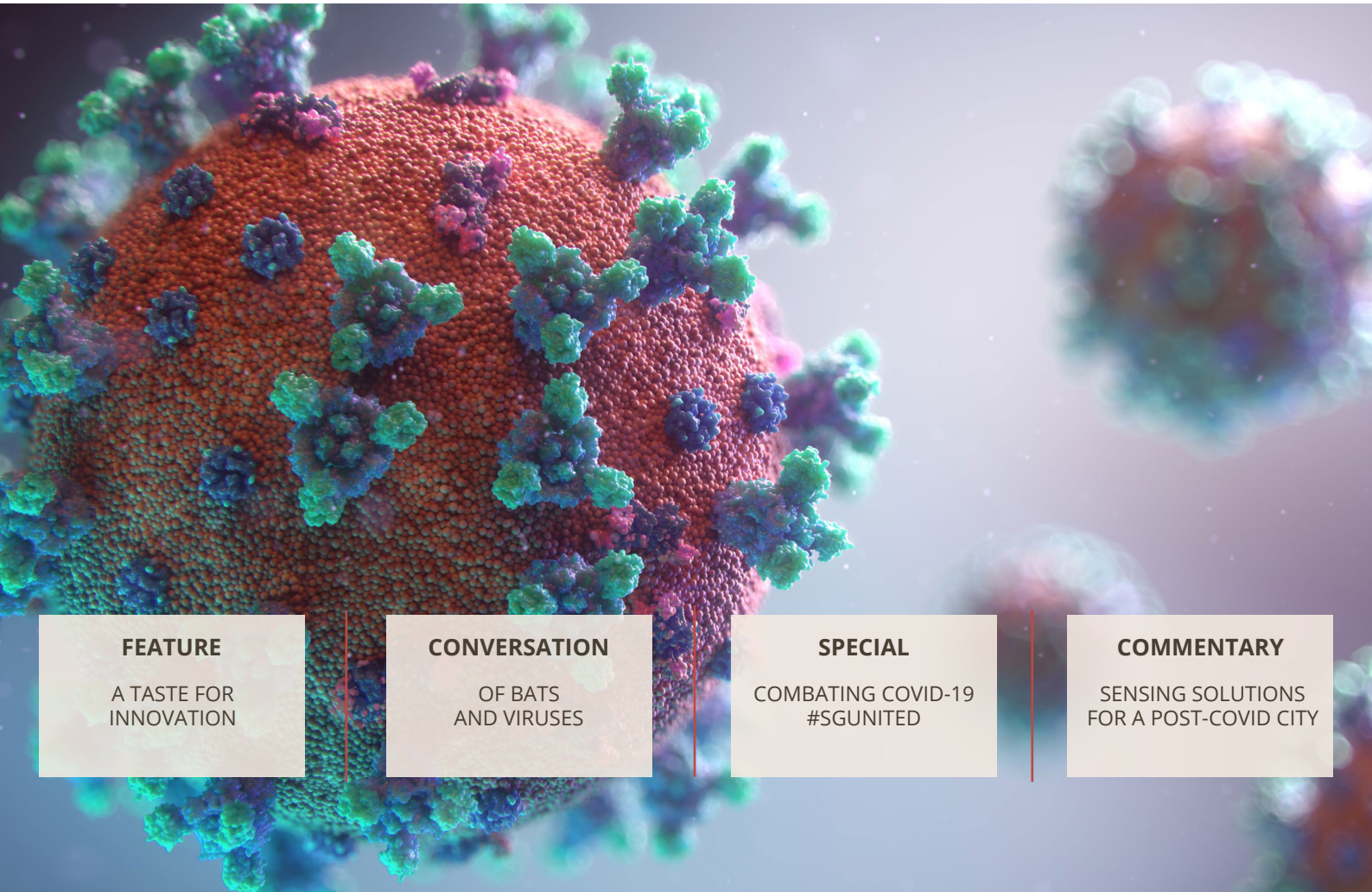
RIE NEWS

JULY 2020

SG GUIDE TO TECHNOLOGY, INNOVATION AND ENTERPRISE



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A TASTE FOR INNOVATION

CONVERSATION

OF BATS AND VIRUSES

SPECIAL

COMBATING COVID-19 #SGUNITED

COMMENTARY

SENSING SOLUTIONS FOR A POST-COVID CITY

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RESEARCH ROUNDUP

QUANTUM COMMUNICATIONS TECH FROM SPACE

An international team of scientists led by the Centre for Quantum Technologies at NUS, has successfully tested quantum communication technology 400km above the Earth by using lightweight nanosatellites. This opens new doors for quantum internet and communications as it overcomes limitations of optical losses in using fibre-optic cables. Supported by NRF's Competitive Research Programme funding scheme, this technology could help build a resilient and reliable quantum network that ensures digital privacy is more secure than ever.

Image: NASA

OPEN INNOVATION NETWORK SG

ENHANCING ECONOMIC RESILIENCE THROUGH INNOVATION

Encouraging greater collaboration in critical areas for businesses and companies, a series of seven National Innovation Challenges was launched on the Open Innovation Network. These challenges range from strengthening the productivity of our air and shipping sectors, to new ways to safely reopen construction, tourism and MICE activities. Jointly launched by NRF, ESG, and IMDA, the initiative aims to build a stronger culture of innovation, by bringing together individuals, companies, trade associations, research and academic institutions, and government agencies, to come up with innovative solutions for a post-COVID world. Click **here** to find out more.

Image: NTU

NOISE CANCELLATION TECH THAT IS MUSIC TO YOUR EARS

Researchers from NTU and the University of Southampton have developed a gadget that can reduce the intensity of noise pollution passing through an open window. The device can be attached to existing windows and help reduce the need for air conditioning as people would be able to stay cool by leaving their windows open. Published in the journal Scientific Reports, the system was tested with road traffic, train and aircraft noise, resulting in a 10 decibel noise reduction for sounds above 300Hz. The NTU researchers are currently working with government agencies in Singapore to reduce the gadget's size and make it more cost-effective to produce.

SINGAPORE'S FIRST END-TO-END DECARBONISATION PROCESS

Paving the way towards a greener future, Keppel Data Centres, Chevron, Pan-United and Surbana Jurong Private Limited have joined forces with an MOU to implement Singapore's first end-to-end decarbonisation process. Supported by NRF, the collaboration will develop an energy-efficient carbon capture, utilisation and sequestration (CCUS) system. These systems work by removing carbon dioxide from the atmosphere, and store it for other use or to create products such as concrete. When commercially viable, it is expected to help Singapore achieve its climate goals of halving emissions by 2050 from its 2030 peak, and achieve net-zero emissions as soon as viable in the second half of the century.

SINGAPORE-MADE SWABS THROUGH 3D-PRINTING

Teaming up with Temasek Foundation, National University of Singapore researchers have developed a new method of producing nasopharyngeal Covid-19 testing swabs and are preparing to produce 40 million of them in the coming months. They made three different swab designs that can be produced using 3D-printing and a manufacturing process known as injection moulding. Armed with a specially designed tip, these small and flexible sticks are inserted through the nose to the back of the nasal cavity to capture and retain fluid samples for accurate results. Researchers believe that this makes Singapore the first country in Asia to use 3D-printing to produce swabs and the first in the world to use injection moulding.

