent (SPASCA): an interactive virtual avatar jointly developed by the A*STAR Institute for Infocomm Research (A*STAR I²R), Singapore Management University (SMU) and Dementia Singapore.

At its core, SPASCA combines two artificial intelligence (AI) components: a dialogue model that learns how to

personalise its conversations over time, and a digital 'talking head' avatar that can display empathy through facial expressions and gestures.

"Traditional AI responds the same way to everyone, but our system adapts like a skilled human caregiver—being more passionate for someone who is energetic, or calmer for someone who gets easily overwhelmed," said Ali Köksal and Qianli Xu, respectively a Scientist and a Principal Scientist at A*STAR I²R.

SPASCA's dialogue model—developed by SMU's Jing Jiang and Kotaro Hara—was trained on recorded conversations between real-world physiotherapists and PLWDs during reminiscence therapy sessions.

Photo credit: Freepik / Freepik

“SPASCA could act as a skilled nursing assistant that never tires, handling routine tasks so human caregivers can focus on what they do best.”

“Being a small specialised model, SPASCA builds a memory bank of interactions with individual users to develop a conversational style suited to each one,” said Xu. “This lifelong learning capability means that the system—like a personal assistant—gradually attunes to a person’s unique needs, communication style and cultural background.”

Coupled with the dialogue model, SPASCA’s video generation arm includes an emotion recognition module that

allows it to synthesise a human avatar with poses and facial expressions that not only adapt to ongoing conversations, but can be customised to each person’s unique needs, such as by taking on the likeness of a familiar caregiver.

“Achieving natural mouth movement, head gestures, blinking and believable facial expressions needed extensive engineering work, especially as the system needs to run smoothly on everyday computers,” said Köksal.

The team is currently evaluating SPASCA’s performance and efficacy with PLWDs and has developed three prototypes of the agent with varying voices and interaction styles. A surprising discovery was that some details that had been emphasised during SPASCA’s development, such as accurate lip synchronisation, were less impactful for target users than expected.

“This experience helped us understand that supporting PLWDs requires focusing on the right details, not necessarily the most technically impressive ones,” said Köksal.

The team aims for SPASCA to complement human care, rather than replace it. “Ideally, SPASCA could act as a skilled nursing assistant that never tires, handling routine tasks so human caregivers can focus on what they do best,” Xu added. ★



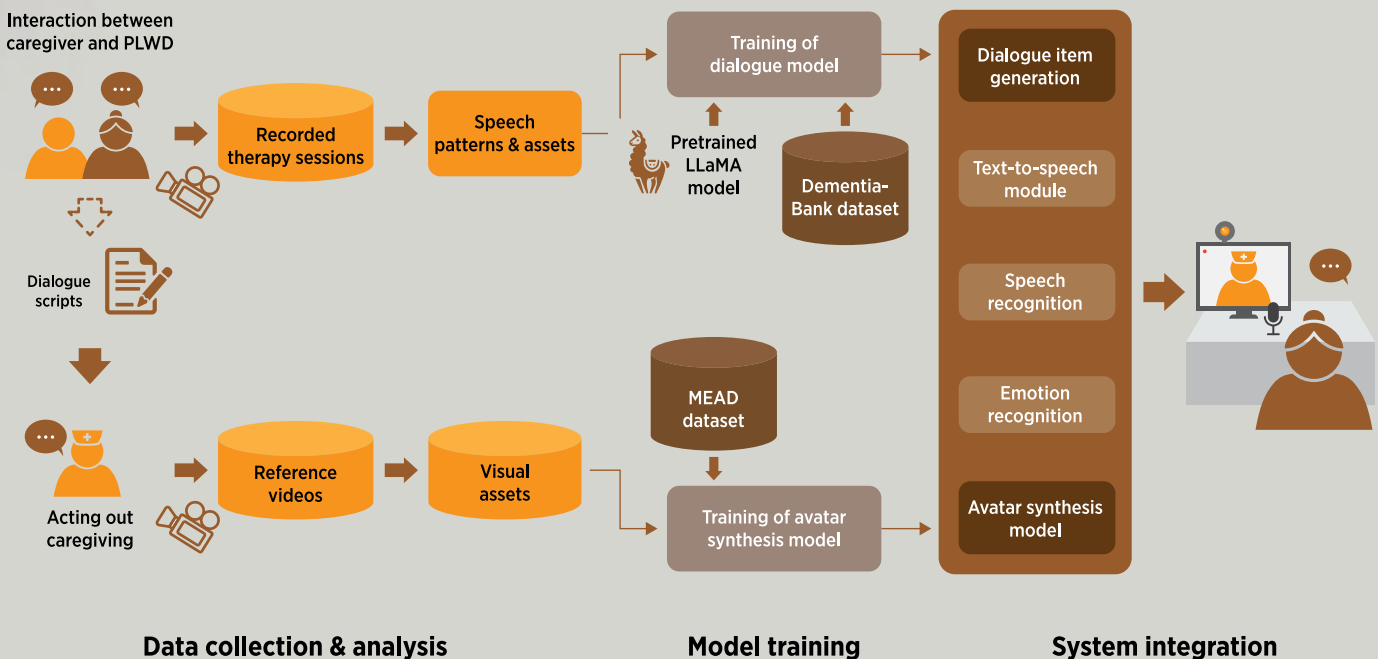
Researchers

Ali Köksal and Qianli Xu,
A*STAR I2R

IN BRIEF

SPASCA, an interactive virtual companion with a customisable video avatar and a dialogue model trained on reminiscence therapy, delivers personalised engagement and adaptive interaction for persons living with dementia.

1. Köksal, A., Gu, J., Hara, K., Jiang, J., Lim, J.-H., et al. SPASCA: Social presence and support with conversational agent for persons living with dementia. *Proceedings of the Thirty-Ninth AAAI Conference on Artificial Intelligence* **39** (28), 29649-29651.

