YOUR SG GUIDE TO
RESEARCH, INNOVATION AND ENTERPRISE

RIE NEWS

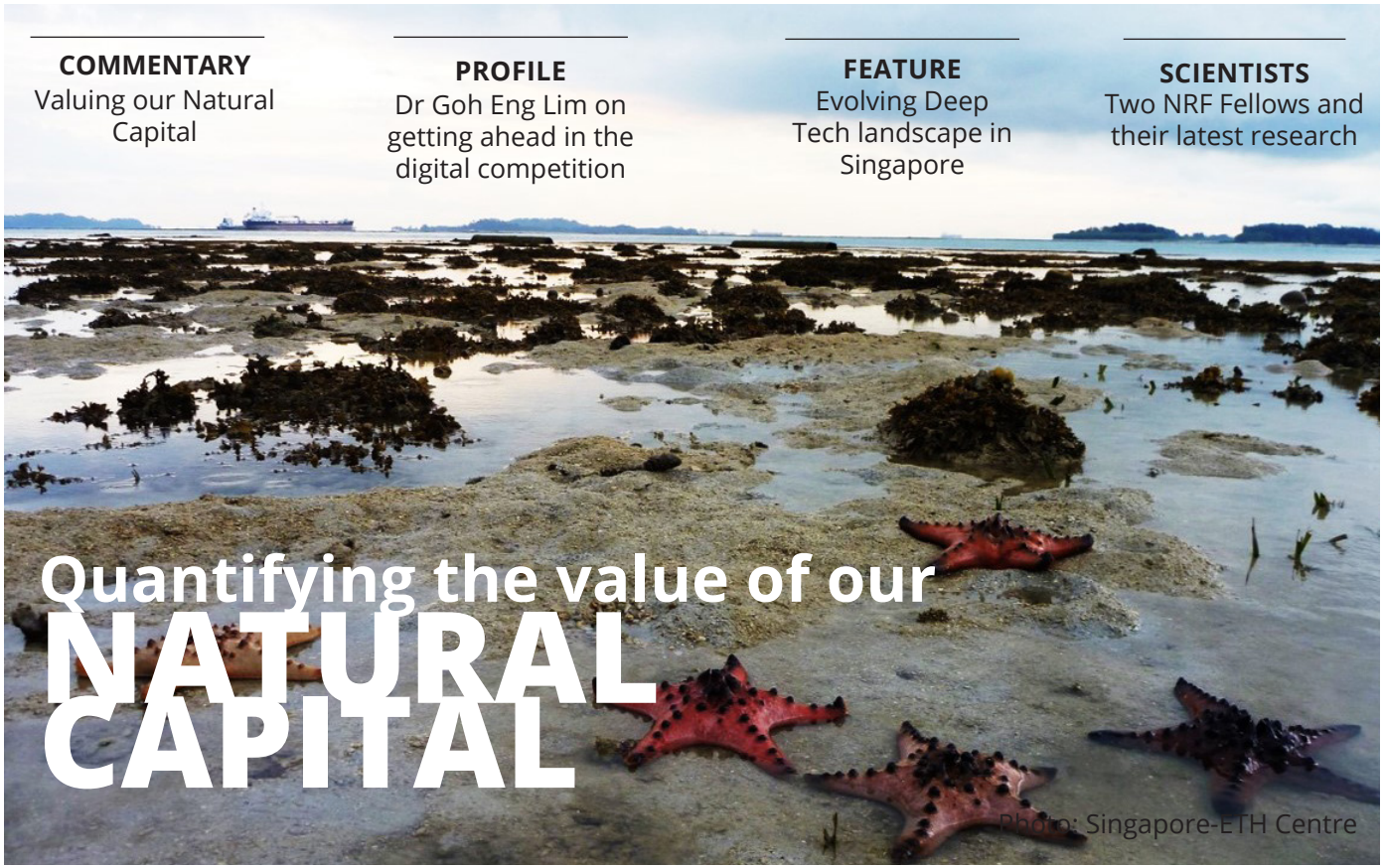
October 2018

COMMENTARY
Valuing our Natural Capital

PROFILE
Dr Goh Eng Lim on getting ahead in the digital competition

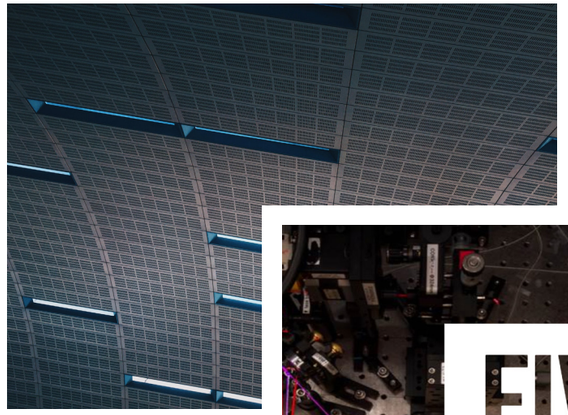
FEATURE
Evolving Deep Tech landscape in Singapore

SCIENTISTS
Two NRF Fellows and their latest research



Quantifying the value of our NATURAL CAPITAL

Photo: Singapore-ETH Centre



1 New corporate lab tie-up for Surbana Jurong, NTU

Sustainability rules at the new Surbana Jurong-NTU corporate laboratory that was launched in July. For example, researchers will explore underground spaces for storing liquefied natural gas so that the space aboveground can be freed up for other uses. Another project that deserves attention is a chilled ceiling technology that uses special composite materials for ceiling panels. The panels transfer heat more effectively than conventional aluminium panels, reducing the need for air-conditioning, thereby improving energy efficiency.