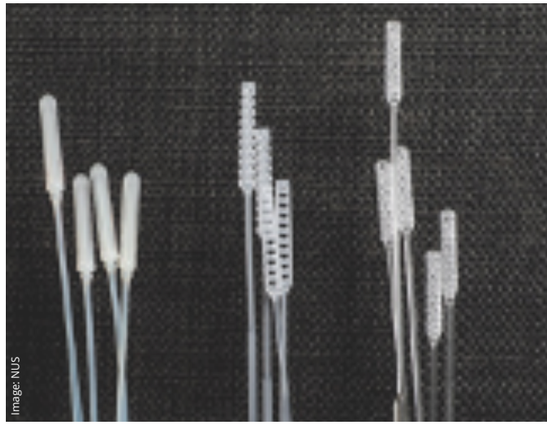


Image: NUS

SOWING THE SEEDS FOR CLEARER SKIES

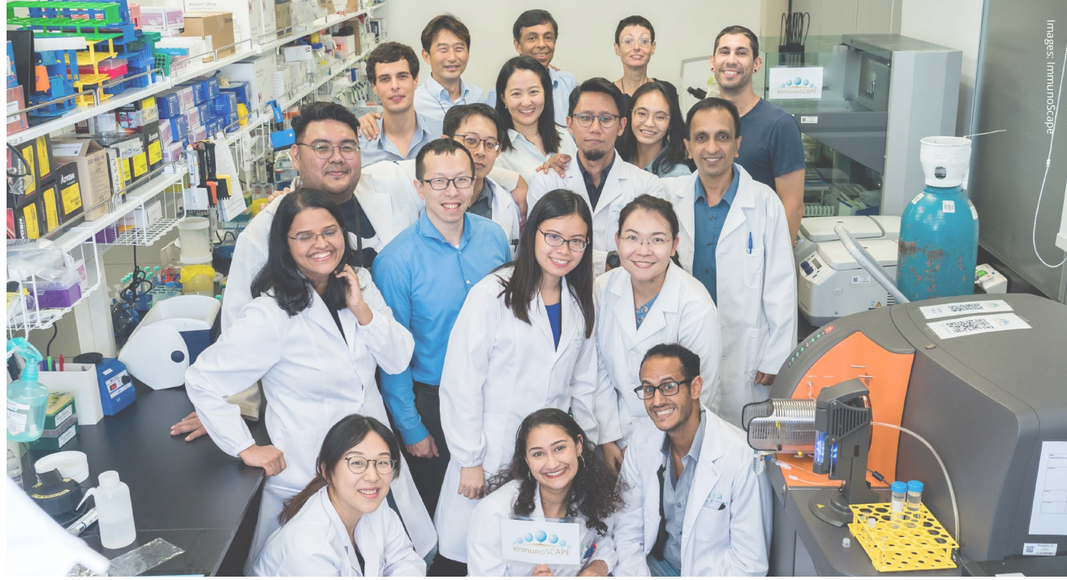
Researchers from the Massachusetts Institute of Technology and the Singapore-MIT Alliance for Research and Technology (SMART) discovered that peatlands – which are wet forest lands – contribute to global warming and rampant wildfires when they are drained to make way for roads and canals. The peat becomes highly flammable when dried, and even when left untouched, it releases its store of accumulated carbon during decomposition. Peatlands are commonly found around Southeast Asia and researchers demonstrated how satellite mapping can be used to monitor greenhouse gas output, and help implement local regulations on land use for a greener tomorrow.

CONVERSATION

BOOSTING SINGAPORE'S VACCINE CHANCES

Since May 2020, researchers at local biotechnology startup **ImmunoScape** have been racing against time, studying how patients' immune systems react to the coronavirus which causes COVID-19. Their work with local and overseas partners has been moving along rapidly, as part of the global effort to find a vaccine against the virus.

We speak to chief executive officer **Ng Choon Peng**, who shares with us his team's progress, the challenges they face, and his thoughts on what the biotechnology industry needs as we march into a new, "post-COVID" world.



Images: ImmunoScape

Small but mighty: The ImmunoScape team in good spirits while racing against the clock to uncover the impact our immune system has on coronavirus-specific T cells.

Could you tell us more about ImmunoScape's work?

We have a unique high-dimensional immune profiling technology which creates "maps" that help navigate how immunotherapy affects the immune response in cancer, autoimmune, and infectious diseases. For our COVID-related work, in collaboration with our partners, we study the behaviour of coronavirus-specific immune cells, which can recognise and kill cells infected by the virus. Happy to share that we successfully repurposed our technology in a very short time to screen antigens, which are molecules from the coronavirus that stimulate an immune response. Hopefully the insights we uncover will reduce the clinical trial failure rate and speed up the development of COVID-19 vaccines.

What are the partnerships about and how are they coming along?

One of our projects is with infectious disease experts, Dr Antonio Bertoletti from the Duke-NUS Medical School and Dr Carlo Ferrari from the University of Parma in Italy. This study involves patients who have recovered from COVID-19. By comparing the coronavirus-specific T cells of patients with mild versus severe symptoms, we can begin to understand the immune response needed to control the disease. We are expecting the first data sets soon, which is very exciting!

Another project is a research collaboration with Dr Patrick Reeves from the Massachusetts General Hospital in Boston. It investigates how the immune system itself contributes to the progression of COVID-19 to a more severe stage. We have sent

our proprietary reagents to the US researchers, who will use them to prepare the samples collected in Boston and run them using the ImmunoScape protocols. By tracking the immune cells that trigger the COVID-19 disease progression and learning about the early signs of abnormal immune cell activation, we hope to predict which patients will be more severely ill.

Separately, we are also working with Arcturus Therapeutics, an RNA vaccine development company from San Diego, on a clinical trial. ImmunoScape will conduct T-cell immune profiling on the samples of the clinical trial subjects and compare them across patient groups and over different time points. This exercise will provide insights to how patients respond to the vaccine under development.

How is your team taking to the work?

The first wave of samples for the Duke-NUS study has just arrived in our Biopolis lab, and there is a sense of urgency in Team ImmunoScape. We know that we have the unique opportunity to announce to the world what the immune response to coronavirus is like through our unique technology that was developed right here in Singapore!

We are excited to get the data out and let people understand our work better.

There are reports that the virus has mutated, does this affect your work?

Scientists still do not fully understand if the virus is changing in significant ways, but viruses are naturally prone to mutate frequently – that's their normal life cycle. However, the mutation itself does not necessarily suggest that the virus spread among people is accelerating or that the severity of the disease intensifies. At this point, there is still not enough evidence to prove whether the mutated viruses behave differently from the original ones. Using our technology, we have the possibility of studying the impact of these mutations on immune cells and whether these mutations elicit an immune response. Viral genetic diversity data makes it particularly interesting for us to identify new and potentially better targets which will help further vaccine development.

There have also been reports that show the antibody levels in recovered patients decline significantly in 2-3 months, raising questions about the length of any immunity. Does this finding impact your work and how so?

If the antibody levels in recovered patients decrease, other parts of the immune system may still offer protection. T and B cells from the immune system work together to attack coronaviruses, but the way they respond to infection is different. B cells make antibodies that block the viruses, whereas cytotoxic T cells which kill infected cells provide another line of attack. ImmunoScape's technology is reliable and very sensitive and we can screen T cell responses to a large pool of antigens. By comparing the phenotypic difference of the T cells, as well as their function and potency during and after infection, to the changes in antibody secretion, we hope to answer what is behind a good immune response.

ImmunoScape co-founders (L-R): Evan Newell, Alessandra Nardin, Ng Choon Peng, Michael Fehlings.

What are some of the challenges you are currently facing?

The main challenge for us is to reach out to as many of the 130 programs that are ongoing around the world today to identify how we can contribute to the speeding up of vaccine development programmes.

