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CONTENTS

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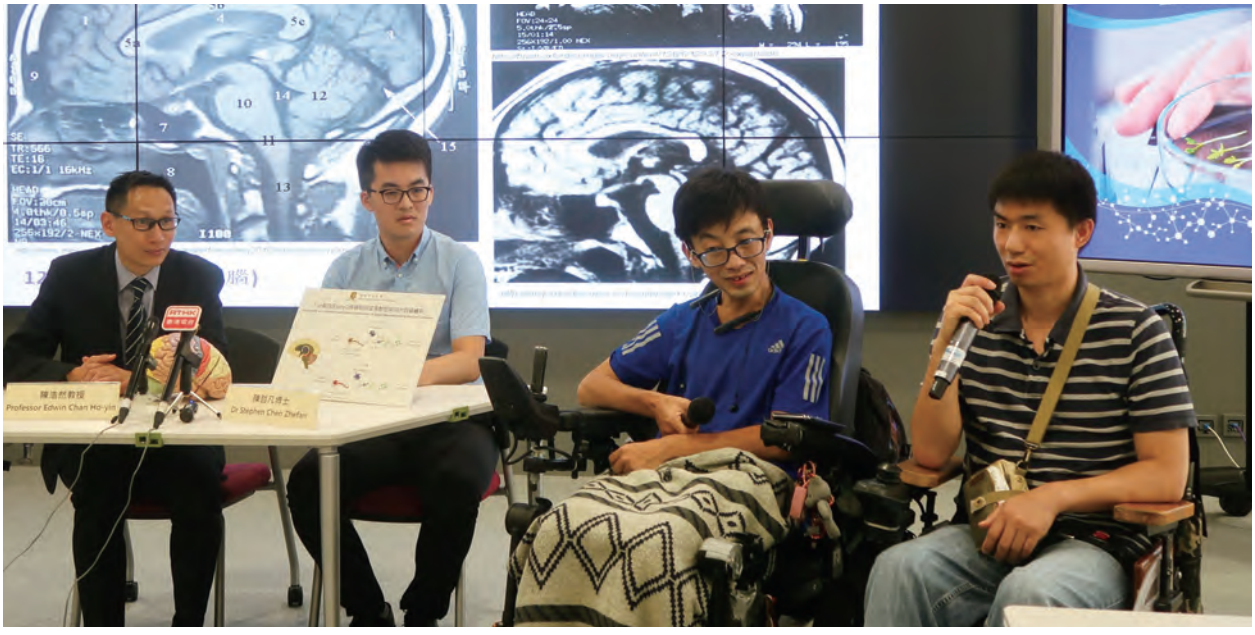
Prof. Edwin Chan
Life Sciences

A Rare Talent for a Rare Disease

Edwin Chan takes on Spinocerebella Ataxia



▲ *From left: Prof. Edwin Chan, Dr. Stephen Chen, SCA patients Mr. Cheng and Mr. Fung*

Prof. **Edwin Chan** is a champion for sufferers of spinocerebellar ataxia (SCA). He has identified a specific gene that causes one version of the disease. And he and a partner in Denmark are working on drugs to prevent the onset of the disease altogether.

SCA patients have fully clear and functioning minds, but often have blurred speech and vision. They cannot walk freely due to tremors, because their cerebellum, the part of the brain that governs motor control, is not functioning normally.

They demonstrate many of the same symptoms as people with motor-neuron disease. But SCA kills cells in the brain, while motor-neuron disease targets cells in the limbs. It normally takes a MRI scan and a series of physical tests to diagnose SCA.

SCA is just one of around 6,000 conditions in the world that are classified as 'rare diseases', defined in Europe as those that affect one in 2,000 people. They are so rare that Hong Kong—well behind the West in treating them—doesn't even have a definition, and has no system in place for supporting patients.

They are normally hereditary diseases—80% of them are genetic. They are frequently disabling, affecting the patient's entire life, and occasionally degenerative and life-threatening. But there is often no treatment, or even ways to alleviate the symptoms.

There are more than 40 subtypes of SCA. Professor Chan has concentrated on the polyglutamine subgroup of six SCAs, in which stress within the nucleolus, a small part of the nucleus, causes cell death in the neurons of the brain. The main agent in the process is nucleolin, a protein that causes stress in the brain if it malfunctions.

Professor Chan tracked the process to its origin. He identified that nucleolin gets 'hijacked' by a certain form of toxic ribonucleic acid (RNA). The nucleolin does not function properly as a result, ultimately resulting in the death of the cell.

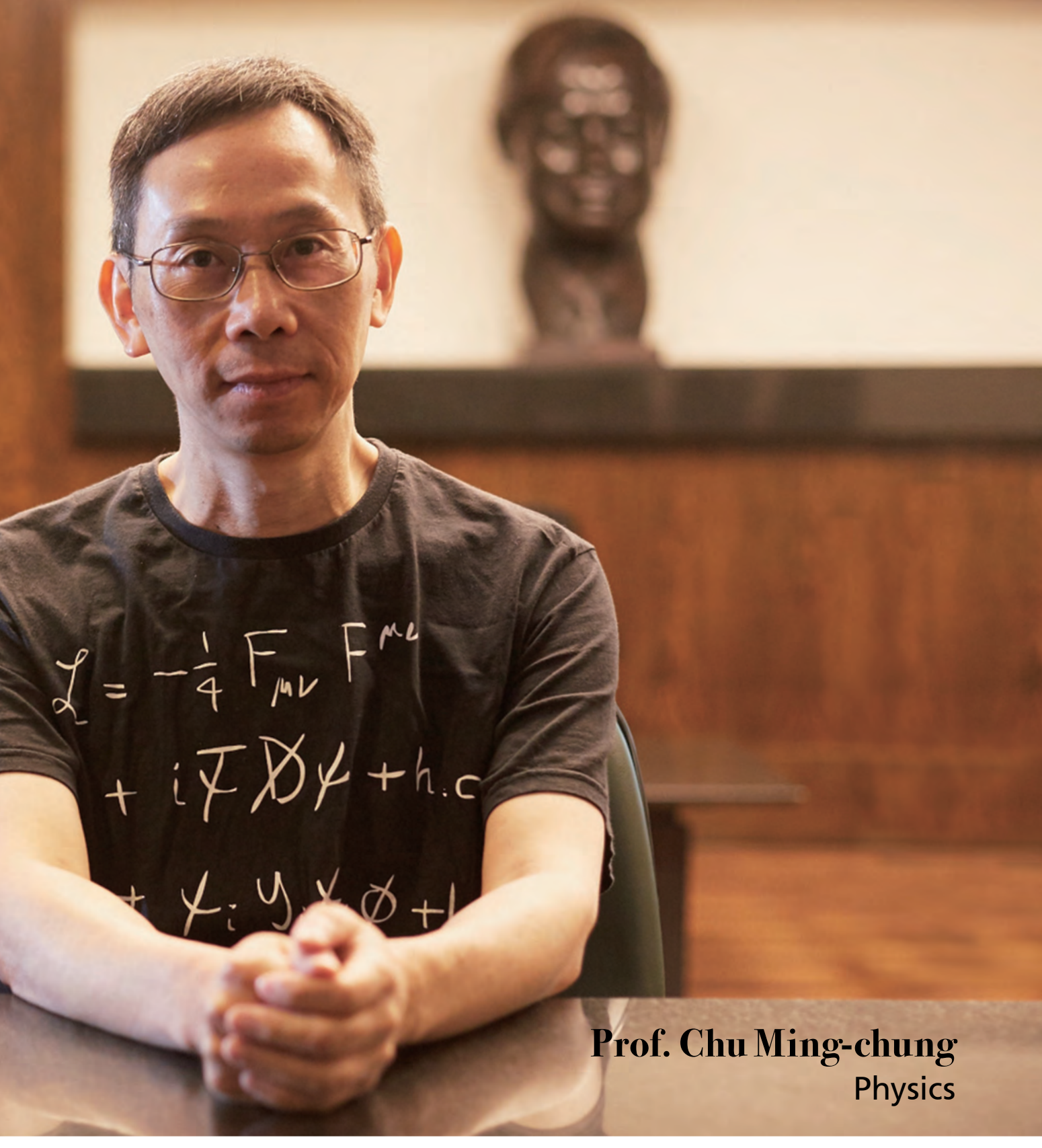
Having identified the process, Professor Chan set about designing a drug to prevent the cell hijack from occurring in the first place. He set about a systematic screening of peptide sequences, and made an educated guess that one of a family of six peptides might work. The peptide acts as a decoy, getting sucked up and hijacked by the RNA instead.