2 Robots and sensors to feature in train maintenance

Researchers at the SMRT-NTU corporate laboratory have been exploring how technologies can be used to enhance train maintenance and improve travel experience. One new tool that has been developed is a portable robot that uses sensors to inspect train axles. The automated system saves time and manpower costs – checks can be done without disassembling the train wheels and axles from the train bogie.

3 Novel method to cut fat absorption by human body

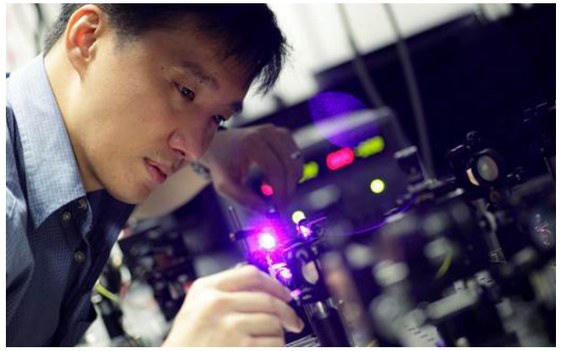
The fight against obesity has been given a boost with the discovery that nano-sized cellulose fibres added to food could cut fat absorption by up to 48 per cent. Typically, digestive enzymes in the gut will break down triglycerides into fatty acids, which are absorbed by the small intestines and converted to fat by the human body.

However, NTU and Harvard researchers have found that when triglycerides are trapped in nanocellulose fibres – like how cotton balls absorb oil – enzymes involved in breaking down triglycerides for fat absorption are less effective, thus reducing the amount of fatty acids that can be absorbed by the body. This method has been granted a US provisional patent. The researchers are working to produce adequate scientific evidence to prove the efficacy and safety of the application, to convert the provisional patent into a full patent application in a year's time.

Associate Professor Ng Kee Woei and Associate Professor Joachim Loo discovered that nanocellulose can bind and trap fat molecules known as triglycerides. Photo: NTU

4 New programme to translate quantum science

Singapore has been investing in quantum research for about 20 years. NRF has just launched a quantum engineering programme to translate this body of quantum knowledge into applications such as quantum cryptography to safeguard against cybersecurity threats, precise quantum clocks, and enhanced imaging technology. The programme office will be set up at NUS.



Alexander Ling, Head of the Centre for Quantum Technologies at NUS

5 More secure online activities in the works

Early demonstration of new quantum technologies deployed in space could lead to more secure online activity for consumers in everything from financial transactions to online conversations. Singapore and UK will collaborate to build a satellite quantum key distribution test bed. The satellite will test the secure distribution of cryptographic keys over globe-spanning distances. In Singapore, work will be led by the Centre for Quantum Technologies at NUS.

GETTING AHEAD IN THE DIGITAL COMPETITION

DR GOH ENG LIM CITES SINGAPORE'S REPUTATION AS A TRUSTED COUNTRY AS THE TOP REASON WHY THE CITY-STATE IS POISED TO BE A GLOBAL DIGITAL HUB

The engineer Dr Goh Eng Lim has been interviewed on numerous occasions on the Spaceborne Computer project – a joint experiment by Hewlett Packard Enterprise (HPE) and NASA to send the first ever commercial off-the-shelf (COTS) computer system into space. But his eyes light up when asked to talk about it again.

"The original idea was to see if a COTS supercomputer that has not gone through all the long years of hardening can function in space," he says. "Many thought it wouldn't, and that's the reason why we hardened it with only software and sent it up. My proposal to NASA was why not turn the problem around to just send an unhardened computer up and see when it will break, and perhaps we will learn something."

Sent to the International Space Station (ISS) in August 2017, the software-hardened COTS supercomputer recently completed its operations in space as part of the year-long experiment aboard. Although some peripheral parts broke down, the system kept going and has succeeded in becoming the first COTS to run one teraFLOP (over one trillion calculations per second) onboard the ISS in the harsh conditions of space. "The results so far have excited NASA enough to want to bring it back carefully to study why it had lasted so long," he says.

The Spaceborne Computer has laid the groundwork for performing compute-intensive experiments without aid from Earth, which will be necessary to advance space exploration on journeys millions of miles away from our home planet. The supercomputer was initially scheduled to return to earth in November 2018, but will now remain in space for a while longer as NASA trials the operation of an Above the Cloud service.

Dr Goh shares how a life lesson can be taught through the project. "I think it is important for students and researchers to know that sometimes when your proposal can't get accepted in one way, it may be accepted in another way," he says.

Gap between human and machine intelligence

Dr Goh was recently appointed to the scientific advisory board of the National Research Foundation. He is the first Singaporean to be appointed, owing largely to his decades of experience with high-performance computing and artificial intelligence technologies.

Will machines be indistinguishable from humans one day? Dr Goh thinks so. Some of the best chatbots that run on extensive computing power and have undergone deep learning are already quite indistinguishable from humans, albeit still prone to a certain degree of error now.

"By training machines with data attributed to humans, they can engage in a conversation with you. (Although) Some people may get a little uncomfortable after finding out that they are talking to a machine," he says.

"Some of the best voice transcription and translation systems today already produce high quality results," he says, before proceeding to demonstrate this by whipping out his mobile phone and uttering some lines in English into a translation app. The mobile phone begins broadcasting the exact lines in Chinese language with a standard accent almost instantaneously.