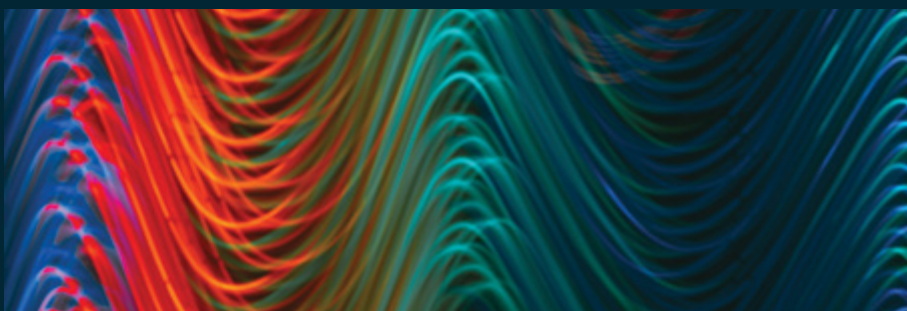


An overview of the SPASCA system. (Adapted from Köksal et al. 2025)

OPTICS AND PHOTONICS

Rippling new colours from quantum emitters

A new method of electrically controlling light emissions from nanoscale light sources opens new possibilities for quantum photonic devices.



In today's digital world, screens and communication systems are as essential to daily life as roads and plumbing. As demand grows for sharper displays and more secure data, so does the need for powerful and efficient light sources. While most systems today make use of light emitting diodes (LED) for a range of visual, sensory and signalling applications, scientists are looking at novel nanomaterials to reshape how tomorrow's technologies harness light.

Perovskite quantum dots (PQDs) are among the most promising of these materials. "Though thousands of times smaller than a human hair, PQDs can shine with incredibly bright and pure colours at room temperature," said Zhaogang Dong, a Principal Scientist at the A*STAR Institute of Materials Research and Engineering (A*STAR IMRE) and A*STAR Quantum Innovation Centre (A*STAR Q.InC).

Dong added that while PQDs are also inexpensive and easy to make—handy for large-scale use in ultrasharp TV screens, super-secure communications, highly sensitive detectors and other cutting-

edge applications—one major technical challenge has been the dynamic control of PQD light output at room temperature.

To build on previous work that used nanometre-sized arrays of optical 'antennae' to control the direction and colour of PQD emissions, Dong and A*STAR IMRE colleagues including Scientist Yan Liu teamed up with researchers from the Singapore University of Technology and Design; National University of Singapore; University of Southern Denmark; and University of Birmingham, UK.

In a recent study, the team investigated a new PQD design: a nanoarray of patterned antimony telluride (Sb_2Te_3) antennae with integrated PQDs, designed to harness an optical phenomenon known as surface-enhanced Landau damping.

"We found that when light hits patterned Sb_2Te_3 , it excites waves of electrons on the material's surface that produce extremely energetic 'hot' electrons and holes," explained Dong. "These hot electrons are then injected into nearby PQDs, shifting the colour of light they emit.

This dramatic change can be switched on or off by transforming Sb_2Te_3 's phase between a disordered form and a neatly ordered crystal form."

The team fabricated a prototype Sb_2Te_3 -PQD nanoarray to test their theories. They found that their device could not only shift light emission energy by 570 meV, but also enhance the intensity of emitted light up to 22-fold through adjustments in the applied electrical voltage bias.

"Our approach transforms PQDs from static light sources into electrically tuneable and reconfigurable platforms by coupling them with phase-changing Sb_2Te_3 nanostructures that enhance Landau damping," said Liu. "This opens the door to highly versatile, non-volatile, tuneable quantum light sources for next-generation applications such as on-chip photonics, where control of light's colour, direction and polarisation at the nanoscale is critical."

The team is now focusing on refining their materials and nanostructures to improve their reliability under real-world conditions. "We envision that compact single-photon emitter devices based on our work could be integrated onto satellites for secure communications," Dong added. ★



Researchers

**Zhaogang Dong, A*STAR IMRE and A*STAR Q.InC
and Yan Liu, A*STAR Q.InC**

IN BRIEF

Perovskite quantum dots paired with antimony telluride nanostructures successfully harness surface-enhanced Landau damping and electrically tuneable phase changes to boost the intensity and dynamic control of quantum light emissions.

1. Liu, Y., Zhang, J., Csányi, E., Adanan, N.Q., Wang, H. *et al.* Electrically tunable and modulated perovskite quantum emitters via surface-enhanced Landau damping. *Advanced Materials* **193** (16), 2419076 (2025).

SENSORS

SEA-ing into machines' future life

A new computational framework aligns data from multiple sensors across time, boosting the accuracy of machine failure predictions.

How can we predict when a piece of equipment will stop working? This is an important question in many industries, from manufacturing and logistics to energy and infrastructure. Companies rely on these predictions to devise appropriate contingency plans, intervening before entire workflows are suspended or setting backup machines into motion to sustain operational flow.

At the heart of these capabilities are sensors that track critical parameters, such as device temperatures that indicate overheating. Such data are then integrated and processed by machine learning models to evaluate how well a machine is functioning and predict the 'remaining useful life' (RUL) of the system.

Due to a labelling issue in real-world applications, the typical model used for these scenarios is known as Unsupervised Domain Adaptation (UDA), where knowledge from a labelled source domain, such as data from a known machine, is transferred to a new machine as the unlabelled target domain. However, UDA methods often fall short when dealing with the data from multiple sensors across multiple timepoints, compromising the accuracy of RUL predictions.