By introducing the peptides into animal cells, Professor Chan tested whether or not they halted the cell death. Two of them proved to be very promising. He then turned to a partner in Denmark, **Knud Jensen**, a professor of peptide engineering at the University of Copenhagen, to synthesize them.

With Chan designing the peptide and Jensen manufacturing it, they are developing therapeutics that can block that nuclear pathway, and hold the potential for drugs.

Courting Miss Minutest

Chu Ming-chung: voyager in the subatomic



Prof. Chu Ming-chung
Physics

It is through the examination of the smallest parts of the universe that we may come to understand its biggest secrets, according to the work of CUHK physicist **Chu Ming-chung**.

Professor Chu has devoted his life to the study of neutrinos, some of the least understood subatomic particles on the planet. Thanks to ground-breaking work at the Daya Bay Nuclear Power Plant, he and his team discovered that neutrinos transform in a way that helps explain the evolution of the universe.

Professor Chu is the principal investigator of the Hong Kong team involved in the Daya Bay Collaboration, which has established that neutrinos 'oscillate' or change form. There are three kinds of neutrino—electron, muon and tau—and his research proves that the electron form of neutrino can transform into both the muon and the tau forms.

Neutrinos and their counterpart, anti-neutrinos, were some of the first particles emitted after the Big Bang, and are continually produced within stars. Anti-neutrinos are plentiful in nuclear reactions, hence the experiment is located near Daya Bay power plant's six reactors. Measuring the anti-neutrinos also provides data about neutrinos, since scientists believe the two types of particle have near-identical physical traits.

After correcting for distance, the Daya Bay study showed that 8.4% of the anti-neutrinos were vanishing unexpectedly by the time they reached the detectors, demonstrating that they had transformed. Anti-neutrinos travel almost at the speed of light and respond only weakly to gravity, given their tiny mass, and so are incredibly hard to detect. Through tens of thousands of calculations, the scientists established the precise amount of 'leakage' as the anti-neutrinos change.

What's more, the oscillation indicates that the three forms have different weights, establishing that neutrinos themselves have mass. The 'mass squared' discrepancy established by the Daya Bay experiment is expressed as Δm^2_{13}, while the rate of oscillation is known as theta one-three, or θ_{13}.

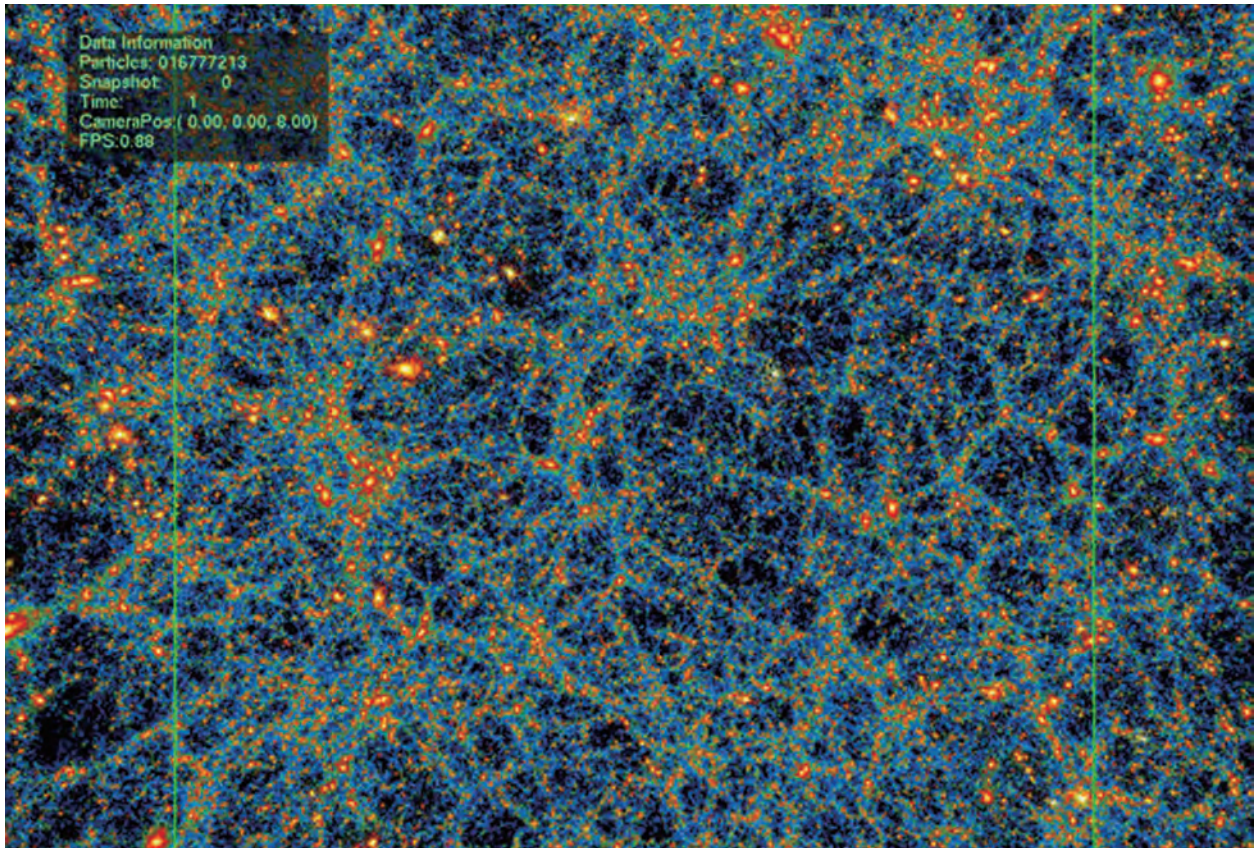
▲ *A full size anti-neutrino detector model at the underground Daya Bay Far Experimental Hall*

Meanwhile, the evidence that neutrinos transform from one type to another helps indicate the likely original forms of particle and matter created by the Big Bang. 'We have shown that the neutrinos are part of the same entity, and we have shown quantitatively how much one transforms into another,' Professor Chu says. 'Now we are chasing back in history to trace the original of the universe when everything was unified.'

