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From bench to market

Many have wondered if eating a local delicacy – frog porridge – sparked the development of a wound-healing collagen product made from bullfrog skin in Singapore.

"But the leap from porridge to science wasn't how it happened," says Assoc Prof Dalton Tay, one of the developers of the innovation from NTU's School of Materials Science and Engineering.

Instead, the researchers had been looking for an eco-friendly source of collagen from Singapore when their search led them to discarded bullfrog skins from farms near their laboratories.

Together with Assoc Prof Tan Nguan Soon from the University's Lee Kong Chian School of Medicine, Assoc Prof Tay is upcycling the skins to create clinical-grade collagen patches that can accelerate the healing of chronic wounds.

NTU's innovation and enterprise company, NTUitive, exclusively licensed the patented technology to local medtech firm Cuprina Wound Care Solutions in 2022. NTUitive comes under the NTU Innovation and Enterprise (NTU I&E) initiative, which seeks to

nurture entrepreneurs by mentoring and supporting students, faculty and alumni looking to turn their ideas into market-ready products.

After setting up a lab to scale up its commercial production, Cuprina is now planning clinical trials at local hospitals.

"Licensing allows us to focus on innovation and scientific advancement while leveraging the business acumen and market presence of established companies like Cuprina," says Assoc Prof Tay.

Developing wound healing patches made of amphibian skin is one example of how NTU scientists are creating game-changing solutions to real-world problems.

In fact, the United Kingdom-based global information services provider Clarivate listed NTU as the No. 7 research organisation globally for the greatest number of research papers referenced by the inventions of Clarivate's top 100 global innovators.

Says Prof Louis Phee, Vice President (Innovation and Entrepreneurship): "We've set up an ecosystem where NTU students, graduates and faculty members with guts and ideas can create an innovation and spin off a company from it, while being supported by the University."

Leap, license, launch

While Assoc Prof Tay and Assoc Prof Tan chose to license their technology, other NTU scientists have dived into entrepreneurship.

Dr Shi Xu, former Associate Professor at NTU's School of Electrical and Electronic Engineering (EEE), is a pioneer in Singapore's deep-tech startup ecosystem. In 1999, he founded Nanofilm Technologies International (NTI), which provides advanced nanomaterial solutions using vacuum coating technologies and processes that Dr Shi invented and patented during his tenure at NTU.

Since spinning off from NTU, Nanofilm has become the first local deep-tech unicorn to be listed on the Singapore Exchange. It continues to expand into growing areas in nanotechnology to keep up with market demand.

The company has presence in Europe, China, Vietnam and Japan, and is constructing a 44,000-sqm mega plant in Vietnam.

In 2023, Nanofilm and NTU launched the NTI-NTU Corporate Lab, a multimillion-dollar facility supported by Singapore's public sector that brings industry together with academia to develop next-generation nanotechnology solutions.

Reflecting on his technopreneurial journey, Dr Shi explains that scientists face common challenges when turning their research into a business: "Scientists often dive too deeply into research and may miss the sweet spot for commercialisation."

Dr Shi emphasises the importance of being commercially savvy and having skills in areas such as effective business structuring and people management.

Finding harmony between science and business is not a one-person job, as seen in the partnership between Assoc Prof Darren Sun from NTU's School of Civil and Environmental Engineering and Mr Wong Ann Chai, formerly an adjunct professor at NTU's Nanyang Business School.

Assoc Prof Sun has decades of research expertise in nanomaterials and, as an esteemed International Water Association Fellow, he was interested in using advanced additive manufacturing to produce membranes. Meanwhile, Mr Wong has prior experience as a banker helping companies raise capital and go public.

In 2013, this meeting of minds birthed Nanosun, a spinoff that uses 3D-printed nanomaterials to manufacture cutting-edge membranes for water treatment and renewable energy applications.

"NTUitive was instrumental in our growth in the early years by providing an incubator and competencies as well as helping us access grants," says Mr Wong, Nanosun's Managing Director.