We have also been trying to set up a lab in the US. It is difficult to progress quickly on these fronts now with the travel restrictions.

We are also trying to hire more immunologists. They are really a rare talent, a scarce resource! It is especially important now because people are recognising that it is not just in immuno-oncology that needs immunologists – even in infectious diseases, we need their critical expertise.

We also need more data scientists because other than running samples, we also need to make sense of them. A good bioinformatics team is crucial and again, this is a scarce resource. I do not think we are training enough of them. For our work, we need people trained in both computer science and biology – it is an extremely narrow talent pool. It is tough work, but we can be sure that in the next 10-15 years, this is going to be a hot space to work in.

FEATURE

A TASTE FOR INNOVATION

Mass testing is a keystone of Singapore's strategy in mitigating the COVID-19 pandemic, and local medical company **Lucence** has launched a saliva kit to make this daunting task easier and more accessible.

Images: Lucence

Having witnessed outbreaks of dengue and zika in the community, Ms Rachel Sim wanted to make testing of such RNA viral infections more accessible to the community.

"Typically, diagnosis is obtained by testing blood. However, blood-taking is invasive and can be very scary for children," the A*STAR scholar explained. "Hence, we were inspired to develop a saliva collection kit that can achieve mass testing, contain large outbreaks, and be more accessible."

With this goal in mind, Ms Sim and Dr Tan Min-Han, then-principal investigator at A*STAR's Institute of Bioengineering and Nanotechnology (IBN) lab, set out to develop the chemistry for such a saliva kit.

But when the COVID-19 pandemic came around, they realised that their technology could also be used to test for SARS-CoV-2 – which, coincidentally, is also an enveloped RNA virus.

The technology has since been adapted by the team into a saliva sample kit for coronavirus detection, SAFER-Sample. Less painful and risky than the nasopharyngeal swab – currently the most common method of COVID-19 testing – the saliva kit also makes use of a reagent that makes the samples easier and safer to collect and transport. It was launched under Singapore medical company Lucence, a spin-off from the IBN lab.

Developing this reagent was the starting point for the development of the kit, said Ms Sim, who is currently in her final year of her PhD studies in chemical biology at the University of Oxford. She explained that saliva samples tend to degrade rapidly at room temperature, which reduces the accuracy of diagnostic results.

It took the team about half a year to find the right formulation, but several rounds of testing later, the stabilising reagent was optimised to be able to keep viral RNA stable at room temperature for up to one week without degradation. This also helps cut costs by removing the need for cold-chain transport, which is expensive and can limit testing geography – for instance, in countries where access to refrigeration is intermittent.

The chemistry reagent has also been enhanced so it can inactivate SARS-CoV-2 within 45 seconds of sample collection. "This means enhanced safety and reduced risk of exposure for any individual involved in the collection, transport, and testing processes," explained Dr Tan, now chief executive officer and medical director of Lucence.

Today, SAFER is already being used in hospitals and clinics in Hong Kong, where saliva was approved for mass testing in February. Lucence is also working on more validation studies here in Singapore, where the kit is already registered as a Class A medical device, to ensure its feasibility and reliability.

It is also collaborating with local precision engineering company Akribis to develop a robotic saliva solubilisation platform to process SAFER saliva samples automatically for medical labs, with the first automated unit to be deployed in August 2020.

Although some experts still question the reliability of using saliva samples to detect COVID-19, Lucence is hopeful that the kit will eventually be used for airport testing around the world, as well as in mass testing and screening in communities.

"SAFER is already used in Hong Kong SAR, where saliva was first approved for mass-testing in February 2020," said Dr Tan. "We believe that airport testing is key to enable restoration of travel and the economy."

Furthermore, there has been emerging evidence that saliva sampling can be more sensitive than conventional nasopharyngeal swabs. And as saliva sampling is less invasive and more accessible, using saliva sampling for mass testing could improve compliance and pick-up rates.

Even though it was originally meant to target an entirely different outbreak, Ms Sim is proud to see her research turned into a commercial product that is helping to mitigate the COVID-19 pandemic.

"I learnt that it is important to evolve your technology around changing needs," she said. "When we constantly question our existing knowledge and persistently pursue new knowledge, we can find innovative ways to solve problems."

The success of this project has motivated Ms Sim to work on developing more technologies that can help to solve the many problems we face today. "I am still very much in the early stages of my research career and have much more to learn," she said. "Now, when I work on my research, I also consider more about potential applications and how to commercialise my research findings."

> **"This means enhanced safety and reduced risk of exposure for any individual involved in the collection, transport, and testing processes.**
>
> Dr Tan Min-Han, chief executive officer of Lucence

Images: Duke-NUS and Genscript Biotech Corporation

CONVERSATION

OF BATS AND VIRUSES

The accidental biologist and the pandemic: Duke-NUS's **Professor Wang Linfa** is one of the faces of Singapore's war against COVID-19. We speak to him about the pandemic, what lies ahead, and the importance of research and innovation.

Professor Wang Linfa, director of the Programme in Emerging Infectious Diseases at Duke-NUS Medical School, is one of the leading experts in Singapore working with local and international partners to combat COVID-19. Working with industry, he and his team recently developed a rapid serological test kit that can detect COVID-19 in under one hour.

A member of multiple World Health Organisation committees on COVID-19, Prof Wang's work has been recognised internationally through various international awards, numerous invited speeches at major international conferences and over 400 scientific papers published in top-tier journals.

In this exclusive interview, Prof Wang shares his thoughts about COVID-19, the challenges that lie ahead, and the importance of research, innovation, and enterprise.

Why do we need to trace the source of the virus and why are bats the number one suspect?

Understanding the root cause of the virus, including human behaviour and environmental conditions that led to this pandemic may provide clues about risk factors for future outbreaks.

Bats are unique. There are over 1,400 species of bats worldwide, and they can be found on nearly every part of the planet except places with extreme climates such as deserts and polar regions. Some species are also known to have long lifespans with one of the oldest setting a record of 41 years in the Siberian wilds.

An interesting thing about bats is their ability to carry loads of deadly viruses and remain resilient to a large degree. They also harbour several viruses that cause deadly diseases in people, including rabies, Ebola and severe acute respiratory syndrome-related coronaviruses (SARS-CoV). That is why studying them may unearth new discoveries that may benefit medical science and healthcare.

I have been researching bats for the last 25 years, and I continued this in Singapore eight years ago when I was awarded a S$ 9.8 million grant from the National Research Foundation (NRF). While the research was much broader, the focus of it was to learn about bats and the viruses associated with it.

What is unique about the COVID-19 virus?

To me, the uniqueness of viruses are their personalities – their traits such as severity and mode of transmission. There are so many viruses that are hidden in nature, and "invisible" to the world until they mutate and start infecting human populations.

For the COVID-19 virus, firstly, it is not unique but different in the sense that the spectrum from asymptomatic to death, is significantly distributed to the asymptomatic end as around 15 per cent develops severe disease.

Secondly, while it was initially thought to only cause pneumonia, which is a small percentage, scientists have found out that it could affect your blood circulation, liver, kidney and recently, there are reports that it causes problems to the brain.

Lastly, while I have mentioned that COVID-19 is not unique, it has features which makes it different and more infectious. Coronaviruses are named after the crown or 'corona' that surrounds each virus particle, which is a crown of thorns made up of spike proteins. Those spikes give the virus the ability to invade its host, and among the coronaviruses which have jumped to infect humans, COVID-19's spikes seem to be most fit for human receptors. This means that it is much more transmissible.