"Most UDA methods align feature distributions as a whole and ignore sensor-specific distributions, which can lead to misaligning of individual sensors," said Yucheng Wang and Zhenghua Chen, respectively a Senior Research Engineer

"This approach captures local dynamics, and would, for example, reveal a machine's health deteriorating over time."

and a Lab Head at the A*STAR Institute for Infocomm Research (A*STAR I²R).

To address this issue, the researchers worked with collaborators at Nanyang Technological University, Singapore, and National University of Singapore to devise a new Sensor Alignment (SEA) framework and its advanced counterpart, SEA++. These frameworks jointly tackle two separate alignment issues: the alignment among sensors measuring the same type of data in different domains, as well as the alignment among sensor interactions.

Unlike traditional methods that collapse all sensor data into a single representation, SEA and SEA++ break the data into smaller segments and construct multiple graphs.

"This approach captures local dynamics and would, for example, reveal a machine's health deteriorating over time," said Wang and Chen, adding that it also enables the alignment of more complex patterns in the data, such as changes in the relationships between different parameters over time.

In benchmark tests, the SEA and SEA++ frameworks outperformed state-of-the-art UDA models in tasks involving multiple sensors and timepoints, such as RUL prediction for aero engines. "The sensor-level adaptation enables our frameworks to work well in scenarios with various sensor types or placement differences, while its dynamic adaptation enables the model to handle evolving distributions, such as working condition transitions," Wang and Chen said.

While their current methods rely on having open access to sensor data, the team is now working on developing UDA frameworks that can still deliver accurate RUL predictions even in source-free situations, as source data may not be easily retrieved in many real-world conditions. ★



Researchers

Yucheng Wang and Zhenghua Chen,
A*STAR I²R

IN BRIEF

The SEA and SEA++ frameworks align sensor-level data to improve how machine learning models monitor and predict the remaining useful life of a system.

1. Wang, Y., Xu, Y., Yang, J., Wu, M., Li, X., et al. SEA++: Multi-graph-based higher-order sensor alignment for multivariate time-series unsupervised domain adaptation. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, **46** (12), 10781-10796 (2024).

DRIVING SCIENCE TO NEW HORIZONS





In recognition of their research excellence, leadership and impact both locally and globally, ten leading A*STAR researchers have been awarded the A*STAR Distinguished Fellowship and Fellowships.

Science flows like an endless river of questions, propelled by humanity's persistence to solve them. How do our geographic origins shape our immune systems? Can light be deftly controlled at the nanoscale? What materials would it take to safely contain future power plants, or keep advanced aircraft aloft?

Today, researchers at A*STAR continue to push frontiers in the countless challenges and mysteries that occupy a diverse range of scientific and engineering fields. From stem cell biology to additive manufacturing, A*STAR's scientific talents are making breakthrough discoveries and advancing translational efforts that bring cutting-edge insights from the lab into the real world.

In recognition of the outstanding contributions, leadership and impact of leading A*STAR researchers for the local and international research community, A*STAR annually awards the A*STAR Fellowship and Distinguished Fellowships on a highly competitive basis. The Fellowships recognise and honour the efforts of individual researchers who have showcased technical and scientific excellence in their respective fields, as well as stepped into leadership roles at the agency.

In this issue of *A*STAR Research*, we speak to this year's A*STAR Distinguished Fellow and nine A*STAR Fellows, who share the scientific challenges they hope to solve, and their aspirations for the future of their work.

2025 A*STAR DISTINGUISHED FELLOW

Institutional leader of global distinction

Light is more than illumination—it carries information, forms our perception of the world and shapes technologies. For Jinghua Teng, the challenge is to uncover novel nanostructures that can bend, confine and convert light in ways that were previously unimaginable with classical lenses and bulk materials. His goal is to push boundaries in optical communications, information processing, imaging, computing and sensing.

Teng leads the Optoelectronics Group at A*STAR IMRE, where his team integrates 2D materials and 2D metamaterials across a wide range of wavelengths. Their landmark achievement in super-resolution imaging has led to the first ultrathin, supercritical flat lens capable of both superfocusing and wide-field imaging, with a record-long working distance. In collaboration with A*STAR spinoff company Metaoptics Technologies, they have since developed a direct laser writing system based on their supercritical lens designs for higher-resolution lithography.

At the National Semiconductor Translation and Innovation Centre (NSTIC), Teng works with a team tackling several grand challenges in flat lens R&D.

By engaging the entire industrial value chain, the researchers are turning innovative flat lens designs into commercially applicable prototypes for large-scale manufacturing. This work could establish NSTIC as a global leader in flat optics and open new horizons for Singapore's optics and electronics sectors.

Supported by the National Research Foundation's Competitive Research Programme, Teng is also leading efforts to develop mid- to far-infrared technologies using 2D and other quantum materials—advances that could transform fields such as medicine, environmental monitoring, communications and security.

“We will continue to push the boundaries of how light can be controlled and utilised at the nanoscale, enabling faster, smaller and more energy-efficient optics and optoelectronics with enormous transformative potential.”

JINGHUA TENG

*Senior Principal Scientist,
A*STAR Institute of Materials Research
and Engineering (A*STAR IMRE)*



2025 A*STAR FELLOWS

Team leaders of national scientific excellence



AMIT SINGHAL

Senior Principal Scientist,
A*STAR Infectious Diseases Labs (A*STAR IDL)

At first glance, diabetes and tuberculosis (TB) seem unrelated: one is a metabolic disorder, the other a bacterial infection. But in 2014, while screening for potential drugs that target key energy-metabolising pathways in TB pathology, Amit Singhal and colleagues found that metformin—a low-cost drug long used for blood sugar management in diabetes—could inhibit the growth of *Mycobacterium tuberculosis*, even when the bacterium had entrenched itself within host cells.