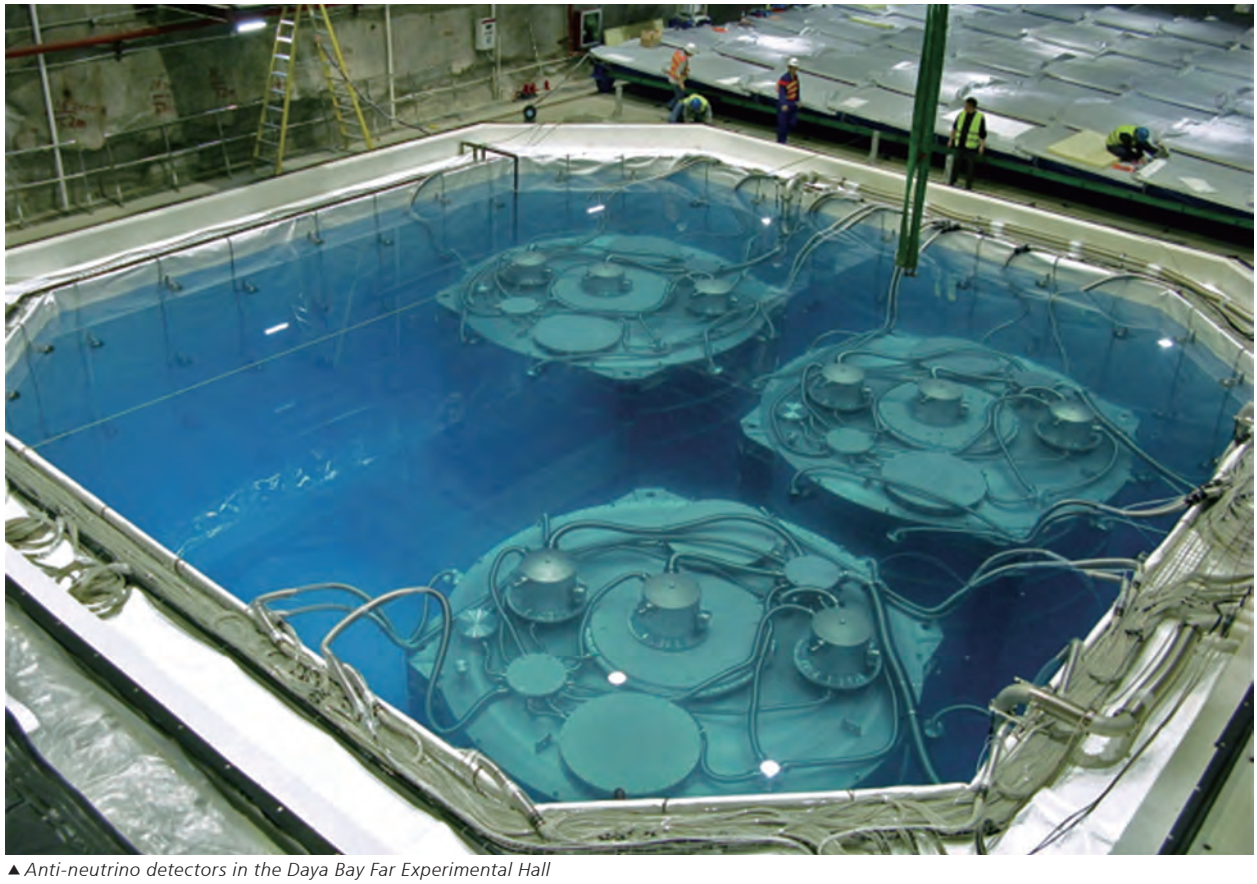
It was only in recent years that scientists established that neutrinos had mass at all. So further investigation into the θ_{13} rate of neutrino oscillation established at Daya Bay could go some way to addressing that mystery.

Professor Chu believes that the discovery of the neutrino oscillation at Daya Bay provides a greater understanding of particular physics that will hone the Grand Unification Theory. That is the overarching theory that unifies all fundamental interactions and fundamentally explains all life.

The theory is constantly challenged and adapted. Measuring the θ_{13} discrepancy helps rule out versions that don't allow for that oscillation. So the discovery of theta one-three is an incremental step towards the construction of that theory. 'I'm optimistic,' Chu says. 'But we're probably less than halfway there.'



▲ *A simulated map of matter (dark matter) distribution in the universe, generated by Professor Chu's student Dalong Cheng*



▲ *Anti-neutrino detectors in the Daya Bay Far Experimental Hall*

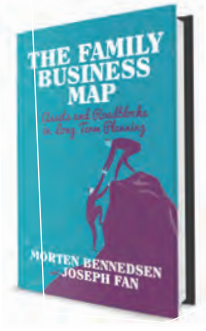
Prof. Joseph Fan
Accountancy

Do Asian Family Businesses Self-destruct?

Joseph Fan analyses how fortune runs in the family

Family businesses the world over face the same difficulty in succession, the issue of transferring the company from one generation to the next. One generation creates wealth, the next maintains it and the third wastes it, conventional wisdom holds.

But the problem is even more severe in Asia. In fact, Asian family firms lose almost 60% of their value in the first transfer of power, when the founder steps down, according to research by finance professor **Joseph Fan**.



Professor Fan's findings, which led to a book he co-authored with **Morten Bennedsen** of INSEAD—*The Family Business Map: Assets and Roadblocks in Long Term Planning*, came from sampling 217 Chinese-run publicly listed companies across Hong Kong, Singapore and Taiwan. He examined the share price of a family company from five years before the year that the founder steps down to three years after a successor takes over. Leading up to the handover, 56% of the company's value was lost, with another 2.9% lost after the transfer of power.

Taiwanese businesses showed the highest propensity for a family transition, with 74% of companies handed down to heirs or close family members. Hong Kong was similar at a rate of 69%, with only 36% of companies in Singapore passed down to the next generation.

The dissipation of wealth was the lowest with Singaporean companies, although they still lost 22% of their value. Taiwanese companies saw almost one-third (31%) of their value destroyed. Hong Kong companies are the most affected—they lost 126% of their value, meaning not only would 'buy and hold' investors have lost all the money they invested in the company, but they would have contributed added funds during the nine-year transfer period and lost those as well.

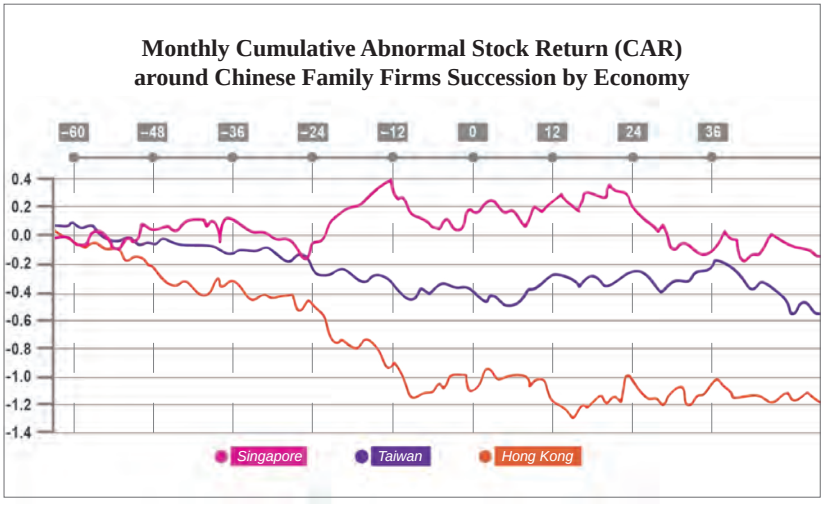
Professor Fan has ruled out that the decline is caused by the incompetence of the successor since the decaying of the company in fact slowed down dramatically after the transfer of power.