Is there a possibility of COVID-19 spreading to animals?

Yes, it seems highly likely. To understand this better, we need to understand what zoonosis is about. It is the occurrence of diseases being transmitted from animals to humans, and reverse zoonosis is when humans infects other living beings.

There were early reports in China that the first reverse zoonosis case for COVID-19 is with cats, and then followed dogs, and much later, tigers in New York. These are limited transmission cases, meaning it is generally contained.

However, recently there were reports on minks in the Netherlands getting infected with COVID-19.

The cPass test kit can detect antibodies capable of neutralising the coronavirus in patients in an hour, instead of the usual several days.

This is a more significant case of "reverse zoonosis", where the virus was transmitted to minks from infected farmers, and the minks in turn, then infected healthy humans.

This is concerning because if this virus gets transmitted to wildlife animals such as bats which are resilient to deadly viruses, they do not get sick, but they create back-to-back transmission of the virus. This may result in a new reservoir of COVID-19 virus in a geographically different location.

This reservoir could greatly amplify the spill over effects of COVID-19, and virus transmission among wildlife is a great concern.

That said, so far, it seems that most of such cases around the world is well contained.

Can you share more about the rapid smart test kit that you have developed?

Together with GenScript Biotech Corporation and DxDHub, we developed a "rapid smart test kit" known as cPass™. It is the first in the world that allows rapid detection of neutralising antibodies (NAbs) – the specific antibodies present in the serum of COVID-19 patients that are responsible for clearing the viral infection, without the need of live biological materials and biocontainment facilities. SARS-CoV-2 requires a Biosafety Level (BSL) 3 lab for testing and handling. cPass™ can be rapidly conducted within an hour in most research or clinical labs, without the need of highly skilled operators, and complex laboratory procedures that are generally less sensitive and require several days to obtain results.

Moving forward, I am looking at how this kit can help other societies at a global level. The current World Health Organisation (WHO) dogma states that virus assessment and neutralisation must be done using live virus samples in an appropriate BSL certified lab.

It is my aim to challenge this and I'm currently working with different regulatory bodies in hopes to replace the current "gold standard" for virus neutralisation tests with cPass™. When mass testing is required, I envision that this would be able to benefit other countries, especially those without proper biocontainment facilities, to monitor the infection and immunity in an easier and efficient way.

Why is research coupled with industry relevance important?

While I am interested in basic foundational research, grounding scientific concepts with industry relevance is very important, and the cPass™ rapid test kit is a good example.

From a scientific idea and proof-of-concept data, to filing a patent and launching a commercial product, me and my team did this in just 70 days. According to our knowledge, the pace of the cPass™ development is the fastest in Singapore, breaking previous records of translational research commercialisation.

I am pleased that Singapore has developed a vibrant research and innovation environment that enables such endeavours of translational research excellence. In my own personal experience, I have never conducted scientific research and made a breakthrough like this at this pace.

> **"To me, the uniqueness of viruses are their personalities – their traits such as severity and mode of transmission.**
>
> Prof Wang Linfa, director of the Emerging Infectious Diseases Programme at Duke-NUS Medical School

That said, there should however be a balance. Basic science is still critical for discoveries to be made and industries or companies are unable to do this kind of research.

What is your advice to budding researchers and scientists?

I grew up in China during the cultural revolution and aspired to become a mechanical engineer because physics was my passion. However, for some reason, educators thought that my math was not good enough and I was told to take up biology instead in a top university in Shanghai.

I made the best of what I had and kept going at it and continuously improved myself in the field, which ultimately shaped who I am today along. The key takeaway is to make the best out of the current opportunities you are have, and doors will open.

Some might say that I am an accidental biologist, but I say that it is no accident but a challenge worth examining and maximising.

#SGUNITED

Answering the call to overcome COVID-19 through

Research Innovation Enterprise

Four home-grown spin-offs rise to the occasion to help the nation overcome the pandemic, by developing innovative technologies that echo the hallmarks of Singapore's Smart Nation objectives.

Image: Nur Amin

LIGHTING-UP DISINFECTION

A spin-off from the National University of Singapore (NUS) has developed a technology that kills microorganisms and even disinfects surfaces using a special spectrum of visible light. What started as a solution to help food become safer is now touted as a chemical-free technology that could prevent infections from spreading.

Founder and CEO of SafeLight, Dr Vinayak Ghate, said that he and his partner are food microbiologists by profession, and the original impetus behind the technology was to prevent foodborne diseases. However, they realised that the same technology could also be used for preventing infections from spreading.

Dr Ghate said, "We started off looking at ways to overcome the limitations of refrigeration and prevent food from being compromised by pathogens. In this endeavour, we found 'visible light' to be a great fit, as it can be used throughout the supply chain, from farm to fork. However, the same antimicrobial properties can benefit many other market segments too, such as healthcare, public transport and residential spaces, to simply name a few."

SafeLight's patented technology works by targeting light-sensitive compounds (photosensitisers) that are naturally present inside microbial cells. Once triggered by SafeLight's unique spectrum of light, the compounds will generate reactive oxygen species that are toxic to the cells, which will lead to cell death. The team identified the potent light properties through several years of research.

The major advantage of the technology is the ability to continuously reduce germs. Dr Ghate added that it would be impractical for chemical sanitisers to be applied constantly, while ultraviolet (UV) light or hydrogen peroxide vapours cannot be safely applied around humans.

"In the food supply chain, disinfection occurs at the processing plant. But once the food leaves the manufacturer, it is only protected by refrigeration, which does not kill microorganisms. This is where SafeLight's technology adds value by complementing refrigeration to kill food spoilage microorganisms and foodborne pathogens. Similarly, this technology can be targeted at high-risk public places to supplement existing episodic measures and reduce the infection risks."

SafeLight is currently exploring public trials in multiple sectors such as real estate, public transportation, healthcare and food & beverage. They aim to start trials by the fourth quarter of this year.

BREATH-TAKING DETECTIVE

The detection of COVID-19 has multiple challenges, especially if people who are infected develop no symptoms (asymptomatic). Another spin-off from NUS, Breathonix, has created a non-invasive solution for disease detection.

With its proprietary breath sampling device and data analysis algorithms, their technology analyses one's "exhaled breath", which provides an extremely precise way to detect diseases by analysing volatile organic compounds (VOCs). Diseases, including viral infections, cause changes in metabolic pathways, which are detectable in breath VOC profiles.

Co-founder and CEO Dr Zhunan Jia said, "Our solution uses breath sampling, a combination of a high precision breath sampling device and mass spectrometry, which provides one of the most precise ways to detect VOCs. Ever-present in anyone's exhaled breath, it can represent biomarkers for certain pathologies such as lung cancer, asthma, and chronic obstructive pulmonary diseases. It is quick, non-invasive, and safe."

Using the latest technological advances in proton-transfer-reaction mass spectrometry (PTR-MS), VOC molecules in the parts per billion (ppt) range are measured in real-time. Together with a special breath sampling device, patients only need to exhale through a disposable mouthpiece into the machine,

and signature molecules in their breath will be measured in high accuracy. Results will be ready within seconds, just like an alcohol breath test.

The research team had successfully applied the advanced technique to detect early-stage lung cancer and tuberculosis in a clinical study conducted at the National University Hospital. Dr Jia shared that their device's precision resulted in an unexpected finding which impacted a patient. "In one of our clinical study sessions when we were using the device to analyse VOCs for lung cancer, we discovered that one of the patients was actually misdiagnosed with lung cancer. It came as a piece of positive news to the patient, and we are glad that the technology is already doing good before commercialisation. The technology's precision of analysis is highly accurate, and this goes to show how it can help detect diseases earlier before it becomes much worse."