Singhal's pioneering work has since led to three phase 2 clinical trials on metformin's efficacy as a TB adjunct therapy. In the METRIF trial in India, investigators found that adding metformin to standard anti-TB treatment reduced excess inflammation and limited lung tissue damage in patients with TB. Two other trials—METHOD and DRTB-HDT—are evaluating metformin's effects in patients with HIV/TB and drug-resistant TB infections; successful outcomes from these will set the stage for phase 3 trials in six countries in 2026.

At A*STAR IDL, Singhal's group is also probing the mechanisms used by respiratory pathogens to sidestep host immune responses, drawing on biochemical, microbiological, molecular biology and omics approaches. Their work on the crosstalk of immuno-metabolic circuits and epigenetic reprogramming has revealed new protein targets for the next generation of host-directed therapies (HDT) against respiratory infections.

*"The A*STAR Fellowship will support our research activities in lung-directed inhalable HDTs for acute and chronic inflammation; new antibiotics to face growing global antimicrobial resistance; and pathogen-agnostic host-targeted approaches as alternative therapeutic avenues."*



ANAND ANDIAPPAN

Principal Scientist,
A*STAR Singapore Immunology Network (A*STAR SigN)

Two-thirds of the world's people live in Asia, yet Asian populations remain underrepresented in biomedical research compared to their Western counterparts. Studies show that the genetics and pathology of many diseases can be quite different between these groups, raising questions about whether treatments optimised for one group will be as effective for another.

As a translational immunologist, Anand Andiappan aims to understand the molecular-level nuances of immune dysregulation among Asian communities in Singapore. To date, Andiappan's team at A*STAR SigN has uncovered significant population-level differences in the immune mechanisms of allergic conditions such as atopic dermatitis (AD) and allergic rhinitis. These variations include the roles of distinct T helper cell classes, skin composition, age of disease onset, responses to medication, and the range of allergen exposure.

Andiappan and colleagues are now building on these insights, exploring how they can be leveraged for early diagnosis, improved treatment outcomes and preventive care. As part of the national-level Atopic Dermatitis Program for Patients (ADEPT), the team is conducting molecular characterisation of AD patients using blood and skin samples. Because AD symptoms often appear similar across individuals, the researchers aim to pinpoint underlying immunological differences that could guide more tailored treatments and new therapeutic strategies.

"We aim to work with clinicians and industry partners to understand patient diversity and find the right treatment for the right patient. We want to move from 'one-size-fits-all' approaches to personalised ones that reduce clinical burden and improve quality of life."



KENNETH LAY

*Principal Scientist,
A*STAR Skin Research Labs (A*STAR SRL)*

Like blank tiles in a game of Scrabble, stem cells can be turned into almost any cell type in the body. Their potential offers hope for regenerative medicine, restoring damaged tissues and organs with cells less likely to be rejected by the immune system.

To realise that possibility, researchers must first address key questions about stem cell stability. How firmly do stem cells retain their new identities? How well do they integrate into target organs? And how can scientists ensure they behave as intended?

At A*STAR SRL, Kenneth Lay and colleagues are making headway in answering these questions. Their recent work shows that even after recovering from inflammatory insults, skin stem cells do not behave as they once did. While their plasticity helps the cells adapt to changing micro-environments, it may also limit their ability to regenerate new skin—insights that could inform strategies to curb the recurrence of chronic inflammatory conditions such as eczema.

Lay's team is also streamlining methods to produce stem cell-derived skin organoids. By shortening the time needed to generate these organoids, they are taking small but important steps towards cost-effective grafts for patients with severe burns or inherited skin disorders.

"Our long-term goal is to create a nurturing environment where students, postdocs and research staff can inspire, discover and translate biological findings into novel stem cell-based strategies to treat skin conditions and sustain skin health."



KOK HAO CHEN

*Principal Scientist,
A*STAR Genome Institute of Singapore (A*STAR GIS)*

The road to breakthrough science is often paved with failure. For Kok Hao Chen, the successful development of MERFISH a decade ago took a dogged amount of faith, persistence and support from collaborators and mentors, leading to what would become a foundational tool in spatial omics today: a highly multiplexed RNA profiler that reflects RNA's location within native tissues, producing crisp images with a high level of agreement with next-generation sequencing tools.

MERFISH and related tools continue to make waves in biomedical research, uncovering new insights in brain development, brain ageing and cognitive decline in Alzheimer's disease and Down syndrome. The tool's applications are also rapidly expanding beyond neuroscience to fields such as immunology, gastroenterology and oncology. Chen believes that in combination with spatial functional perturbation approaches for validation, MERFISH will aid the identification of more meaningful drug targets and molecular markers, helping shape the future of drug discovery, molecular diagnostics and precision healthcare.

Moving forward, a key goal for Chen's lab is to employ advanced MERFISH-like tools in studying the diversity and regulation of transcription and translation at the single-molecule level, providing views of how these factors vary among cell types and tissues at subcellular resolution.

"There's a saying: 'God is in the details.' I hope that by systematically re-examining transcriptional and post-transcriptional processes in light of their spatial organisation, we can uncover fundamental new insights that advance molecular biology and redefine precision therapeutics."



MILE ŠIKIĆ

Group Leader (AI in Genomics),
A*STAR Genome Institute of Singapore (A*STAR GIS)

If the entire human genome were printed on paper, it would produce a stack taller than the Statue of Liberty. Making sense of that vast code has long been a challenge, but artificial intelligence (AI) is now reshaping the field of bioinformatics. By improving the quality of long-read sequencing, AI is enabling scientists to reconstruct and scan through a sea of genetic code with unprecedented accuracy.

Mile Šikić was among the pioneering researchers to show that overlapping reads and correcting them with AI models could improve long sequencing read quality by up to 100-fold. At A*STAR GIS, Šikić and colleagues developed HERRO, a transformer-based error correction model which enabled the automated reconstruction of complex human chromosomes.