'The value destruction started well before the successor took over,' Professor Fan noted. 'It can't be that it's solely the cause of the successor.'

His best theory is that much of the value in an Asian family business is intangible—investors look at who is running a company and what the owner's values are, when determining whether or not to invest. That's far more important than the fundamental analysis of revenues and earnings that would drive the investment decision in the West.

Asian families are much more hands-on with their businesses than their counterparts in the West, where the descendants of a founder typically eventually withdraw from working at the company. So it is the values of the founder and his family that explain the company's success, according to Professor Fan. The value also comes from their connections and reputation in society, including with the government and the financial sector.

'Chinese business families should begin to plan their family and business future 20 years before the old generation retires,' Professor Fan said, because it takes that long to transfer the intangibles.



▲ (Source: The Family Business Map: Framework, Selective Survey, and Evidence from Chinese Family Firm Succession)

Prof. Jiang Liwen
Choh-ming Li Professor of
Life Sciences

The Big Bang of Plant Vacuoles

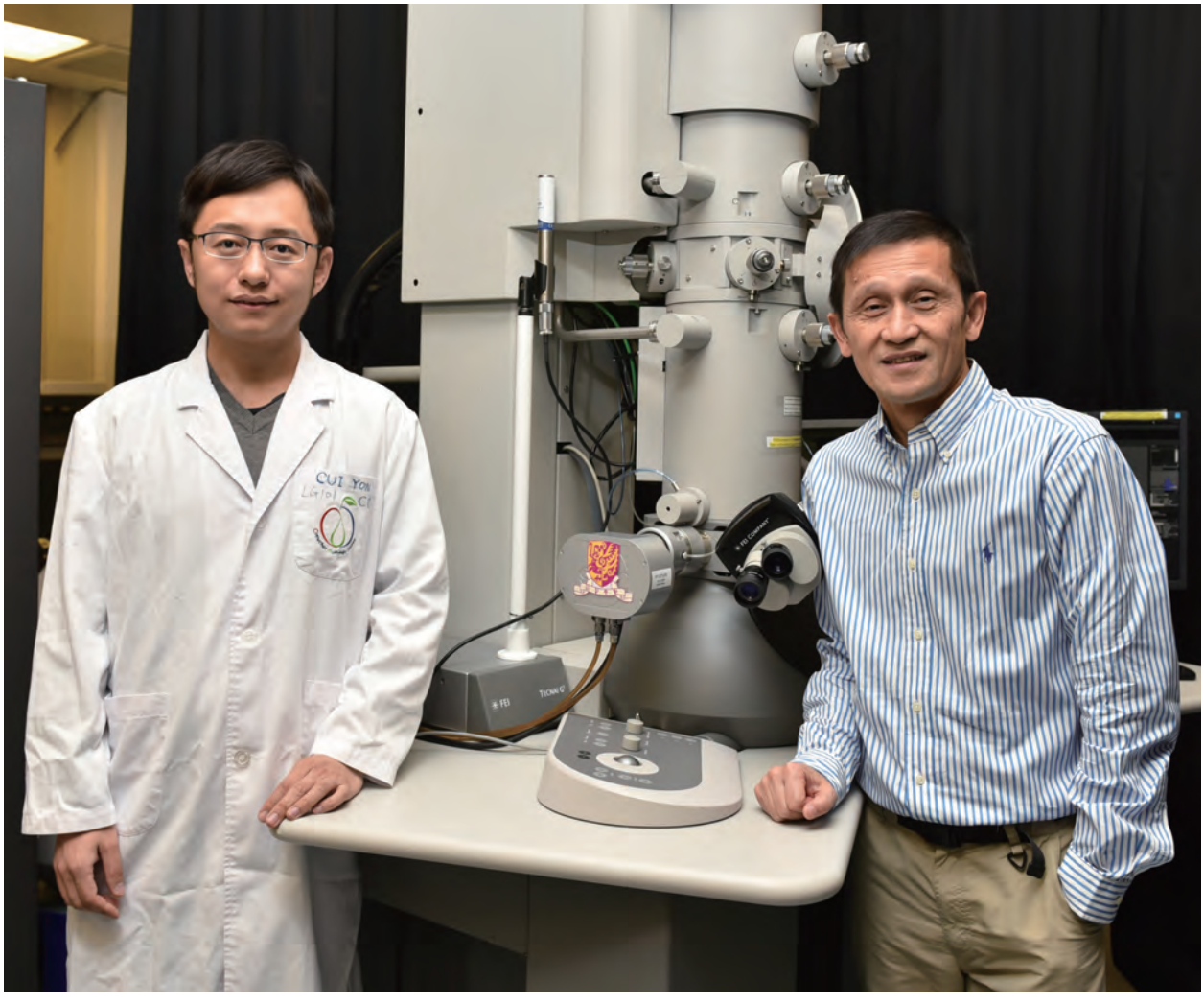
Jiang Liwen rewrites chapters in plant biology textbook

The various life-sustaining functions of a plant cell are performed by its organelles which act like the human organs. Classic textbooks in plant biology differentiate organelles of the endomembrane system into endoplasmic reticulum (ER), Golgi apparatus, multivesicular bodies and vacuoles. The last is by far the largest and most important organelle.