"We've learnt a lot from NTU and it's time for us to see how we can do more."

Starting with microfiltration and ultrafiltration flat sheet membranes, Nanosun has deployed water treatment solutions in Singapore, Indonesia, China and Taiwan, particularly for industrial wastewater treatment. The spinoff has secured million-dollar contracts, bagged awards and established its presence in the Asia Pacific.

Innovating with industry

Speed is key to staying competitive in translational research, and leveraging the expertise of an industry partner could be helpful. NTU's industry partnerships with major corporations, such as Continental, Schaeffler and HP, seamlessly bridge this bench-to-industry gap.

"We assess the complementary resources and capabilities each party brings to the table to ensure a collaboration that can eventually bring about impact to the research and development ecosystem," says Prof Lam Khin Yong, NTU's Vice President (Industry).

By working with industry, NTU researchers are attuned to real-world pain points. Applying their findings back in the lab, they enhance the impact and relevance of their research by crafting solutions that address market needs.

For instance, technology company Continental and NTU formed a corporate lab in 2019 that receives support through the National Research Foundation, an agency that sets Singapore's direction for research and development.

"The lab's research contributes to Continental's strategy in developing new products and services in artificial intelligence (AI), future mobility, cyber security, wireless technologies and more," says Dr David Woon, Director (Academic Liaison) at Continental and Co-Director of the Continental-NTU Corporate Lab.

The lab is working with public transport operator Go-Ahead Singapore to enhance the driving safety management systems of Go-Ahead's buses. In the tie-up, NTU researchers built an AI model that predicts potential accidents and alerts fleet operators to abnormal driving patterns that indicate a heightened chance of accidents.

In 2023, the lab started piloting the system on 10 Go-Ahead buses and collected driving data to refine their AI model and enable more accurate predictions.

Partnerships with industry also lead to research that enhances the quality of education, resulting in training that can benefit industry, says NTU's Prof Lam Kwok Yan, Associate Vice President (Strategy and Partnerships).

For instance, a joint lab between Mastercard and NTU not only conducts cyber security research, but also offers relevant skills training and education programmes to better equip students for future careers in cyber security and digital trust and further research in these areas.

"This builds a talent pipeline with critical research and operational skills that are in short supply in industry," adds Prof Lam, who co-leads the Mastercard-NTU joint lab.

At a joint lab between automotive and industrial components supplier Schaeffler and NTU, scientists and students work with Schaeffler employees to develop insights from application-driven research projects that flow directly into the development of new products and technological solutions.

"The company-on-campus concept enables intensive exchange and close cooperation between our employees and doctoral candidates and students from NTU on future-oriented research projects," says Dr Alvin Wong, Head of Digital Transformation Asia/Pacific at Schaeffler and Deputy Director of the joint lab called the Schaeffler Hub for Advanced Research (SHARE) at NTU.

The lab focuses on expanding the state of advanced innovation and technology in areas like robotics and Industry 4.0. It also plans to venture into professional service robotics. To date, it has over 40 invention disclosures, with 17 patents awarded.

One success story is the Dual EXtendable (DEX) autonomous mobile robot designed to work with shopfloor employees to boost productivity in industrial settings.

DEX can communicate with different robots, recognise speech and gestures, and avoid obstacles, including moving ones.

Building tools for societal good

Multi-institutional collaborations involving academics, policymakers and industry players bring together diverse expertise and perspectives. Through this, research findings can be translated to benefit industry and the broader community.

Prof Theng Yin Leng and Dr Vered Seidmann from NTU's Wee Kim Wee School of Communication and Information gained these insights from working with the Workplace Safety and Health Institute at Singapore's Ministry of Manpower and the Republic's Workplace Safety and Health Council (WSHC).

Together with Dr Seidmann and six co-investigators from the School, Prof Theng spearheaded the creation of a digital tool that measures a company's level of workplace safety and provides recommendations for improvement.