The analysis of the data is managed by an AI-based computer algorithm, which is not only able to detect anomalies in VOC profiles, but also produces results that can be easily understood by healthcare practitioners.

Moving forward, Dr Jia said that their technology is a perfect fit to detect COVID-19 as a form of a rapid breath test, and she is now working with the National Centre for Infectious Diseases (NCID) to use the technology as a mass screening tool. "With plenty of reports indicating that COVID-19 can spread through people without any symptoms, we strongly believe that this technology would be very useful for healthcare practitioners and even other countries to quickly detect COVID-19 and contain its spread."

BIOTECH BOOST TO VIRUS DETECTION

According to two top epidemic research institutes in China, since January, the SARS-CoV-2 virus, commonly known as COVID-19, has gone through at least six major gene changes that boosted its ability to infect and evade the human immune system. This means that the virus may spread for a longer time than expected, and vaccine development may be ineffective if the mutations are not detected promptly.

One home-grown company, SinGENE biotech is looking to empower detection techniques with microbiology. With a unique microbial database and machine learning algorithms, SinGENE biotech tests the microbial community including bacteria, fungi, and viruses, with a genetic-based method at higher accuracy and faster turnaround.

"We have developed a unique database powered by AI to quickly detect the DNA and RNA of microbes, and it reinterprets them in a readable language quickly and with precision," said co-founder and CEO Dr You Fang. "Generally, this technology is based on bioinformatics, an interdisciplinary field that creates methods and software tools to understand biological data. This allows us to understand the genetic make-up of these germs, how it works, and how the human body reacts to them."

SinGENE biotech has worked with clients in the food & beverage (F&B) and waste management sectors, to identify, quantify and characterise microbes in their sample matrix. With over 500 algorithm sets already built into an AI-powered system, SinGENE's technology can comprehensively analyse the SARS-Cov-2 virus directly from environmental samples. Also, the technology can be used to track the mutations of the virus, which will help predict the viral evolution and drug design of vaccines.

Dr Fang said, "It is extremely important that we track the evolution of the COVID-19 virus as it has a high propensity to change or mutate. This greatly affects vaccine development as it may render them ineffective if the mutation is significant."

"While SinGENE can keep track of the virus, it also generates a pattern of its mutation, which helps predict its future evolution and aid vaccine development further."

SinGENE is now working with healthcare authorities and research agencies to further develop their technology so that it can contribute to Singapore's ongoing battle against COVID-19.

SEEDING THE FRUITS OF ANTIMICROBIAL SUCCESS

Image: Ghim Li Group and NTU

With international bodies encouraging nations to wear masks to curb the spread of COVID-19, mask manufacturers were struggling to keep up with demand due to shortage of materials and stifling global supply chain issues.

A team of scientists at the Nanyang Technological University (NTU) led by Professor William Chen, director of NTU's Food Science and Technology Programme, has developed a sustainable and green way to extract high-quality antimicrobial compounds from seeds.

Keeping his research grounded, Prof Chen worked with global apparel and textiles manufacturer Ghim Li Group (GLG) to ensure that his innovation is industry relevant. The new antimicrobial compound will be used as a fabric finishing in GLG's reusable masks sold locally and overseas. The masks were distributed to Singaporeans and permanent residents last month as part of the Government's strategy to fight the COVID-19 pandemic.

"Our innovation was built from the ground-up, in our search to find unique ways to reduce waste by giving them life once again. Our method of creating antimicrobial compounds from seeds is sustainable and is a good fit to enhance fabric-based masks to kill bacteria," said Prof Chen.

The natural antimicrobial compound developed by Prof Chen contains powerful antioxidants found in seeds. During lab tests, the compound killed 99 per cent of harmful bacteria by disrupting their cell walls.

Prof Chen's team experimented using the extracted antimicrobial liquid compound, and tested it on common food pathogens. When the compound came into contact with bacteria, it bonded to the bacteria wall, inactivating the protein and enzymes on the wall, and inhibiting bacterial growth.

Prof Chen shared that his research was originally to create antimicrobial food packaging, but discovered that it can be applied to reusable fabric masks, giving them an antimicrobial property . However, Prof Chen emphasised that the direction of the research remained the same – that is to upcycle waste.

"Obtaining high-value ingredients from organic parts discarded during food processing, such as stems, seeds and husks, is an innovative way that can contribute towards a sustainable circular food economy and a key research focus of NTU's Food Science and Technology Programme," said Prof Chen.

"More importantly, we are delighted that we have a hand in helping reduce COVID-19 transmissions, through sustainable and cost-effective ways that will benefit industry."

COMMENTARY

COLLABORATING FOR SUCCESS

As the **Singapore-ETH Centre** celebrates its 10th anniversary, director **Professor Gerhard Schmitt** and managing director **Thomas Rufener** share their recipe for the centre's success.

Fourteen years ago, the then-chairman of the National Research Foundation, Dr Tony Tan visited the Swiss Federal Institute of Technology Zurich (ETH Zurich).

During the visit, the idea to set up a research centre in Singapore was discussed. The institution has had a long-standing relationship with Singapore, dating back to 1996, and Singapore seemed like a natural choice for the university's first and only research centre ouside Switzerland.

In 2010, the Singapore-ETH Centre (SEC) was established as one of the centres under the Campus for Research Excellence and Technological Enterprise (CREATE). The SEC was not alone, having been preceded by the Singapore-MIT Alliance for Research and Technology (SMART), and joined by other excellent universities in the years to come. In the past ten years, the spirit of collaboration has continued to bear fruit. In addition to collaborating with other CREATE entities, the SEC has also worked with government agencies, and industry on projects such as Cooling Singapore, Cities Knowledge Graph, and Digital Underground, that aim to inform the planning of Singapore both above and below ground and to make the city more sustainable, resilient and liveable.

All around the world, successful scientific collaborations have spurred scientific progress and innovation for the betterment of societies. Tackling complex social, environmental and economic challenges, such as climate change and

urban resilience, increasingly requires collaboration between universities, governments and industry.

The question is: What are the key ingredients for successful collaborations?

Shared interest and values

Singapore's collaboration with ETH Zurich was seeded by a mutual interest in learning from each other and complementing existing capabilities. ETH Zurich was also keen on context-based research that could not be done in Switzerland for climatic or geographic reasons, and that would benefit both partners and science in general.

Another pre-requisite for a successful collaboration is shared values. The SEC is first and foremost a research centre, and researchers are intrinsically driven by an interest in investigating a topic in-depth and publish their findings to share them with the academic community and beyond. But in addition to academic interests, the SEC believes in translating knowledge to action.

This has existed in the university's DNA since its founding in 1855. ETH Zurich believes not just in teaching and research, but also in sharing knowledge with, and serving society. It is interested in formulating relevant questions, tackling urgent challenges, and creating a real impact on society. This has led us to work closely with agency and industry partners, and we have found that engaging with real-world problems experienced by stakeholders often leads to new and meaningful questions for science.

Trust

Going into unchartered territory is always risky. In such context, trust is an essential ingredient – the glue that keeps partners together. When the SEC was first set up, the Future Cities Laboratory – our first programme – had to start conversations and establish trust between partners. One of the programme's first collaborative projects was with the Urban Redevelopment Authority and the Land Transport Authority, to model land transport in Singapore using diverse data streams with the agent-based simulation tool, MatSIM. The trust built through this first project was the foundation upon which later projects were developed.