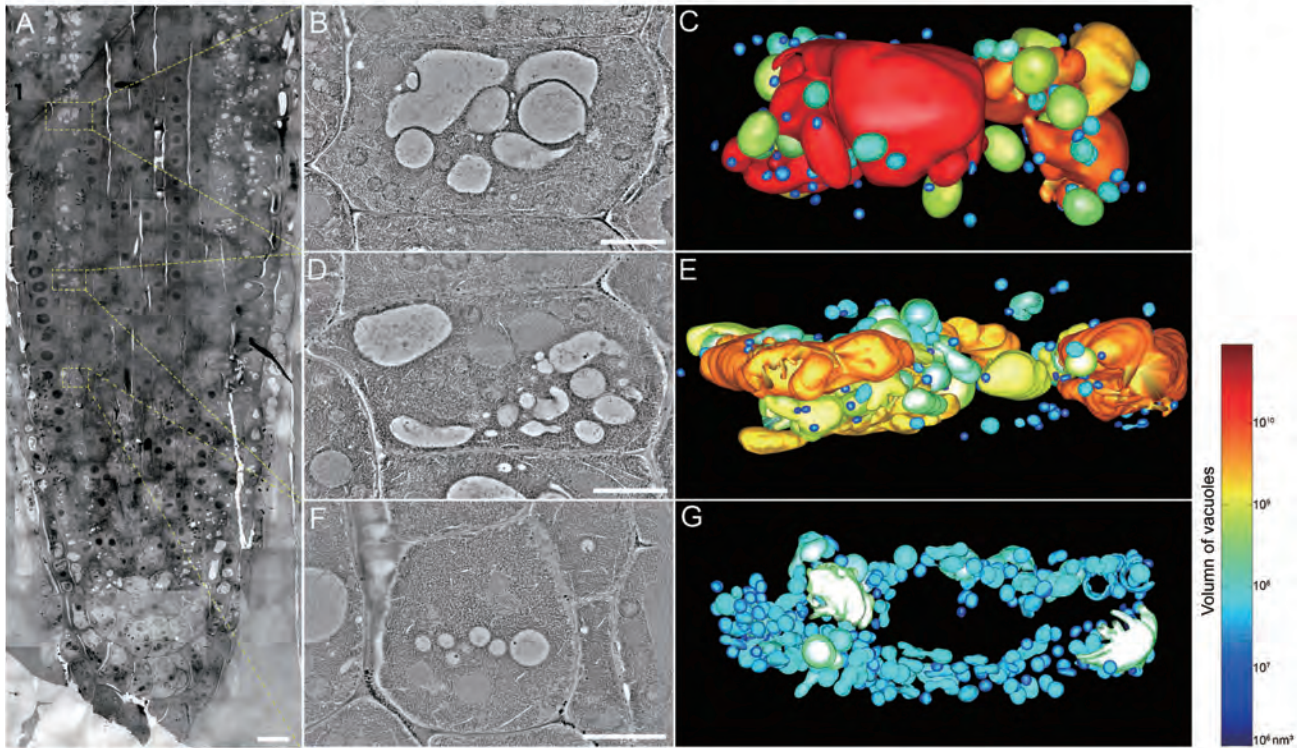
Vacuoles are essential in regulating a plant's growth and development. They are the master regulator responsible for the lytic function (degradation and waste storage), the storage of proteins and sugar, maintenance of turgor pressure, the balance of cell volume and defence responses.

Despite their significant roles very little is known about their genesis or evolution. In the past 40 years two models have been proposed to explain their biogenesis. One school claims that vacuoles are formed by the fusion of endosomes. The other school hypothesizes that the vacuole is derived from the ER as a single interconnected organelle and that there is only one vacuole in every cell. With the advent of 3D transmission electron microscope technology with nanometre resolution (one nanometre (nm) is one billionth of a metre), Prof. **Jiang Liwen** took on the challenge to engage in the debate on vacuole biogenesis. His team used a state-of-the-art 3D electron tomography (ET) equipment to study vacuole biogenesis at different developmental stages in the Arabidopsis root cells.

At the nano-level, a new picture of the morphology and distribution of the organelles was revealed. In the early stages of the development of a cell, many small vacuoles (SVs) with sizes ranging from 400 nm to 1,000 nm in diameter are observed. In later stages, however, the number of such SVs decreases and in their place larger vacuoles (1,000–2,000 nm, then over 2,000 nm in diameter) can be found. This suggests that vacuoles are formed by the fusion of smaller vacuoles, a direct refutation of the 'one single interconnected vacuole' model mentioned above. Professor



▲ *Professor Jiang and postdoctoral fellow Dr. Cui Yong* (left)



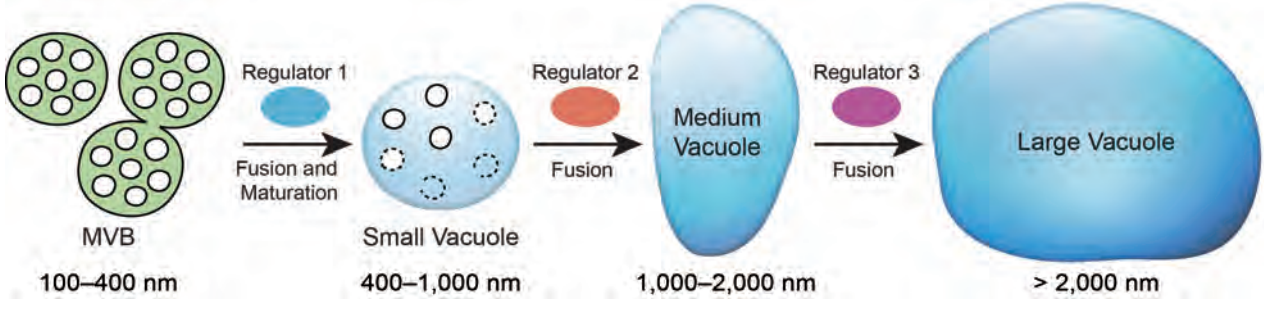
▲ *The whole cell tomography of vacuole biogenesis* (Cui Y et al., (2018))

Jiang explained with a metaphor: 'We are given a more powerful zoom lens now. What used to appear as a house in the hazy distance can now be seen in sharper focus. We can see the details inside the house such as the furniture, the persons and their relative positions to each other and at different times. We understand better what's happening inside the house.'

The team also came upon the discovery that the SVs are formed from the fusion of multivesicular bodies (MVBs) measuring 100–400 nm in diameter. Because of their similarity in appearance (both have a number of vesicles or pockets enclosed by a membrane wall), SVs and MVBs can easily be mistaken for each other. But Professor Jiang concludes from their sizes, membrane composition, and distribution at different developmental stages that the latter indeed fuse and mature into the former.

Based on their findings from whole-cell tomography and experimenting with different gene mutants, the team has proposed a new model of vacuole biogenesis: vacuoles are mainly derived from the fusion and maturation of MVBs with each phase of the process regulated by a specific molecular regulator.

Professor Jiang said, 'This work has redefined the concept of vacuole nature and vacuole formation in plants in textbooks which will certainly have a significant impact on applied plant biology.' He further pointed out its implications for further research on how to improve crop quality to overcome an adverse environment or pathogen infection as well as how to use and manipulate seed protein storage vacuoles in plant bioreactors for manufacturing pharmaceutical proteins.



▲ *A new model of vacuole biogenesis*

Source: Radio Television Hong Kong

Prof. Lam Hon-ming

Life Sciences

Bean for the Future

Lam Hon-ming advocates bigger role for the soybean

Beans are common foodstuff, but they remain the supporting cast in our diets. Few are aware that grain legumes contain more proteins than cereals and that soybean is a major source of protein meal and vegetable oil. In addition to its nutritional value, the agricultural properties of soybean may prove to make it the most important source of our food in future.

Prof. **Lam Hon-ming** is a pioneer in enhancing the genetic make-up of soybean to help alleviating the looming problems in world food supply and security. Professor Lam had decoded the genomes of many wild and cultivated soybeans and concluded that wild soybeans have more genetic biodiversity within themselves than cultivated ones and that the recovery of those stress-tolerance genes lost in the process of domestication may lead to the breeding of soybean varieties that thrive in adverse environment. The publication of these findings in *Nature Genetics* in 2010 laid down the foundation for related research projects and programmes which had since mushroomed in many parts of the world.

Professor Lam has been an advocate for a more prominent role for the soybean in our agricultural practice to address the issue of shrinking arable land worldwide. He said, 'Grain legumes are currently underutilized despite their known benefits to agricultural productivity, sustainability and human health. Insufficient knowledge of legume science and technology also limits their production and consumption.' The problems are more acute in China, where drought and land salinity have combined to diminish the arable land and the crop thereon every year.