Another contribution to the field by Šikić's team is RiNALMo, an award-winning RNA-focused large language model. They demonstrated that RiNALMo and similar models can deliver significant advances in RNA-specific tasks, including more accurate predictions of RNA secondary structure—a key determinant of RNA function.

Building on these breakthroughs, Šikić and team plan to reconstruct and elucidate the evolutionary trajectories of cancer genomes using advanced AI models, and to optimise RNA molecules for therapeutic use in cancer and cardiovascular disorders.

"[Our AI models] position Singapore at the forefront of global research. Among the three biologically essential macromolecules—protein, DNA and RNA—Singapore now leads in the development of RNA foundation models."



PEI WANG

Principal Scientist,
A*STAR Institute of Materials Research
and Engineering (A*STAR IMRE)
A*STAR Strategic Research & Translational Thrusts - Future
Energy Acceleration & Translation (A*STAR SRTT-FEAT)

From planes to power plants to smartphone batteries, advanced metallic materials underpin almost every sector of modern technology. Combined with additive manufacturing (AM), they offer unprecedented design freedom, allowing engineers to create complex, lightweight and high-performance structures that were previously impossible to construct.

For Pei Wang, this convergence not only drives innovation in cutting-edge industries, but also delivers lasting economic and social impact through energy-efficient products and sustainable manufacturing. Wang and colleagues at A*STAR IMRE and A*STAR SRTT-FEAT have developed new structural metal alloys that address long-standing production challenges, drawing on diverse expertise and a shared vision for advancing AM.

In parallel, the team's work on accelerated materials discovery and manufacturing has fundamentally changed existing frameworks for alloy design. By moving beyond conventional trial-and-error to high-throughput AI-guided approaches, the researchers have been able to rapidly design, prototype and evaluate new alloys. These innovations led to patents and opened new pathways for advanced alloy development and translation with industry partners including Makino and TE Connectivity.

"Beyond the lab, I aim to translate AI-driven approaches in materials discovery and manufacturing to industry, enabling faster, smarter and more cost-effective alloy design. The A*STAR Fellowship will be instrumental in building these AI-enabled platforms, expanding collaborations and accelerating the translation of our research into tangible impact."



SHIJIE WANG

*Senior Principal Scientist,
A*STAR Institute of Materials Research
and Engineering (A*STAR IMRE)
A*STAR Strategic Research & Translational Thrusts - Future
Energy Acceleration & Translation (A*STAR SRTT-FEAT)*

From the first clay bricks to today's turbine engines, ceramics have shaped technological progress for centuries. Modern advanced ceramics drive both innovation and sustainability, offering extreme temperature resistance, high strength and excellent electrical insulation. Their exceptional properties make them indispensable as lightweight and durable components in aircraft and automobiles; biocompatible implants in healthcare; and advanced solutions in power generation, energy storage and filtration systems.

At A*STAR IMRE and A*STAR SRTT-FEAT, Shijie Wang focuses on creating advanced ceramics with enhanced performance or novel functions, aiming to create more robust, multifunctional devices that transform industries and improve everyday life. His work aims to bridge the gap between materials discovery and application in various sectors including aerospace, defence, semiconductors and clean energy.

Wang's patented innovations to date include a novel wear-resistant smooth coating for aircraft engine components, which extends their service life while cutting overall production costs. He has also developed a series of tungsten coatings for ceramic tiles that can withstand the extreme neutron and plasma irradiation of fusion reactors. This technology has already been licensed to a local company to produce tungsten-coated tiles for the fusion industry.

"My long-term vision is to establish a leading research lab focused on developing novel advanced ceramic materials and processes for use in harsh environments, spanning the aerospace, defence and clean energy sectors."



YING SWAN HO

Senior Principal Scientist,
A*STAR Bioprocessing Technology Institute (A*STAR BTI)

As a chemical engineer by training, Ying Swan Ho did not expect to find herself at the forefront of metabolomics when she returned to A*STAR BTI after her PhD degree. Yet a pivotal opportunity arose: to establish a metabolomics platform that could transform how scientists understood cell culture systems at a time when few tools existed to deeply characterise how cells utilised nutrients.

Today, as A*STAR BTI's Division Director of Analytical Science and Technology, Ho leads a multidisciplinary team that integrates advanced analytics, omics technologies and computational modelling as they tackle pressing challenges in biologics and cell therapy development. Her group's work spans three key areas: optimising bioprocesses, uncovering novel therapeutic targets through metabolic profiling, and supporting regulatory science for next-generation modalities such as mRNA and cell therapies.

Among her flagship initiatives is the BioStream programme, a joint effort with the National University of Singapore to accelerate lead optimisation for biologics through AI and rapid experimental-analytical platforms. Ho also co-leads ASCENT¹, an inter-agency collaboration with Singapore's Health Sciences Authority to build regulatory science capabilities for novel biotherapeutics. Her team aims to understand how mRNA-lipid nanoparticle heterogeneities affect efficacy and safety.

"It's an exciting time to be at the intersection of science, technology and translation. The A*STAR Fellowship will help us nurture talent and grow a strong pipeline of researchers who can drive innovation in analytical science and precision biomanufacturing."

1. The Centre for Advancing Regulatory Science Research in Next-Generation Therapeutics (ASCENT) is supported by the Singapore Ministry of Health through the National Medical Research Council Office, MOH Holdings Pte Ltd.



YOUXIANG CHEW

Principal Scientist,
A*STAR Advanced Remanufacturing
and Technology Centre (A*STAR ARTC)

Directed energy deposition (DED), a specialised form of industrial 3D printing, first captured Youxiang Chew's attention during his PhD degree as a promising remanufacturing process. He has pursued DED ever since for its unique ability to fabricate and remanufacture large, complex and high-value parts. What drives Chew's research is the technology's direct relevance to industry—reducing lead times, extending component lifespans and enabling new material combinations that support sustainability.