"This is one of the best translation apps now. I do not have to train it with my accent. I don't know what accent I have now, but it translated every word I said,"

"I think it is important for students and researchers to know that sometimes when your proposal can't get accepted in one way, it may be accepted in another way,"

Dr Goh Eng Lim is the vice-president and chief technology officer for high performance computing and artificial intelligence at Hewlett Packard Enterprise. Photo: Hewlett Packard Enterprise

he laughs and adds: "So imagine if this is used in a bot and even the voice and accent sound human-like."

But Dr Goh highlights that whether machines can be indistinguishable from humans is a different question from whether machines can think like humans – the latter being a further away reality. He cites the limitations of today's artificial networks as one of the reasons – the networks today are too simplistic to mimic the functions of the human brain.

He adds that the Ecole Polytechnique Fédérale de Lausanne's (EPFL) Blue Brain project in Geneva, which will deploy a HPE supercomputer for modelling and simulation of the mammalian brain, is starting to uncover the complexities of the living brain – a rat's brain neuron alone could contain 20,000 equations – and how they are much more complex than today's networks used in artificial intelligence.

Smart Cities

How well a smart city functions is underpinned by how quickly it transforms digitally, and Dr Goh thinks that Singapore has unique advantages that put it ahead of other countries in the race to become the leading smart city.

"One thing about Singapore is that it is a city and also a country," he says. "This is powerful due to the speed in which a vision can be funded and implemented from the get-go."

But perhaps Singapore's reputation as a trusted country trumps all other structural reasons as to why we are in a strong position to build up a global digital hub. Having worked for a Silicon Valley company since 1989 and being based there since 2000, Dr Goh thinks this is a key differentiator in attracting companies to set up shop here. Even then, a vibrant research and enterprise ecosystem is only sustainable if companies can continuously tap into top talent circulating in the country, because "companies are willing to hire talent to innovate for a need that generates profits," he says. It is therefore crucial that Singapore is able to continue attracting new talent, so that even if established ones are drawn to other countries, fresh talent continues to rejuvenate the R&D ecosystem.

Learning from Failure

How does Dr Goh view failures in his successful career? He says that failure can actually be seen as a badge of honour and he has gone through it himself. Having spent the bulk of his career with Silicon Graphics International (SGI) which was later acquired by HPE, he has been through ups and downs in the company and learnt life values that failure brings, such as the need to listen thoughtfully to others and stay humble.

But he quickly adds that while failure can bring important lessons, it does not mean that one person should go through "lots of failures". Instead, he muses: "This is why there is an immense need to attract lots of talent because in doing so, we allow the room for individuals to learn from each other's failures and experiences in order to eventually succeed."

Dr Goh backs this up with the example of the Libratus computer programme that he was involved in. Libratus is an artificial intelligence computer programme designed to play Heads-Up, No-Limit Texas Hold'em Poker. Carnegie Mellon University first received funding from the National Science Foundation (NSF) to develop an AI programme to beat humans in the game with more decision points than atoms in the universe. This is after AI defeated humans in checkers, chess and Go. "But poker is more challenging because you don't know the other players' cards," he says. "So we took up that challenge. In 2016, we competed and failed. We lost to the top four poker players. But NSF continued funding their research, and learning from these top poker players, we won in 2017."

"If you don't give that freedom or allowance to fail, then people don't try. If we just get enough people to try new things, you create a culture conducive for unicorns to emerge... I think this is one of the secret sauces of the valley," he says.

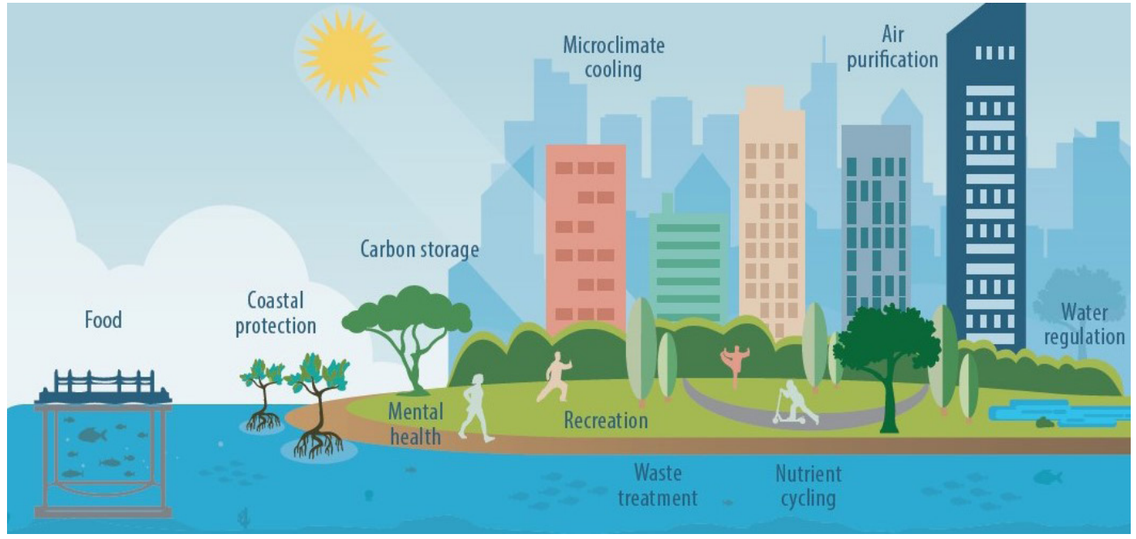
Dr Goh Eng Lim sits on the National Research Foundation's Scientific Advisory Board. The board convenes annually to advise on Singapore's R&D policies and programmes.