Another dimension of trust pertains to the sharing of data and resources, including the issue of data privacy – something that is particularly important when working with government agencies. Apart from non-disclosure clauses, our researchers have developed creative ways of ensuring data privacy, such as by building synthetic populations representative of the actual population. This method guarantees the robustness of the research, while preserving the privacy of the population.

The Reimagining Cities exhibition at the URA, under the Future Cities Laboratory programme.

Furthering communication

Communication is crucial in every partnership, whether in setting realistic goals and expectations or deciding on future intellectual property and publication authorship. Yet different disciplinary backgrounds, technical expertise, professional interests, and perspectives often get in the way. Therefore, in addition to regular and open communication, creative communication is also important.

In research, communication is typically done through scientific publications, conference presentations, and posters. In addition, our researchers look towards innovative and impactful ways to convey ideas and findings. For instance, by translating data-rich results into interactive information maps, videos and other visual outputs, we have been able to visualise the state of the Urban Heat Island effect in Singapore, map urban vegetation, as well as model energy consumption of buildings and districts.

Keeping collaborations strong

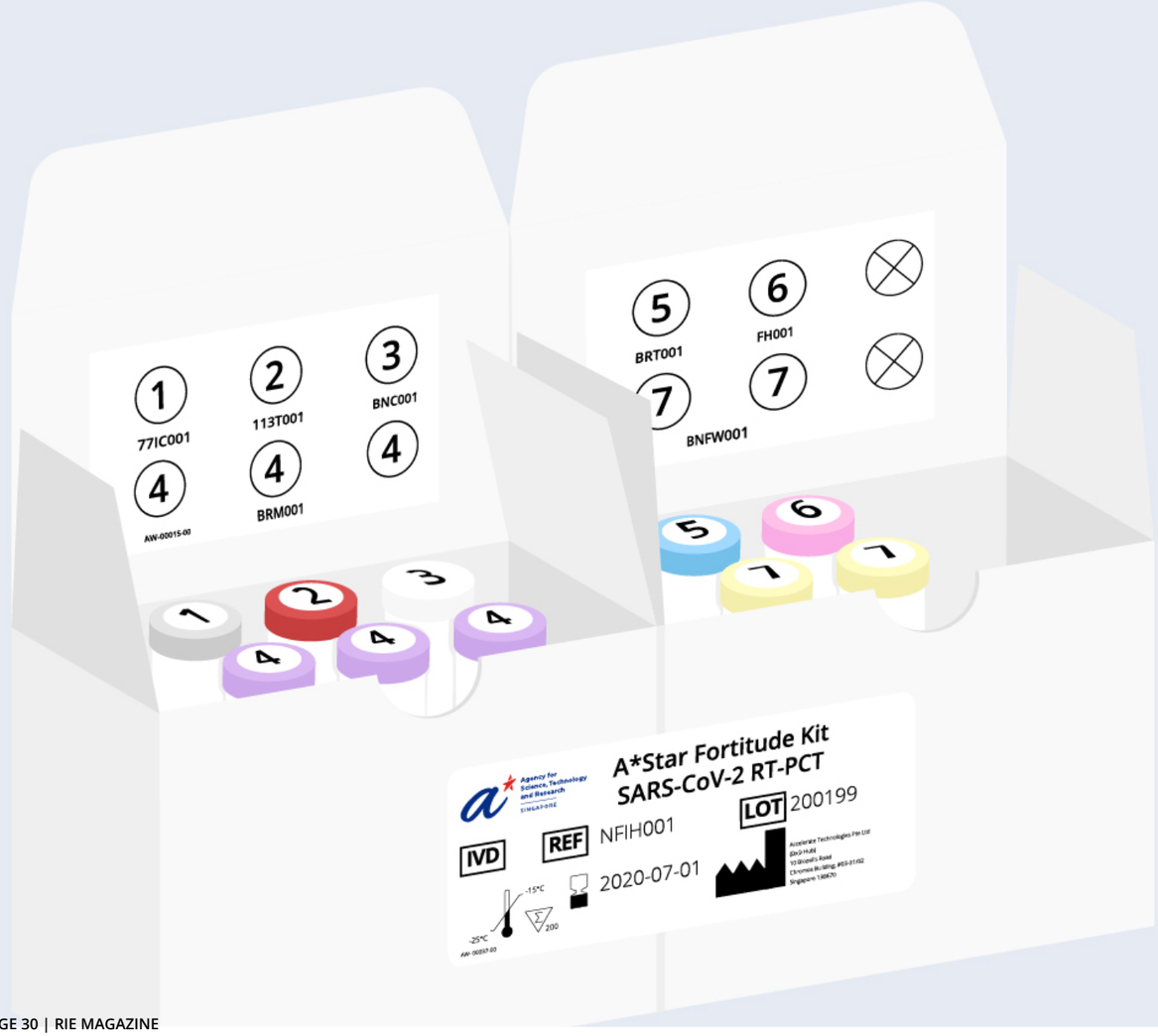
Ten years on, the partnership between ETH Zurich and Singapore has only deepened through new programmes and projects. A combination of communication, mutual trust and respect are critical ingredients that give researchers the degrees of freedom to follow the path that their research takes them.

The Digital Underground project, in partnership with the Singapore Land Authority since 2017, is still going strong. In 2018, NParks researchers collaborated with us in our Natural Capital Singapore project, demonstrating our joint commitment and interest in preserving Singapore's ecosystems. We are also working with the National Healthcare Group, SingHealth, and the National University Health System to ensure that the technologies developed under our Future Health Technologies programme are applicable to Singapore and can be rolled out in hospitals here.

Both Switzerland and Singapore recognise the importance of conducting research to benefit the wider society. As a result, the SEC is also looking beyond Singapore to improve urban resilience and design in the fast-growing cities in the Southeast Asian region.

THE IMPORTANCE OF BEING COORDINATED

When a virus such as that of the SARS-CoV-2 spreads, response time is of crucial essence to combat the fallout. The team behind **A*STAR's** Fortitude Kit share with us how good relationships made all the difference when they came together to tackle the virus.



Images: A*STAR

By now, the success story of the Fortitude Kit – a diagnostic kit that can detect the presence of the novel coronavirus with high accuracy – has been well documented.

It was early January when the first reports of an unknown virus emerged from Wuhan, China. Countries around the world started to raise their outbreak alert levels, including Singapore, and infectious diseases experts were on high alert. By the time the first case was reported in Singapore in late January, they had already sprung into action. The Fortitude Kit – a diagnostic test kit with high accuracy – was ready for deployment in less than a month.

A joint effort by the Experimental Drug Development Centre (EDDC), Bioinformatics Institute (BII) and Department of Laboratory Medicine, Tan Tock Seng Hospital (TTSH), the Fortitude Kit comprises a pre-packed mix of reagents to test patient samples.

It is a huge time-saver, allowing hospitals and laboratories to conduct their own tests. This effectively shortens the wait time for results, enabling those infected to be treated sooner. Since February, the kit has been used in 13 Singapore hospitals and labs. Healthcare professionals globally use it to fight the pandemic, and it has been deployed in more than 20 countries.

A collective effort pays off

The timeline of the Fortitude Kit's development is astonishing.

The genome of the 2019-nCoV was made available on the Global Initiative on Sharing all Influenza Data (GISAID) by scientists in China, early in January. Dr Sebastian Maurer-Stroh, deputy executive director of research at BII, had been asked by the GISAID to examine the genetic material of the SARS-CoV-2 and study the virus evolution.