In collaboration with Mencast, a Singapore-based marine propulsion system manufacturer, Chew and colleagues at the A*STAR Singapore Institute of Manufacturing Technology (A*STAR SIMTech) and A*STAR ARTC delivered the region's first qualified additively manufactured ship propeller, certified by global maritime classification agencies. The team is also building capabilities in remanufacturing high-temperature nickel-based superalloy components through the Smart Manufacturing Joint Lab 2, a partnership between A*STAR, Rolls-Royce and Singapore Aero Engine Services.

Looking ahead, Chew is aiming for even greater precision and impact. He envisions next-generation remanufacturing methods that can achieve precision wire-based deposition while overcoming typical trade-offs between build rate and quality. Chew also plans to explore novel hybrid manufacturing pathways where DED is more effectively combined with other additive processes and forged components through deep-penetration electron beam welding.

"We aim to position Singapore as a leader in smart and sustainable manufacturing. The A*STAR Fellowship will provide a platform for pursuing high-risk, high-reward research while translating outcomes into industry impact, talent development and national competitiveness." ★

OPTICS

Seeing the invisible

An all-in-one approach to visualising near-infrared light stands to enhance medical imaging and security systems.

As many colours as the human eye can see, these represent only a small range in the full spectrum of light. Just beyond it lies near-infrared (NIR) light: an invisible yet vital part of the spectrum used in night vision, environmental monitoring and medical imaging. However, to make NIR signals accessible for everyday applications, they must be transformed into visible light through a process known as photon upconversion.

“Conventional photon upconversion systems often suffer from significant energy losses, particularly during the diffusion and transfer of energy states called triplet excitons,” said Le Yang, a Group Leader at the A*STAR Institute of Materials Research and Engineering (A*STAR IMRE). Yang added that this inefficiency stems from using a single-component sensitizer to both absorb the invisible photons and transfer energy to emitter molecules.

Working with the Institute of Chemistry Chinese Academy of Sciences and Shandong University in China, as well as Nanyang Technological University, Singapore, Yang and A*STAR IMRE Scientist Pengqing Bi led a team in designing a bulk-heterojunction (BHJ) donor-acceptor (D-A) sensitizer. This D-A type sensitizer efficiently generates a large number of free charge carriers, which then recombine at a sensitizer-emitter interface to form triplet excitons. Unlike conventional upconversion systems that rely on triplet exciton diffusion and energy transfer, this approach significantly suppresses

related energy losses and enhances upconversion efficiency.

“We aimed to reduce the threshold amount of NIR light needed to trigger photon upconversion, while also improving the conversion efficiency,” explained Yang. “Think of it as trying to light a bulb with as little electricity as possible and making sure it glows brightly.”

Both sensitizer components worked in tandem to accelerate the formation of triplet excitons on the emitter, enhancing overall upconversion performance.

Despite the promise of the BHJ strategy, the team found that photon upconversion efficiency still decreased significantly under low-light scenarios where NIR signals are much too weak. They then integrated electroluminescence-based light compensation to achieve more reliable NIR detection.

“Under weak NIR illumination, the device can be switched to a mode where it actively emits light using electrical input, which helps visualise NIR photons even when upconversion alone is insufficient,” Yang said.

By combining NIR sensing, photon upconversion and electroluminescence into a single platform, the team’s new multifunctional optoelectronic device effectively adapts to the intensity of NIR light present.

“We essentially built a smart ‘skin’ around our light-converting material, so the device can do more than just see NIR—it can interact with its environment,” said Yang. This could support the development of various practical applications, such as night-time security systems that can see in complete darkness, non-invasive blood flow monitors and other advanced healthcare sensors.

The researchers are upgrading their multifunctional optoelectronic device by improving its upconversion efficiency, potentially enabling it to function under even weaker NIR light conditions. They also aim to develop flexible array-type devices with higher spatial resolution to enable real-time NIR detection and imaging capabilities. ★



Researchers

Le Yang and Pengqing Bi,
A*STAR IMRE

IN BRIEF

A new multifunctional optoelectronic device combines efficient photon upconversion and electroluminescence-based light compensation to enable the visualisation of near-infrared light across a spectrum of conditions.

1. Bi, P., Zhang, T., Guo, Y., Wang, J., Chua, X.W., *et al.* Donor-acceptor bulk-heterojunction sensitizer for efficient solid-state infrared-to-visible photon up-conversion. *Nature Communications* **15**, 5719 (2024).
2. Bi, P., Wang, J., Chen, Z., Li, Z., Tan, C., *et al.* Weak near-infrared light visualization enabled by smart multifunctional optoelectronics. *Advanced Materials* **37** (11), 2416785 (2025).



MATERIALS SCIENCE

Washing surface defects away

A serendipitous encounter leads researchers to discover a new fabrication method for a key crystal in nanophotonics.

Just as gemstones need the right cuts and careful polishing to reveal their brilliance, the tiny crystals at the heart of chip technologies depend on detailed patterning during fabrication to unlock their full potential. One such crystalline material, α -phase molybdenum trioxide (α -MoO₃), is under the spotlight for its ability to tune electromagnetic fields, making it valuable for nanophotonic applications such as infrared (IR) light manipulation and optical signal processing.

α -MoO₃ crystals consist of layers of tightly bound atoms, with each layer held together by weak van der Waals forces. “This unique structure allows them to be exfoliated into atomically thin sheets with novel electronic, optical and mechanical properties,” explained Qian Wang, a Principal Scientist at the A*STAR Institute of Materials Research and Engineering (A*STAR IMRE).