COMMENTARY

VALUING OUR NATURAL CAPITAL

DAN RICHARDS

PRINCIPAL INVESTIGATOR
NATURAL CAPITAL SINGAPORE
SINGAPORE-ETH CENTRE



Nature provides us with many benefits in Singapore. Photo: Singapore-ETH Centre

Nature provides us with many benefits: roadside trees provide shade and cooling, forests regulate flood risk, and parks provide spaces for recreation. The ecosystems that provide these benefits are sometimes referred to as a nation's natural capital. In spite of its importance to society and the economy, the role of this natural capital has historically been under-recognised and undervalued.

In many parts of the world, particularly in new economies that prize economic growth, the failure to recognise the benefits obtained from natural capital has resulted in ecological degradation, leading to urban warming, destructive floods, the loss of biodiversity, and compromised health of the residents. Urban planners and other policy makers routinely consider manufactured, human, social, and financial capital in reaching their decisions. To ensure that they also consider natural capital, it is essential that we can represent its value to human wellbeing.

For this reason, natural capital is increasingly being quantified in countries around the world. Globally, the economic value provided by natural capital is substantial, with estimates reaching trillions of dollars per year - equivalent to two or three times the global gross domestic product.

While several national-scale assessments of natural capital have been conducted, for example in Europe and North America, such national assessments have never been done in a tropical and largely urbanised country. To make an assessment relevant to the context of Singapore, it is important to account for the warmer climate and heavy rainfall, urban ecosystems such as green buildings, and forest types like mangroves that only occur in the tropics. It is also necessary to include the wealth of marine ecosystems present within Singapore's territorial boundaries.

As one of the global leaders in green urban development, Singapore has long recognised that the quality of the natural environment is key to economic growth and urban liveability. Government agencies have already introduced many schemes to promote the greening of the city, such as the Landscaping for Urban Spaces and High-Rises Programme by the Urban Redevelopment Authority and the Skyrise Greenery Incentive Scheme by the National Parks Board (NParks).

NParks has also introduced biophilic design typologies in green spaces such as the Singapore Botanic Gardens Learning Forest, and the Housing and Development Board has since embraced biophilic design concepts as well. These are excellent initiatives, but a unified valuation of all Singapore's natural capital is also needed to secure the long-term delivery of benefits from the environment.

"

"A unified valuation of all Singapore's natural capital is needed to secure the long-term delivery of benefits from the environment."

Dr Nigel Goh, Director of Research at NParks' Centre for Urban Greenery and Ecology (CUGE), said: "Natural capital assessments provide a basis for conserving Singapore's biodiversity and natural ecosystems. They will enrich the suite of tools and techniques that NParks and other agencies have developed for evidence-based urban planning, development, and management. Arising from this project, NParks hopes that there will be greater understanding and awareness of the value of our natural ecosystems."

Researcher from the Singapore-ETH Centre conducting biodiversity surveys. Photo: Singapore-ETH Centre

The National Research Foundation is supporting research on natural capital in Singapore by funding a new cross-institution and interdisciplinary research project - “Natural Capital Singapore”. This project will undertake the first national assessment of natural capital in Singapore. By mapping the current state of Singapore’s ecosystems, and quantifying the benefits that they provide to people, this project will help government agencies make more informed decisions in assessing the trade-offs between future development and environmental concerns.

Ms Hwang Yu-Ning, Deputy CEO and Chief Planner for the Urban Redevelopment Authority (URA), said: “The Natural Capital Singapore project is important because it strengthens our ability to do evidence-based planning to help in our decision-making. There will be other considerations as well but the project will help us to better define and understand the contribution of natural capital so as to initiate a more robust conversation about the different trade-offs”.

An ambitious project of such a scale calls for diverse expertise. Led by the Singapore-ETH Centre and the Department of Geography at the National University of Singapore (NUS), the project brings together a multi-disciplinary team with expertise in ecology, geography, urban planning, landscape architecture, and environmental economics. In addition to researchers from ETH Zurich and NUS, the team includes researchers from Nanyang Technological University (NTU), the Singapore-MIT Alliance for Research and Technology (SMART), and CUGE. Natural Capital Singapore aims to provide an understanding of the current health and status of Singapore’s ecosystems, and develop tools to predict the potential environmental impacts of future urban development. To assess natural capital in Singapore, the project will first build on existing ecological studies.

Several research groups in Singapore have measured some of the value of natural capital. Work by the Urban Climate Lab at NUS has shown that trees can contribute to lower urban temperatures, as illustrated by the forest area of the Singapore Botanic Gardens being 1-2°C cooler than the more built-up Visitor Centre. A number of projects initiated by CUGE are also underway to quantify the physical and psychological benefits of people-nature interactions in green spaces. Findings from these studies will contribute toward the planning of greenery and development of therapeutic gardens.

In addition to synthesising existing ecological knowledge, Natural Capital Singapore will develop new methods to model and map the benefits of ecosystems. Satellite images and point-cloud data from laser scanning will be used to map the different types of ecosystems and their structures. A national survey will be conducted to better understand people’s perception of ecosystems and the opportunities for recreation that they offer.

By the end of the project, the team will produce a report on Singapore’s natural capital to help guide policy, and develop an interactive digital planning tool. The tool will help urban planners, developers, and architects to visualise data on the benefits of ecosystems, as well as predict the impacts of new designs through simulation. With more accurate information on the impacts of developing natural areas, planners will be better equipped to select designs with the smallest environmental impact and bring the greatest benefits from ecosystems.