That information was passed to Dr Masafumi Inoue, head of the Diagnostics Group at EDDC, A*STAR. "It took only 48 hours to design detection primers for nCoV from the time complete sequences were published," said Dr Inoue. His close collaborator, Associate Professor Dr Timothy Barkham, Senior consultant medical microbiologist from the Department of Laboratory Medicine, TTSH, then provided the clinical expertise, helping to optimise test parameters and evaluate the diagnostic kit on clinical samples.

Finally, the prototype was handed over to Dr Sidney Yee, CEO of Diagnostics Development Hub (DxD) Hub – a national platform led by A*STAR's commercialisation arm A*ccelerate. Dr Yee and her team further optimised, verified and validated the tests before rolling out production. The know-how was transferred non-exclusively to a handful of biotechs to scale-up and manufacture the diagnostic kits.

"These companies have since taken on the role of mass-producing locally-developed diagnostic test kits for the novel coronavirus to meet high levels of demand both locally and internationally for reliable SARS-CoV-2 tests," said Dr Yee. "Moving ahead, we must continue to scale up capability and capacity, and be willing to innovate out of our comfort zone to operate in crisis mode."

A strong, collaborative ecosystem

The extraordinary timeline of the Fortitude Kit from conception to production is impressive, considering how a comparable test kit during the outbreak of the severe acute respiratory system (SARS-CoV) in 2003 took months to develop. Dr Inoue attributes this to years of close collaboration between the research and clinical community, and Singapore's investment in health and biomedical sciences.

"Since the SARS outbreak in 2003, the local R&D ecosystem has been very coordinated, taking on a multi-disciplinary and collaborative approach to research on infectious diseases," said Dr Inoue. "For example, A*STAR and TTSH have been working closely on research in infectious diseases such as swine and avian influenzas, and as a result of the knowledge and capabilities gained, we were better prepared to respond to the COVID-19 pandemic."

"Another important aspect is that we have also established good relationship with reliable manufacturers in the supply chain," Dr Inoue added.

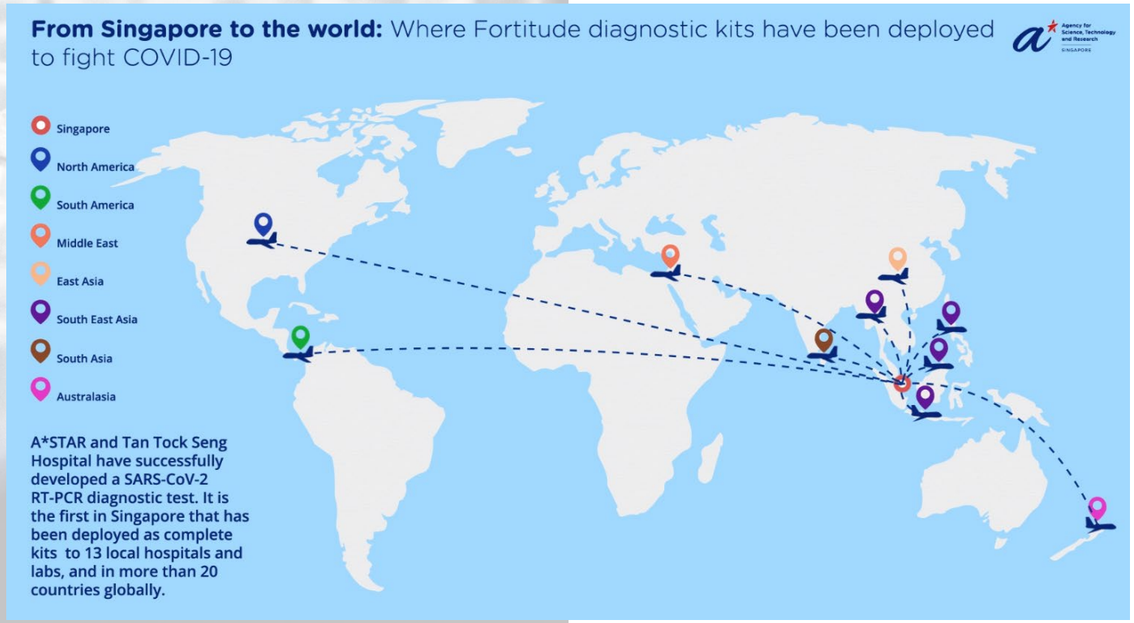
The work continues

As with the natural cycle of all viruses, the SARS-CoV-2 virus is constantly evolving. "To ensure the continual high accuracy of the Fortitude Kit in detecting the virus in COVID-19 patients, I track the virus' evolution through the GISAID platform to stay ahead of the mutations," explained Dr Maurer-Stroh. "A constant flow of viral genomes from global surveillance efforts is important to always stay ahead of changes in the virus. This also enables A*STAR to update or upgrade the Fortitude Kit on an ongoing basis."

Dr Maurer-Stroh's team in Singapore is part of the GISAID core scientific and curation team, and they regularly feed their findings back onto the platform to keep the scientific community abreast of the latest developments. "Our work for GISAID not only benefits us, but the whole world," he added.

Keeping close ties in the road ahead

It seems the only certainty in these uncertain times is that COVID-19 is here to stay for the indeterminable future. The next virus outbreak could be right around the corner. The radars on infectious disease experts continue to be attuned to the news and updates in their field, homing in on any blips and pings that might foreshadow the next pandemic. To fight the next unknown effectively, a concerted effort at collaboration is imperative. Dr Maurer-Stroh said, "Continued collaboration across the whole-of-government and international agencies in 'peace-time' are critical to maintaining essential infectious disease R&D capabilities and networks for rapid responses to pandemics."



COMMENTARY

SENSING SOLUTIONS FOR A POST-COVID CITY

Researchers at **TUMCREATE** have developed a low-cost, privacy-preserving solution for crowd management in a COVID-19 era. Principal investigator **Dr Alok Prakash** tells us more.

Images: TUMCREATE

The COVID-19 pandemic took the world by storm at the start of 2020. With its ability to spread like wildfire, even through asymptomatic carriers, the disease quickly made its way across the globe, infecting and killing thousands.

Globally, authorities rushed to contain the situation by employing various measures and rules in order to stem the spread of this new and dangerous virus. A new term 'social distancing' was introduced for the first time to encourage everyone to maintain a safe distance from one another in public places. Large congregations were also quickly banned to limit the virus's spread in the community.

In Singapore, the government imposed a 'circuit-breaker' to curb the spread of the virus, during which all but the essential services were put on hold, forcing majority of the population to stay indoors. This resulted in a drastic reduction of up to 75 per cent in the use of public transport services. To enforce safe distancing measures and prevent crowding, enforcement officers were immediately roped in from both the civil service and members of the public.

As Singapore exits the circuit-breaker period and many people resume their day-to-day lives, the number of people taking public transport has risen sharply. There is a growing need to ensure that the spread of the virus is kept under control, while mitigating manpower costs and minimising risk to our enforcement officers – and this is where technology can come into play.