A major obstacle in commercialising these materials, however, lies in the fabrication process. While current techniques can etch the desired intricate patterns, they also introduce artifacts to the crystals. Wang, Qiyao Liu of A*STAR IMRE, Zheng Liu of Nanyang Technological University, Singapore, and collaborators from institutes in China found a simple solution to this issue: introducing a hot water rinse after the traditional patterning step.

“During our attempts to transfer MoO₃ flakes assisted by water vapour, we observed that the vapour caused surface smoothing with slightly enhanced optical signal,” said Wang. “We immersed a patterned sample in hot water for just one minute and, to our surprise, observed a pronounced and reproducible anisotropic etching.”

Based on this discovery, the team dug deeper to explore how hot water could be used to improve nanofabrication techniques, determining the effects of variables such as temperature and soaking time on the etching of van der Waals materials.

Besides smoothing out defects during fabrication, the researchers also achieved directional control over the etching process by exploiting the difference between weak interlayer van der Waals forces and strong intralayer binding interactions.

“Breaking the crystal lattice in the intralayer direction exposes planes with different densities of dangling bonds,” Wang explained. “These bonds influence the rate of the chemical reaction, allowing etching to proceed much faster along the intralayer and creating nanostructures with precisely aligned edges.”

Having validated their technique with a prototype, the team is optimistic that their chemical-free etching methodology can be applied to a broader range of van der Waals materials, potentially leading to the development of better nanophotonic devices.

“It paves the way for the integration of this method with scalable lithographic processes to develop large-area, low-loss devices for mid-IR nanoscale sensing and imaging applications,” Wang said. ★



Researchers

Qian Wang and Qiyao Liu,
A*STAR IMRE

IN BRIEF

Introducing a hot water rinse step not only counteracts defects caused by traditional nanofabrication techniques but also improves control in etching van der Waals materials.

1. Liu, Q., Li, Z., Ma, X., Liu, Q., Wei, F., *et al.* Anisotropic crystallographic engineering of α -MoO₃. *ACS Nano* **19** (22), 21179–21188 (2025).



MATERIALS SCIENCE

Shaping strength with thinner composites

A new computer modelling approach lends a hand with designing lighter, sturdier aircraft components from next-generation composite materials.

When you step onto a plane bound for a holiday, the aircraft's tapered curves are probably the last thing on your mind. Yet those contours embody a delicate balancing act in aerospace engineering: the trade-off between weight and strength. Every extra kilogram of material adds to an aircraft's fuel consumption, but trim away too much and a fraction of a millimetre could mean the difference between structural safety and failure.

To walk this tightrope, most aircraft today are built partly from composite laminates. Similar to plywood, these advanced materials comprise overlapping layers or 'plies' of strong elastic fibres. However, while they can have impressive

strength-to-weight ratios, laminate parts can also pose problems when engineers taper them to reduce weight.

"Conventional laminates use Quad layouts, where plies are stacked with their fibres laid at 0°, 90°, or $\pm 45^\circ$ angles in varying sequences," said Dan Wang, a Senior Scientist at the A*STAR Institute of High Performance Computing (A*STAR IHPC). "Removing or 'dropping' a single ply from a Quad laminate to gradually taper it can alter the material's stiffness unevenly, often leading to design difficulties."

In collaboration with Stephen Tsai of Stanford University in the US, Wang and A*STAR IHPC colleagues have been investigating Double-Double (DD)

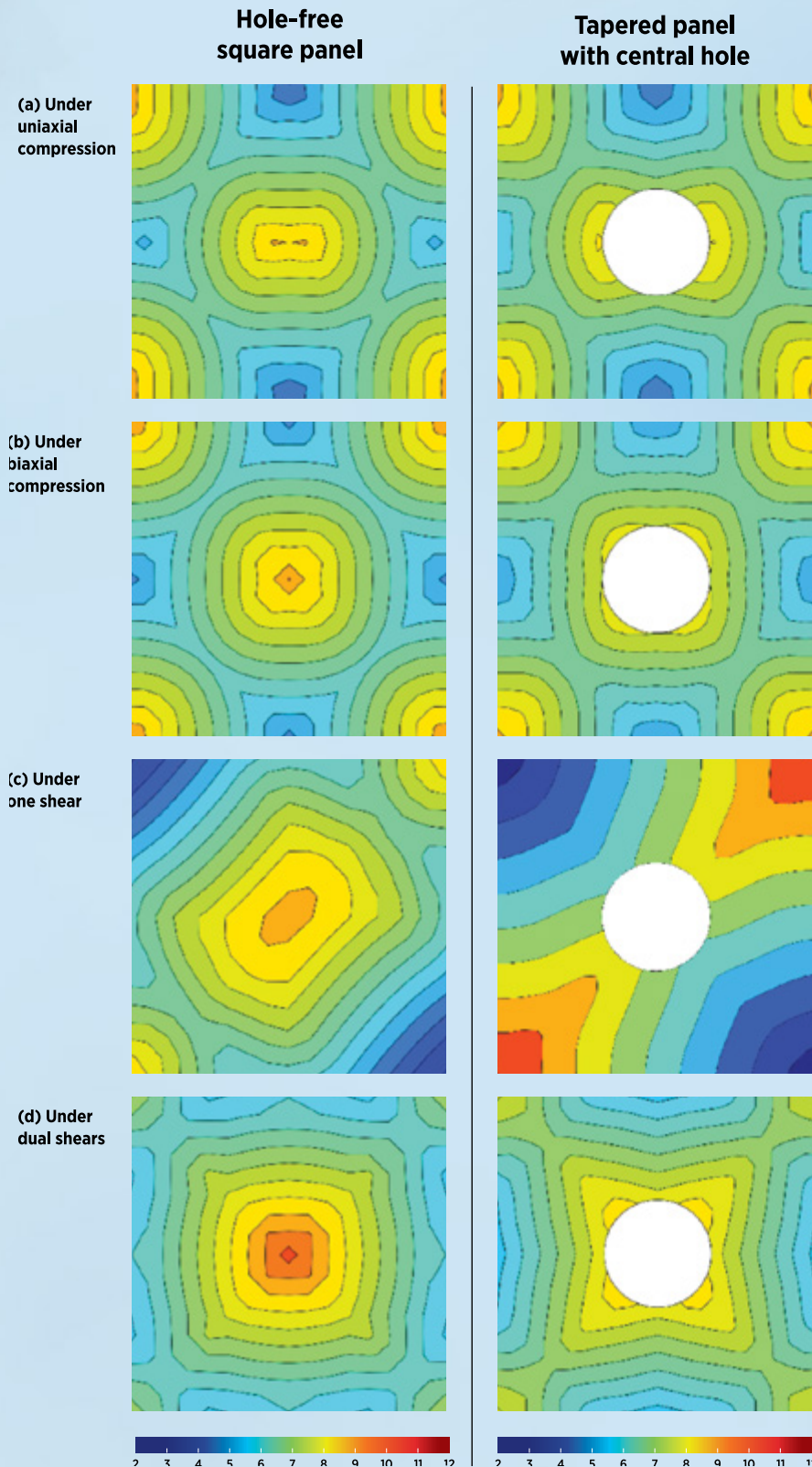
laminate designs as a more versatile option. Built from repeating pairs of fibre layers laid at balanced angles, DD laminates change their stiffness with a metal-like consistency, simplifying the design process and reducing the risk of local buckling and delamination when considering spacing constraints.