The Natural Capital Singapore research project was launched in August 2018. The three-year project is co-led by the Singapore-ETH Centre and NUS, and supported by the National Research Foundation under the CREATE programme.

FEATURE

DEEP TECH LANDSCAPE GAINING GROUND IN SINGAPORE

A panel session at Deep Tech Summit, one event at the Singapore Week of Innovation and Technology.

Nearly 30 speakers of renown from Singapore and around the world were at the event to discuss deep tech issues around AI, blockchain, medical technology, venture building and the future of talent. They include Professor Subra Suresh, president of Nanyang Technological University; Steve Leonard, founding CEO of SGInnovate; Professor Tsuhan Chen, chief scientist, AI Singapore; Dr Caroline Hargrove, chief technical officer, McLaren Applied Technologies, England; Joe Fitzsimons, principal investigator, Centre for Quantum Technologies, Singapore; Dr Ayehsa Khanna, co-founder and CEO, Addo AI, Singapore; and Katherine Myhre, CEO, Norway Health Tech, Norway.

About 500 participants including investors, government officials, corporate innovators, researchers and deep tech entrepreneurs from around the world attended the event.

Singapore-based startup Seitee and Blickfeld from Germany are some of the deep tech startups that exhibited their innovations at SWITCH. Seitee gathers processing power from mobile devices around the world to offer a decentralised cloud computing and storage platform. Blickfeld has developed 3D solid state LIDAR, or light detection and ranging, technology that can be applied in the automotive, industrial, smart city and security sectors.

Deep tech is dependent on scientific talent and innovations. Since the 1980s, the Government has supported R&D activities including developing research engineers and scientists. The latest Research, Innovation and Enterprise Plan received a whopping S$19 billion budget for five years ending in 2020. The Government has also backed the startup ecosystem, providing grants and funding. These efforts resulted in the Republic being ranked fifth – two ranks higher than the 2017 list - by the Global Innovation Index (GII), an annual ranking done by Cornell University, Insead and the World Intellectual Property Organization (WIPO) to compare the innovation performance and capabilities of global economies. Singapore was named the most innovative country outside of Europe and is the only Asian country to make the top 10.

From the talent perspective, deep tech is an area only a few are qualified to do, said Steve Leonard, SGInnovate's CEO. Deep technology is about scientific discoveries or meaningful engineering innovations in biomedical, renewable energy, aerospace, marine and other sectors. When commercialised, deep technologies are able to create a big impact on societies, economies and lives.

In Singapore, researchers and scientists are using science to improve many areas from boosting water purification and enhancing autonomous vehicles to developing nano satellites and building machine vision capabilities.

"SGInnovate wants to help individuals to do more of this. It includes investing in their startups. By taking equity, we demonstrate our seriousness in assisting them to build their businesses," said Leonard. By the end of this year, SGInnovate will have invested in about 40 deep tech startups. The agency actively helps to identify appropriate talent to aid expansion as well as link them up to potential customers here and overseas.

Such is SGInnovate's reputation for successfully placing dozens of people in these startups that academic staff at local universities are beginning to refer their doctoral fellows and other students to the agency for potential jobs at the deep tech startups.

One deep tech area that has recently grabbed headlines here and around the world is blockchain

Panellists discussed how artificial intelligence will change the future of work at Deep Tech Summit.

and cryptocurrency. Many investors were apprehensive about investing in blockchain because the concept of a distributed ledger on the Internet is difficult to understand. While blockchain was first used for cryptocurrencies, it is now being applied to other areas like manufacturing and financial services.

Venture capitalist Mock Pak Lum who has invested in blockchain and cryptocurrency startups has two tips for investors looking to step into this area, that is, examine the strength of the startup team and its advisors, and ensure that the startup has access to development resources with proven blockchain expertise. "It's important to contact the advisors and talk to them as part of the due diligence process. Development resources with blockchain expertise is also crucial for executing the startup's business plan, so checking on the availability and access to these facilities is crucial," said Mock, managing partner, Blockchain Fund 1, Tembusu Partners.

"SGInnovate wants to help individuals to do more of this. It includes investing in their startups. By taking equity, we demonstrate our seriousness in assisting them to build their businesses,"

- Steve Leonard, CEO, SGInnovate

Investors like Mock have less trepidation in recent months about investing in deep tech. They have gotten a deeper understanding of deep tech and learnt how to evaluate them. Alex Crompton, managing director of Entrepreneur First Singapore recalled that when he first arrived in Singapore in 2016, he discovered that venture capital (VC) partners were apprehensive about investing in deep tech startups. Entrepreneur First assists researchers and scientists working in R&D organisations or tech companies to found their own startups.

The VCs felt they did not have the skills set or the deep understanding of the science or technology to evaluate them, said Crompton. VCs are warming up to such investments. The component of technology in deep tech is much higher so VCs among other things, would have to closely inspect the technology architecture. If they do not have the skills set to do this, they can always seek an expert to do the tech due diligence.

"Once you've gotten over this hump, building a company is no different from any other startup because the issues of marketing, growth, hiring and product development are the same everywhere," added Crompton.

This positive mindset has also gradually pervaded among researchers and scientists, he said, pointing to the nearly eight times hike in applications last year to join Entrepreneur First startup bootcamp classes. This is good news because it showed that Singapore-based scientific talent are interested in entrepreneurship.

WILMAR-NUS CORPORATE LABORATORY

THE NEW WILMAR-NUS CORPORATE LABORATORY WANTS TO CREATE HEALTHIER FOODS FOR SINGAPOREANS. DR REBECCA LIAN, DISTINGUISHED FELLOW AT WILMAR, TELLS US HOW.