For over a decade, Professor Lam's team had been adopting state-of-the-art genome sequencing technology to map the genetic make-ups of highly adaptive wild soybeans and cloning stress-tolerance genes from them with advanced molecular biology technique. In 2014, he successfully identified and cloned a new salt-tolerance gene from wild soybeans which greatly enhanced the efficiency of breeding salt tolerant soybeans. At the same time, Professor Lam lost no time in working with soybean breeders in China to produce soybeans that can be grown on saline lands. Experiments are also carried out in semi-arid and arid regions in Northwest China with the aim to identifying drought-tolerance genes from wild soybeans. The ultimate goal is to transfer the lab results to the fields and produce stress-tolerant soybeans.

Professor Lam's work has taken him to some of the most poorly endowed regions in China. He has been conducting fieldworks in collaboration with various agricultural institutes on the mainland to breed stress-tolerant soybeans and help to improve or restore arable land with pioneering crops. The experiments and experience in Qingyang and Pingchuan, Gansu, to name but two, are particularly encouraging. In these experiments, a newly-bred cultivar was selected because it requires very little water and can live longer to complete the growth cycle so that the land will be revived to the requisite level of biodiversity. The cultivar has all the characteristics of a first-generation migrant: resilience, thriftiness and flexibility.

▲ *Biodiversity of soybean* (courtesy of Prof. Lam Hon-ming)

Prof. Gabriel Lau

AXA Professor of Geography and
Resource Management

Feeling the Heat?

Gabriel Lau warns of soaring temperatures

Thanks to global warming, heat waves will triple in frequency and soon take up half the summer, according to the work of Prof. **Gabriel Lau Ngar-cheung**. The definition of a heat wave is that average temperatures rise into the highest 10% of their typical range and remain there for three or more days. The cause of a heat wave is a 'dome' of hot air that forms during very clear weather with more sunshine. The land becomes baked, and the dry conditions enhance 'sensible heat' that can be felt, as opposed to the latent heat associated with moisture.

The heat-wave dome then holds at bay other weather systems. Research continues in an attempt to quantify, as surmised, the effect of remote processes in causing and extending heat waves. For instance, it is likely but not yet proven that a rise in sea temperatures in one part of the world can augment a heat wave in another part.

Heat waves cause a significant number of deaths in their most severe form, particularly among elderly people. Heat waves also cause a very dry climate, and ultimately droughts. Agriculture suffers, and forest fires increase in frequency and magnitude. In the American West, there are now fire and drought emergencies virtually every summer.

Professor Lau's computer modelling indicates that heat waves will lengthen from the typical three to four days, to seven to 10 days. Instead of one per summer, there will be three or four. The combined effect is profound, meaning heat waves occur for more than 50% of the summer season in many parts of the world, instead of just a few days per year.

Professor Lau has devoted his 40-year career to climate research, scouring through observational climate records and prediction computer models to 'map' the progress of climate variations and their likely future paths.

Heat Waves in Europe and China

	Europe		*China*	
	In the Past	Late 21st Century	In the Past	Late 21st Century
Duration (days per year)	11.7	16.0	12.3	26.6
No. of heat waves per year	1.9	4.3	1.4	3.6
No. of heat-wave days per year	22.6	69.0	17.0	95.9

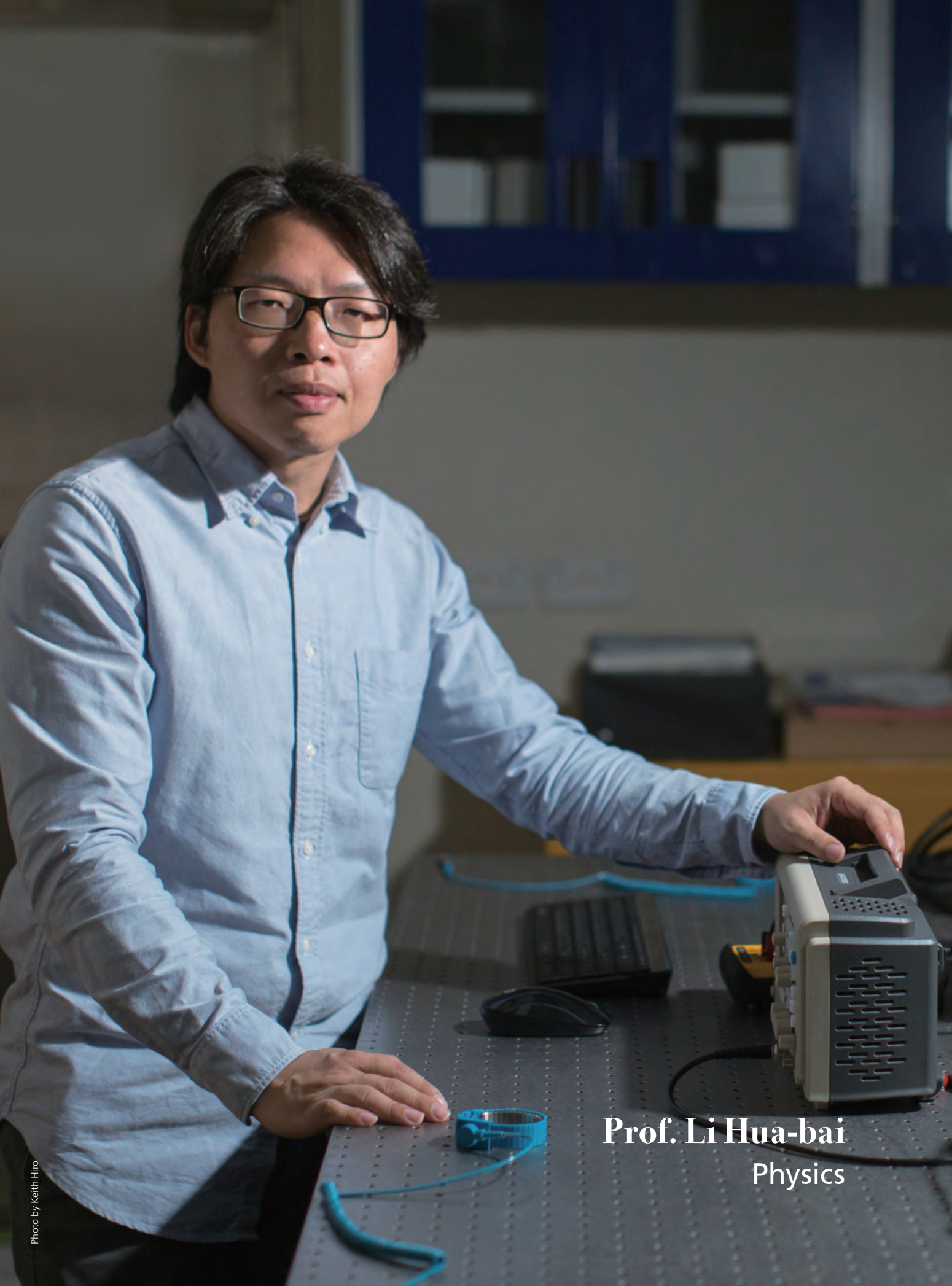
Heat waves have been his specific focus for the better part of the last decade. North America was his original focus, but his gaze then shifted to Europe and then to Asia. The results are equally if not more alarming:

'Global warming is so pervasive that all these regions will experience some increase in heat waves,' Professor Lau said. He felt sure that examination of other parts of the world would lead to similar results: 'Climate change has profound implications on the socioeconomic well-being of the entire global population.'