"This smooth transition also enables the use of powerful, gradient-based optimisation methods on DD laminates to create complex aerospace structures," Wang added.

The team recently published a new computer modelling approach for optimising the buckling resistance of gradually tapered DD laminate designs.

"Our findings illustrate that properly chosen design strategies and defined design spaces are crucial for optimisation to yield effective results."

Photo credit: Sven Siegenthaier / Unsplash



Optimal thickness profiles for a hole-free square DD laminate panel (left column) and a tapered panel with a central hole (right column), as represented by the contours of repeating sub-laminates. Spacing constraints have been included. (Adapted from Wang *et al.* 2025)

Their method combined high-fidelity local models to capture how ply drop-offs behave in gradually tapered parts, then translated that detail into homogenised material properties for a larger global model.

“Our model captures the real effects of tapering in the global search, iterates as needed, then re-validates locally,” said Wang. “By doing so, we can lower computational costs while enabling a cleaner, scalable formulation of thickness variation.”

The team tested their method on a series of benchmark problems, including flat panels and a C-spar structure representative of an aircraft wing. They found that not all tapering strategies were beneficial: a simple linear tapering strategy reduced a DD laminate’s buckling resistance—measured as first buckling load, or λ_1 —by over 50 percent. In contrast, an optimised gradual tapering improved λ_1 up to 280 percent without adding weight.

“Our findings illustrate that properly chosen design strategies and defined design spaces are crucial for optimisation to yield effective results,” said Wang.

Wang added that the team plans to experimentally validate their method on scaled composite panels, integrate more manufacturing constraints into its optimisation, and work with industry partners to embed it into existing design workflows. ★

Researcher

Dan Wang,
A*STAR IHPC



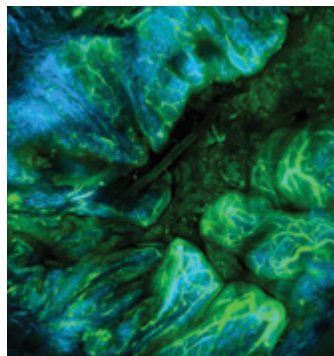
IN BRIEF

Using an implicit global-local optimisation method, a combined model maximises buckling resistance in Double-Double composite laminates by combining homogenised modelling, gradient-based optimisation and spacing constraints that prevent delamination, enabling more efficient aerospace component design.

1. Wang, D., Su, Z., Narayanaswamy, S. and Tsai, S.W.L. Buckling optimization of Double-Double (DD) laminates with gradual thickness tapering. *Composite Structures* **351**, 118568 (2025).

SNEAK PEEK

A brief look at upcoming research highlights in the next issue of A*STAR Research



IMMUNOLOGY

BROAD NEW HOPE FOR LATE-STAGE IV CANCER

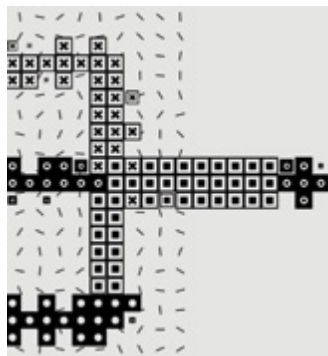
Clinical trial results show a new antibody drug with an unconventional approach improves survival for patients with various aggressive cancers.



ENERGY

TRACING THE TRUTH OF GREENWASHED FUELS

Advanced chemical fingerprinting tools and international standards offer new ways to verify the production origins of purported low-carbon fuels.



ARTIFICIAL INTELLIGENCE

TAKING SHARPER AI LEARNING OFFLINE

A new learning framework for large language models aims to enhance their reliability in complex logical reasoning tasks.



MATERIALS SCIENCE

A STICKY NEW TACK FOR E-WASTE

Reversible glues that bond and detach with different types of light could solve a common hurdle in recycling discarded electronics.

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KEYNOTE SPEAKERS



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Evelyn WANG
Massachusetts Institute of Technology



Huimin ZHAO
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National Science Scholarship (BS-PhD) Recipient
& Music Enthusiast



“

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