One of the aims of the Wilmar-NUS Corporate Laboratory is to prevent and manage diseases or promote health through healthier food. Under this, you are looking to create healthier oils through the blending of different source oils or using the method of enzymatic structuring. Could you share a bit more on the two approaches?

Depending on the type of seeds it is extracted from, the oil will have a unique fatty acid profile as well as different types of intrinsic phytonutrients. Fatty acids matter because they are an essential component of all cell membranes. Cell membrane allows nutrients to enter the cell and at the same time keeps toxins out. As our body does not synthesise fatty acids, we consume them through food such as the cooking oil we use.

Blending different types of oils is a potential reformulation method to make healthier oil. By blending, you can create oils that have the right fatty acid profile, for example, for use in lipid management in the case of hyperlipidaemia. You can also attain a higher level of vital nutrients from different oils. These nutrients include phytonutrients such as phytosterol, omega 3 and gamma oryzanol, which are important contributors to health as they possess antioxidative properties and are able to lower cholesterol and the risk of heart disease.

A well-known example in the enzymatic structuring of edible oil is in the formulation of a mother's milk fat (OPO), which is an important ingredient in baby formula. Fat contributes to almost half of a baby's energy intake. The structure of the fat molecule in vegetable oil (POP) is different to that of OPO as illustrated in the diagram below. This unique OPO structure mimics the fatty acid profile of human milk and allows babies to absorb more palmitic acid and calcium, hence bringing about important benefits

such as improved energy intake, reduced constipation and increased bone mineral density.

As the world's largest producer of consumer pack cooking oils and a major supplier of oils and fats to the food manufacturing industry, Wilmar will be able to translate positive clinical findings into a solution to deliver health-enhancing benefits.

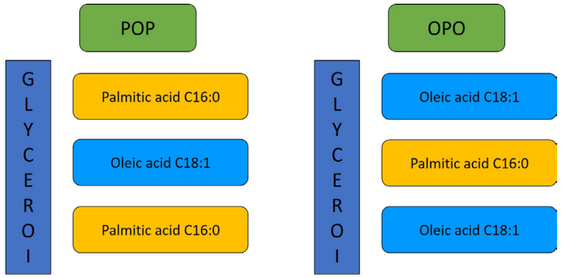


Diagram showing the structure of the fat molecule in vegetable oil (POP) and mother's milk fat (OPO).

There is a global shift from animal protein to plant protein driven by health and sustainability concerns. One project you are working on to support this is to identify plant protein that can create healthier and tastier meat-mimetic with less unhealthy constituents compared to animal meat. How difficult is it to create palatable substitution for meat that is acceptable to consumers?

The challenge is there but not unsurmountable to create a palatable plant protein meat analogue that will appeal to consumers. Meat alternatives are currently made the artisanal way. To create the desired taste and texture, it involves several aspects of engineering of the plant protein to create the right texture, emulsion structure and develop right flavour chemistry.

As plant protein is a natural stream from oil extraction, Wilmar has the opportunity to experiment with many different plant proteins to bring interesting and healthier products to market.

You have talked about the benefits of incorporating natural dietary fibre into carbohydrates. For instance, dietary fibre can help lower glycaemic index and reduce the risk of obesity and diabetes. How would your research go about creating products that are high in fibre content for the Asian diet?

Nature has given us an array of beans, pulses and grains which are rich in natural dietary fibre. The challenge is to have the right processing and product design to re-introduce these healthy foods to consumers and win over their taste buds.

In the Asian diet, polished rice is a carbohydrate rich staple, one of the three macronutrients required by our body. Unfortunately, there is not a lot of fibre in polished rice and hence what we are trying to do is to deliver a healthier carbohydrate that contains natural dietary fibre and is still acceptable to the Asian palette. In doing so, we will be able to prevent or reduce the risk of metabolic disorders like Type 2 Diabetes and obesity.

There is a huge potential for Wilmar to translate clinical findings in healthier carbohydrates into consumer products given that Wilmar is a global leader in flour and rice processing as well as in the manufacturing of consumer pack flour and rice.

What are the upcoming developments in food research that you think would be the most significant?

In my view, the three developments in food research that will have the most impact in Asia are:

a) Industrial translation of clinical knowledge on the health of macronutrients to products which are tasty, convenient, contemporary, natural and healthy for consumers.

b) Leadership by the food industry with the support of governing authorities to make available healthier food products and ensure that our dietary guidelines are aligned with research findings. The public must also be provided with factual, easy-to-understand science-based information on food and health so that they can make informed healthy choices.

c) Many meals are taken out of home today hence it is becoming more important that the food industry and government bodies work together to deliver healthy solutions in the "out of home food landscape".

The three developments above are fundamental in ensuring that going forward, we adopt a holistic approach in formulating health solutions that are centred on the idea that "prevention is better than cure". This will lead to a society that is adding health quality to the years of life as it advances in age.

Why did you decide to focus your career on research for healthier food?

I spent more than 45 years studying food and nutrition and subsequently working for the world's biggest food company (34 years in Nestle). In 2018, I came out of retirement to join Wilmar, one of the largest agri-food companies in Asia. I see this as a very meaningful opportunity to put what I have learnt over the years into the area of food and health.

Health is the most important. One can have all the wealth but without health, it is pointless.

Linking food with health is a relatively new area of study especially with Asian dietary habits. Much more research is needed to help us understand this relationship. The lack of research means most food industries have yet to be able to plug the gap. A lot of the "healthy foods" available in the market today are products of marketing rather than factual clinical science results. Making the right choice of the three macronutrients in our diet is key to impact our health in a positive way. With Wilmar's core businesses in these three macronutrients, we can play a significant role in engaging in clinical studies and translating findings into healthier food products for consumers.