Professor Lau has played a prominent role in the work of the United Nation's Intergovernmental Panel on Climate Change (IPCC). The panel combines the work of thousands of climate scientists around the world in the largest scientific assessment of climate change ever attempted.

The IPCC, which was set up in 1988, publishes an assessment report every six to seven years. He first contributed to the 2007 report. Then as a lead author, Professor Lau helped draft the final chapter of the 2013 report. The panel shared the 2007 Nobel Peace Prize with former US vice president **Al Gore**, after the release of his climate-change documentary *An Inconvenient Truth*.

'Unless we really take measures in limiting emissions and conserving energy consumption, global warming will continue,' Professor Lau said. 'More heat waves will follow suit.'



Prof. Li Hua-bai
Physics

Photo by Keith Hiro

Before a Star Is Born

Li Hua-bai's quest for the origin of stars

A group of astrophysicists at CUHK led by Prof. **Li Hua-bai** has found that the magnetic field plays a significant role in the formation of massive stars.

The universe is filled with gases and dusts which, when collapsing into sufficient density due to gravitational pull, form the celestial bodies such as our stars and planets. But there are other forces at work where stars are likely to be born. As Professor Li explained, turbulent cloud motions would disperse the gases while the magnetic field, or B-field in astrophysicists' parlance, would align the gas motion along the magnetic field lines because the particles themselves contain ions. The interplay of gravity, turbulence and B-field has long been a subject of rigorous research and debate among astrophysicists.

If gravitation is the sole determinant, the collapse of the gases would be a uniform free-fall into a core which would trigger off the first nuclear fusion. In theory, all the gases should be turned into stars during the free-fall time in the order of one million years. But empirical and statistical data have suggested otherwise. Only a small percentage of gas will eventually form stars.

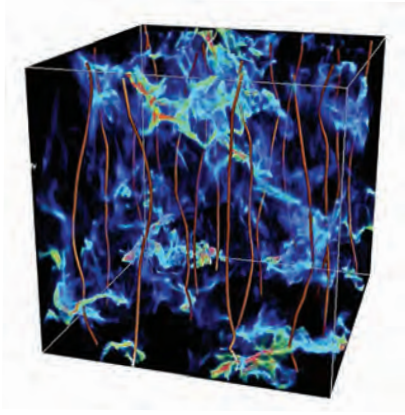
Professor Li and his team examined the role B-field plays in the formation of massive stars. They chose to focus on NGC6334, also known as the Cat's Paw Nebula, because the gas in this region has a total mass 200,000 times that of our sun and is a fertile ground for massive stars to sprout. Also, while its distance from the Earth is a staggering 5,500 lightyears away, in astronomical terms it is close enough for valid observations to be made.

Using data gathered at various observatories in Hawaii and the Antarctica, the team was able to map out NGC6334's magnetic field structure at a range of different scales and examine its cloud fragmentation with ordered B-fields. At all the different scales, the same pattern emerged: the cloud forms itself into a flattened structure perpendicularly to the B-fields, and at the end of the structure, the gas contracts into clumps, slightly pinching the B-field lines.

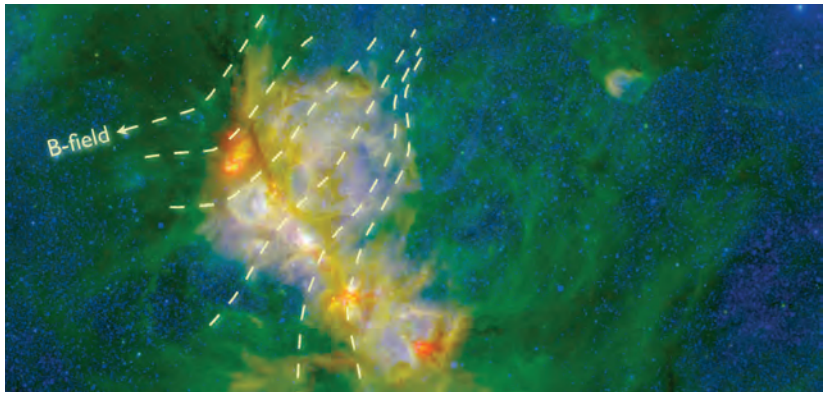
The consistent pattern of gas fragmentation across all scales demonstrates the dominance of the B-fields in the region NGC6334. With the B-fields the primary ordering principle, gravity and turbulence come in to compete for second fiddle. If gravity prevails, the structure would be better defined and the star formation process will be more efficient. If turbulence prevails, the structure would be more tangled and theoretically it will take longer to form a star. These findings were published in *Nature*.

The findings in NGC6334 were repeated in another study. Professor Li's team zoomed in to study the star formation in the molecular clouds in the Triangulum Galaxy, also known as M33, and found the B-fields in these molecular clouds are ordered and aligned with the large-scale galactic B-fields.

The team's simulation of the interstellar dynamics has been greatly helped by the high-power computer at the Department of Physics with 1,500 CPU cores. Professor Li expects more data to come when a new B-field mapping instrument is built at the department and installed on the Atacama submillimeter telescopes in Chile.



▸ *A numerical simulation, carried out by Dr. Frank Otto, of magnetized turbulent cloud. The red lines stand for B-field directions. Colours stands for gas densities (Red–high and blue–low)*



▾ *The dashed lines stand for the large-scale B-field observed using the Viper telescope in Antarctica, on top of the infrared photo of NGC6334 composed by Sarah Willis using data acquired by the Herschel satellite telescope*

Prof. Liu Yun-hui

Choh-ming Li Professor of Mechanical and Automation Engineering

Let There Be Sight

Liu Yun-hui gives eyes to robots

Robots are strong, durable and increasingly smart. They are precise. Science fiction tells us they'll eventually take over the world.

But there's one thing that they can't do well: see. Robots can be equipped with cameras, but there's normally a human set of eyes on the end. Robots that carry out free-flowing movements instead of repetitive tasks must be controlled as a result.