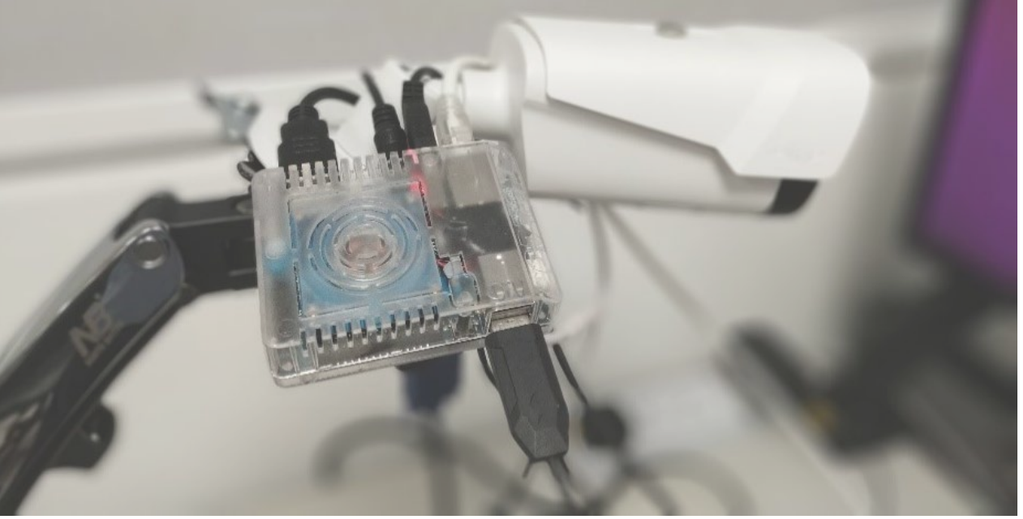
One possible measure is to deploy cameras for automated crowd monitoring for enforcement and information dissemination purposes. However, there are two major concerns in using camera-based sensors for such purposes: cost and privacy.

Existing solutions typically rely on either expensive 'smart cameras', or low-cost 'dumb cameras'. Unfortunately, both are infeasible for large-scale usage – the former would be too costly for citywide deployment, while the latter could result in privacy concerns as they make use of cloud-based systems with long term data storage facilities, which people are generally wary of.

AIoT: Fusing AI and IoT Technologies

TUMCREATE's Sensing and Management for Agile Transport (SMAT) team has developed state-of-the-art camera-based AIoT sensors that can overcome both problems. These sensors fuse artificial intelligence (AI) and Internet of Things (IoT) technologies and cost just a fraction of existing commercial 'smart cameras'. Each sensor processes and estimates the size of the crowd in-situ, and only communicates an estimated crowd level instead of raw video data, which can be immediately discarded to safeguard people's privacy.

The proposed AIoT sensors employ deep learning (DL) based techniques on low-cost IoT platforms to estimate the size of crowds accurately and in real time. The AIoT sensors also make use of off-the-shelf cameras in order to keep costs low. Furthermore, unlike conventional systems, the proposed sensors neither transfer images nor videos for cloud computing, saving communication bandwidth and avoiding the need for expensive and power-hungry computing platforms. As a result, these AIoT sensors are low-cost, energy-efficient, and privacy-preserving, making them suitable for mass volume adoption.



TUMCREATE researchers have developed AIoT sensors to help with crowd management in a COVID-19 era.

A City-Wide Solution

Modern urban cities have already been inundated with thousands of cameras for various purposes such as surveillance, traffic monitoring, and law enforcement. For ease of implementation, the sensors are designed so that they can be directly spliced into such existing camera networks without a need for a complete infrastructure overhaul. In addition, the software-centric approach of this technology allows for the addition of new features with a simple over-the-air update, like the ones we receive on our smartphones.

Such sensors can be deployed citywide in public areas such as malls, bus stops, station platforms, and even inside buses and trains. This can help provide real-time crowding data to the public, so that they can make informed decisions before visiting these places. In addition, they can be repurposed in future to help meet other challenges in public transport: for example, real-time crowd estimation at bus stops can be used to make existing bus services more demand-responsive by sending more or larger vehicles during sudden surges in demand and vice versa. The SMAT team has also developed similar low-cost state-of-the-art sensors to detect illegally parked vehicles or unauthorised vehicles entering bus lanes that impede the flow of public buses.

These technologies have already undergone several months of real-life field trials within the Nanyang Technological University campus to ensure robustness in various environmental conditions and are ready to be deployed. Given the current situation, this is an opportune time to leverage these technologies to tackle the challenges ahead.

UNEARTHING THE HEART OF THE VIRUS

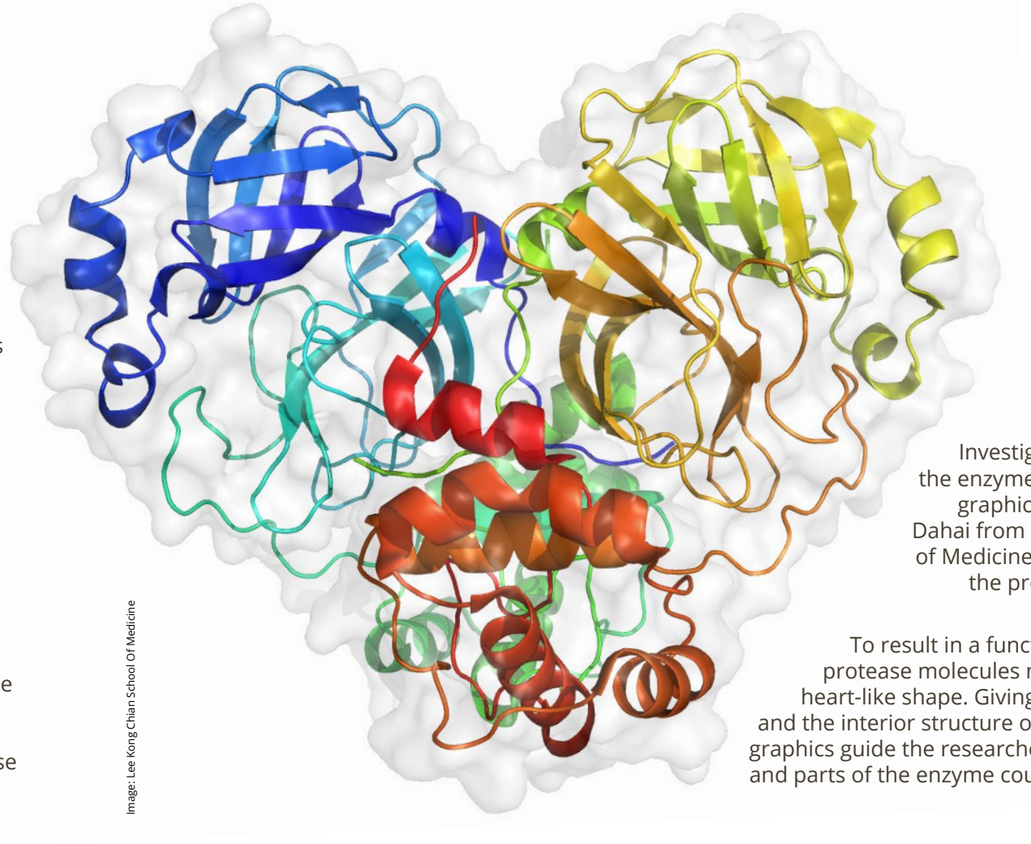


Image: Lee Kong Chian School Of Medicine

The main protease of the COVID-19-causing virus, SARS-CoV-2 – an enzyme that can cleave large viral polyproteins into smaller functional proteins – is essential for the viral life cycle and hence an attractive target for the development of antiviral agents.

Investigating the atomic structure of the enzyme with the help of a molecular graphic software, Associate Prof Luo Dahai from NTU's Lee Kong Chian School of Medicine is finding solutions to inhibit the protease and thus kill the virus.

To result in a functional enzyme, two individual protease molecules need to join as a dimer with a heart-like shape. Giving insights into both the shape and the interior structure of the protease, the molecular graphics guide the researchers with clues on which areas and parts of the enzyme could potentially be inhibited by antiviral compounds.

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