What is your vision for the use of food as the new medicine?

We are at a pivotal time where the food industry is experiencing a paradigm shift towards food as the new medicine. Consumers are demanding healthier and more nutritional food. We have the capability and the responsibility to create and make available food which truly impacts the health of the consumer. At the same time, we have the responsibility to use the knowledge from research and clinical studies to help consumers understand how and why food can be the medicine. Through wiser food choices, we can not only add more years to our lives, but more importantly, improve the quality of the lives we live.

OUR NRF FELLOWS

PROFESSOR ROBIN CHI

DIVISION OF CHEMISTRY AND BIOLOGICAL CHEMISTRY,
SCHOOL OF PHYSICAL AND MATHEMATICAL SCIENCES,
NANYANG TECHNOLOGICAL UNIVERSITY, SINGAPORE

IMPROVED CHEMICAL PROCESSES FOR BETTER PRODUCTS

Professor Robin Chi first became interested in chemistry during his high school days. Coupled with a curiosity about the universe, he chose to embark on a scientific career. “I just feel most satisfied when dealing with science,” he says.

A full professor at the Division of Chemistry & Biological Chemistry at the Nanyang Technological University Singapore’s School of Physical & Mathematical Sciences, Professor Chi first joined the university as a recipient of the 2009 National Research Foundation Fellowship.

Today, his laboratory is committed to state-of-the-art original chemistry research that addresses problems of both fundamental and practical significance. The team works on the areas of organocatalysis, chemical synthesis, and functional molecules.

Professor Robin Chi received the NRF Fellowship in 2009 and the NRF Investigatorship in 2016. Photo: Professor Robin Chi

A key objective is to develop green and efficient synthetic methods to make functional molecules, and to understand the principles guiding bond breaking and formation events.

“My lab creates and develops new chemistry knowledge and solutions that bring cheaper, healthier medicines and related products,” he says.

Even as a chemist, he is inspired by biological processes.

This explains why, as part of the lab’s core objective for green chemical and pharmaceutical industries, his team is working on developing new basic activation modes enabled by biomimetic organic catalysts. These refer to reactions that imitate the biological processes that occur in nature.

The new activation modes provide conceptually novel strategies for chemical bond breaking and formation. This then dramatically reduces the synthetic steps and waste produced in the manufacturing of molecules.

“I feel that many chemical reactions can be done differently, with better outcomes,” Professor Chi says.

What does this mean for society at large? The chemical reactions developed by his lab can be widely used for more efficient synthesis and manufacturing. This will, in turn, lead to cheaper and healthier medicines, cleaner environments, and better economic returns that are brought about by the new chemistry being developed.

Some examples of his lab’s ongoing efforts include application of the latest chemical strategies for the development of antibacterial medical materials, water-treatment materials, pesticides or agriculture chemicals, and the modifications of Chinese medicines and other functional molecules that include peptides and proteins.

As a recipient of the NRF Fellowship in 2009 and NRF Investigatorship in 2016, Professor Chi says he was able to have the necessary academic freedom to focus on his research.

The NRF Fellowship provides early career researchers the opportunity to carry out independent research in Singapore over a five-year period. It is open to outstanding young scientists and researchers of all nationalities, in all areas of science and technology.

Each NRF Fellow is provided with a research grant to support projects that exhibit high likelihood of a research breakthrough, and can be used to cover personnel, equipment and consumables costs.

Professor Chi says that both the Fellowship and Investigatorship schemes enabled him to address some of the most challenging problems in science.

“I absolutely recommend others to apply,” he adds.

Looking ahead, Prof Chi wants to establish a deeper and systematic understanding of several important reactions, especially those in the field of organic catalysis.

He also aims to creatively bring recent advancements from other fields, including artificial intelligence and electrochemistry/electrochemical reactors, to develop better chemical synthesis strategies.

“We’re integrating both the concepts and techniques in these areas to more effectively develop new activation modes and better chemical synthesis processes,” he says.

OUR NRF FELLOWS

DR DAVID LALLEMANT

ASSISTANT PROFESSOR, NANYANG TECHNOLOGICAL UNIVERSITY, SINGAPORE & PRINCIPAL INVESTIGATOR AT THE EARTH OBSERVATORY OF SINGAPORE

HAZARDS MAY BE NATURAL, BUT DISASTERS ARE NOT

Natural hazards such as earthquakes, tsunamis and hurricanes have been associated with catastrophe throughout history. Yet while these events are natural, their impact on society is controlled by where we build our infrastructure (our exposure) and how we build it (our vulnerability).

Dr David Lallemant, Assistant Professor at Nanyang Technological University, Singapore's Asian School of the Environment and a Principal Investigator at the Earth Observatory of Singapore, explains that in fact, disasters are not natural, since they occur only with the combination of hazard, exposure and vulnerability.

With numerous personal encounters with urban disasters throughout his life, he was motivated to study how urban disaster risk is increasing due to increasing hazards driven by climate change, increasing exposure as more people move to cities, and increasing vulnerability as cities become increasingly complex and interconnected. He shares with us about his research to better understand disaster risks, and develop post-disaster assessment methods to better support disaster-response.

First of all, tell us why is there an increasing risk of disasters?