The tool has now been launched by WSHC as a free online company administered assessment platform called iOwnWSH, as part of Singapore's goal to foster a no-blame culture and a mindset that workplace accidents are preventable.

"The tool is particularly useful for high-risk industries such as construction, logistics and transportation, marine, services and manufacturing. Being a free tool, it would also benefit small- and medium-sized enterprises that often have limited budgets for their safety department," says Dr Seidmann.

Gamified solutions, such as pictorial card games featuring common workplace hazards and good practices, were also created. The researchers are working to advance these solutions further and intend to partner companies from high-risk industries to test them.

"We realised that it's important to use pictures when communicating workplace safety and health ownership. With our gamified solutions, we want to turn routine safety briefings into something fun and easy to understand," adds Prof Theng.

Another assessment tool resulting from a multi-institutional tie-up is the Singapore Ability Scales (SAS). A collaboration between NTU, the National Institute of Education (NIE) at the University, Singapore's Ministry of Education (MOE) and test publisher GL Assessments, SAS is a commercially available psychometric tool administered to students to comprehensively evaluate the cognitive abilities important for learning and educational development.

NIE's Prof Kenneth Poon explains that tests developed in other countries are not tailored to Singapore's context and norms, impeding the accurate assessment of children's cognitive abilities.

Together with MOE's Adjunct Assoc Prof Mariam Aljunied, Prof Poon and his NIE team adapted the British Ability Scales by modifying the item instructions, stimuli and scoring

rules for Singapore's context. They also conducted the test with 2,000 local children and youths to create an appropriate benchmarking sample for performance comparison.

SAS provides key information to facilitate school placement decisions for children with special educational needs in Singapore. "We now have a test that gives results we are confident in, which is very important when we advise parents on how best to support their children," says Prof Poon. "At least a quarter of psychologists in Singapore have also been trained to administer this test."

Movers and shakers

Translational research is driven by passionate people who bring innovative ideas to life. To groom forward-thinking talent, NTU seeds the entrepreneurship spirit in students.

"My co-founders and I were students of a Minor in Entrepreneurship course offered at the NTU Entrepreneurship Academy (NTUpreneur) during our undergraduate studies," recounts Dr Rex Tan, Chief Technology Officer of Aevice Health, an NTU spinoff that develops medical devices to monitor patients with respiratory diseases. "That experience certainly helped us appreciate entrepreneurship in a structured way."

The company invented AeviceMD, a smart wearable stethoscope that continuously analyses chest sounds to monitor vital signs and detect early signs of worsening respiratory disease.

During his PhD studies at NTU's EEE, Dr Tan witnessed NTUitive helping research groups spin off technologies. Both he and Aevice Health co-founder Mr Adrian Ang later experienced this when NTUitive provided advice and linked them up with industry stakeholders from the start of their entrepreneurial journey.

Aevice Health has secured regulatory approval for AeviceMD in Singapore and the United States, and continues to grow its pipeline of commercial and pilot partners locally and internationally.

Looking ahead, Dr Tan sees NTU as a launchpad for projecting Singapore medtech innovation globally.

Another pair of NTU graduates who spun off a company from the University are VFlowTech co-founders Dr Avishek Kumar and Dr Arjun Bhattarai. Their spinoff develops vanadium flow batteries for large-scale and long-term storage of renewable energy like solar energy.

Since its 2018 inception, VFlowTech has raised US$13 million (S$17.3 million). Its PowerCube technology was deployed to provide sustainable electricity to Singapore's Pulau Ubin island. PowerCube has also been deployed in several Asia-Pacific countries and Africa.

NTU I&E is also working to encourage more students, graduates and faculty members to dare to dream the startup dream. It does this through NTUpreneur, which aims to cultivate an entrepreneurial mindset in the NTU community.

Says Prof Phee, who leads NTU I&E: "Unlike other places where you're short of ideas or technology, we are full of them at NTU. We're trying to nudge people to try out entrepreneurship and translate these ideas to the next level as an enterprise."

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