I am particularly concerned with the way that disaster and climate risks are growing, particularly in Asian cities. Climate change is increasing the frequency and intensity of floods. Many of our cities are subsiding due to mismanagement of ground-water. Urbanisation is also driving more and more people in hazardous areas, since cities are more likely to be coastal or along rivers. If you look at the urban scale it gets worse, since when cities get constrained in space, people will tend to settle on ever-more hazardous land, often on steep slopes or low-quality reclaimed land. Finally, as our urban infrastructure systems become increasingly complex and interconnected, they develop new vulnerabilities which we currently don't properly understand or measure. The combined effect of increasing hazards events (e.g. more flooding), greater populations exposed, and more vulnerable systems is very concerning. Therefore, the mathematical models I create attempt to capture these dynamics so that we can understand not only our existing risk, but how it is likely to change in the future and how we can control this change through policy.

Dr David Lallemant is a National Research Foundation Fellow (Class of 2018). Photo: Dr David Lallemant

"My goal is to develop models to accurately show us the direction we are heading in terms of risk, so that we may change direction towards a more resilient path."

It is interesting how you are creating mathematical models to understand and mitigate such disaster risks. How exactly do these models help?

I try to understand how natural hazards such as floods, earthquakes and hurricanes can impact cities and communities, so that we can better prepare and mitigate for them. I do this by developing mathematical models of natural hazard events (e.g. earthquakes) and their interaction with the human built environment (e.g. urban buildings and systems) in order to predict their impact (e.g. predicted fatalities, injuries, financial loss, etc). We can use such models to support various risk mitigation measures, such as improved building codes, risk-sensitive urban planning initiatives, design of protective coastal infrastructure and others. Because these models are probabilistic, they are also key for insurance and reinsurance companies to understand the risk and provide appropriate financial protections for their clients.

When natural disasters occur, they often have devastating and long-lasting consequences for the communities affected. Having a good understanding of disaster impact very quickly after a disaster is critical to support humanitarian response and effective planning for recovery. Part of my current research is therefore to develop new models for rapid post-disaster impact assessment. This research leverages technologies such as remote sensing (e.g. satellite imagery), crowd-sourcing (e.g. social media), drones and other sensors, which I aim to combine into accurate disaster impact assessment using methods from spatial statistics and artificial intelligence.

How can your research improve cities' approaches to disaster risk?

I am proposing a paradigm shift in our approach to disaster risk analysis: from static to dynamic, from building-centric to urban and systems-centric, from mechanistic thinking to complexity theory, etc. In the next five to ten years, I hope to have developed the analytical structures and tools to make this paradigm shift possible.

The risk profile of cities - particularly Asian cities - is rapidly changing due to climate change, urbanisation, and new patterns of vulnerability. The development of time-dependent risk analysis models that can account for such dynamics will enable us to anticipate future trends in risk and guide our cities towards a resilient trajectory. In addition, the development of new methods for rapid post-disaster impact assessment has the potential to greatly enhance the response and recovery planning capacity of governments, humanitarian and development organisations.

Ultimately my research aims to support a paradigm shift in our thinking of risk, from "disaster risk is something that happens to us" to "disaster risk is something that we control." The ancient Chinese philosopher Lao Tzu said "if you do not change direction, you may end up where you are heading." My goal is to develop models to accurately show us the direction we are heading in terms of risk, so that we may change direction towards a more resilient path.

As important as the research, I also hope to have created an environment in which the young women and men I teach and supervise can flourish as scientists who excel in and are passionate about the technical discipline of disaster risk analysis, with social consciousness and curiosity.

Your passion in this field of study is inspiring to early-stage researchers. What was the thing that inspired you to take on a scientific career, and in this particular field?

I grew up in many countries: France, the Congo, the United States and mostly in Thailand. In Thailand, our house was along the river, which regularly flooded the city. While studying at MIT, I went on a family Christmas vacation to the south-eastern coast of India, and landed on the day of the 2004 Indian Ocean Tsunami. We were far enough inland to avoid the direct impact of the tsunami, but this event shook me deeply. I returned to MIT and decided to study structural engineering, with a particular interest in earthquakes. I later studied earthquake engineering and risk analysis at UC Berkeley (M.Sc.) and Stanford University (PhD). In between the two programs I lived and worked for two years in Haiti following the devastating 2010 earthquake. Witnessing the impact of the earthquake in Haiti demonstrated to me the inadequacy of our analysis tools to understand risk in complex urban settings. These are the experiences which drive and inform my research interests.

My ambition towards a scientific career was also influenced by my family. My parents are doctors and public health researchers on HIV-AIDS in Thailand. My older sister is a medical doctor in the UK. My younger sister is a researcher on agricultural economics and international development in Washington DC. They are always an inspiration.

That's a series of serendipitous events that led you on this path. If you weren't a researcher, what do you think you would be working as today?

I used to work as a practitioner in the humanitarian and disaster response / recovery field, and that is probably what I would be doing if I wasn't a researcher. In fact, I haven't completely stopped this work. For a few weeks out of the year I am typically still active in responding to disasters around the world. This work informs my research, helps make sure it is still grounded in the reality of disaster risk, and helps in building collaborations with stakeholders. But in situations of crisis, these activities are not driven by my research, but by the humanitarian needs following catastrophe.

The NRF Fellowship is a competitive programme that provides opportunities for early career researchers to carry out independent research in Singapore. It is open to all areas of science and technology, and outstanding young scientists and researchers of all nationalities are welcome to apply.

Application for the next call opens in December 2018. Visit www.nrf.gov.sg/NRFfellowship for more details.

NATIONAL RESEARCH FOUNDATION
PRIME MINISTER'S OFFICE
SINGAPORE