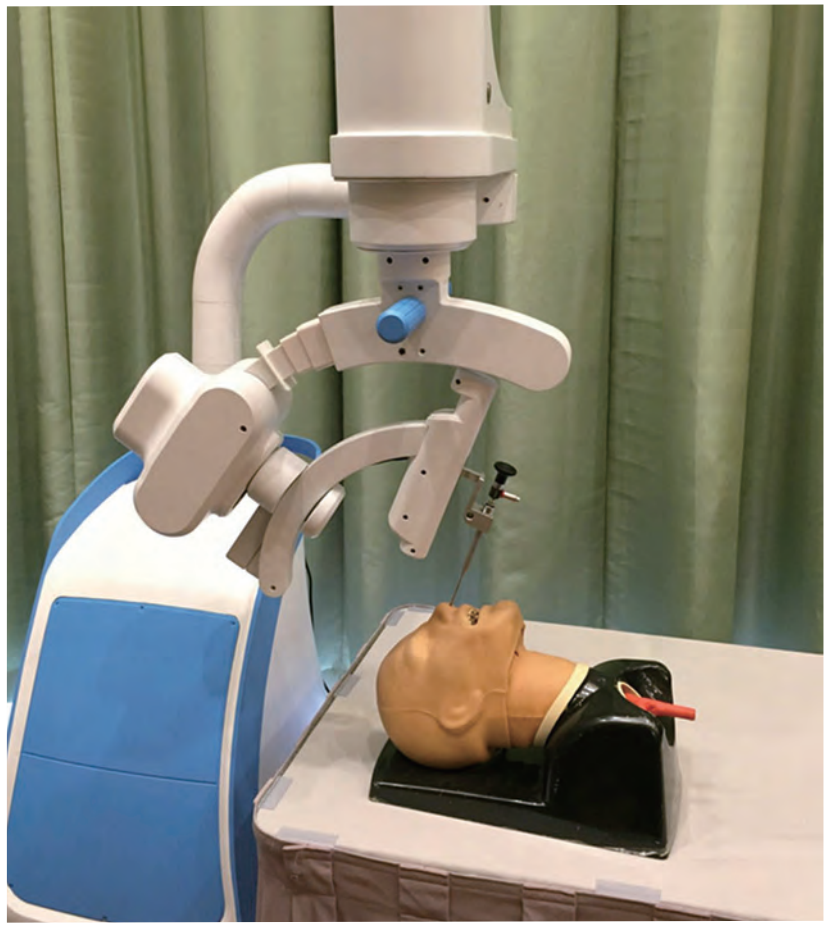
That is an obstacle CUHK robotics engineer **Liu Yun-hui** has overcome. He has pioneered a novel solution that gives robots 'eyes' using what is known as vision-based 3D motion control. By programming a robot with that sort of vision, it can operate independently in a factory, warehouse and even the operating theatre, assisting surgeons.

The main reason that robots can't see well is that they have trouble with depth perception. Humans assess depth naturally and instantaneously. But it is very hard for a robot to judge quickly and accurately how far apart objects are, and as a result even to place itself in a room. Whatever it looks at appears like a flat canvas.

Professor Liu's vision-based 3D motion control allows robots to place themselves without using a Global Positioning System, which does not function well indoors. It also allows robots to manipulate soft objects that bend under pressure, that are 'deformable.'

Professor Liu has applied his work to medicine. He and his team have created two robotic systems in conjunction with the Prince of Wales Hospital that are in testing.

One helps with nasal surgery by maneuvering an endoscope intelligently. At the moment, a surgeon must manipulate the endoscope manually with one hand, while the surgeon's other hand performs surgery, which is obviously inefficient. The new robot can move on its own and be manipulated using a wearable control pedal on the doctor's foot, freeing up both hands.



▲ *One surgery robot helps with nasal surgery by maneuvering an endoscope mechanically*

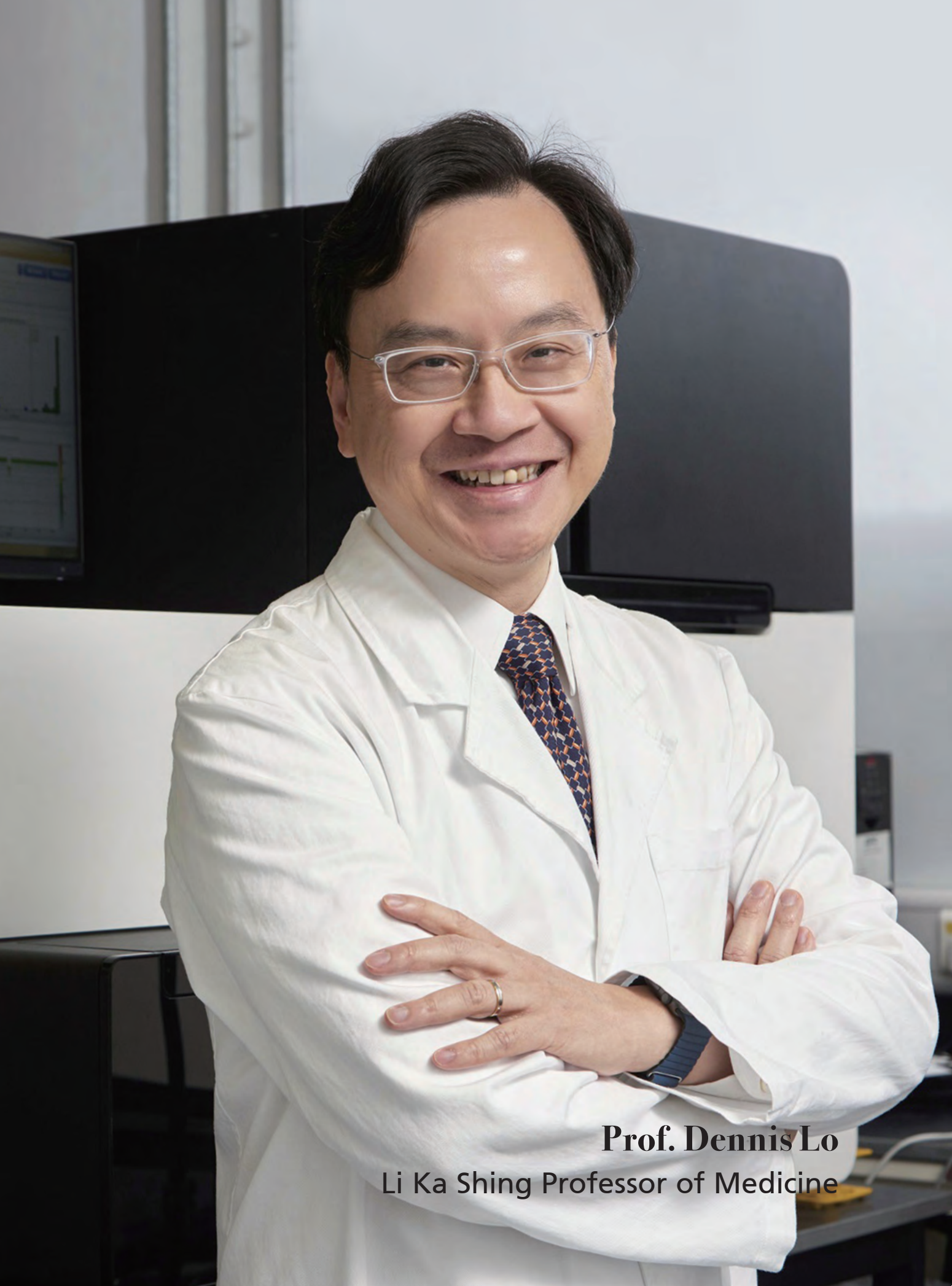
'The idea is to make the surgeon and robot collaborate together,' Professor Liu said. He believes robots will in the future be able to perform basic medical procedures entirely independently. The issue is whether they will be allowed to do so.

Robots enabled with vision can operate independently in a warehouse or factory floor. Working with CUHK's extension at the Shenzhen Research Institute, Professor Liu has created a 'smart forklift' equipped with his control system. The smart forklift is now moving around parts in a factory in Jiangsu Province making components for high-speed trains.

The applications, if not quite endless, are very extensive. Professor Liu wants to see his vision system applied to baggage handling, the manipulation of soft substances such as food, and services such as care for the elderly. 'There are still many problems to be solved to make robots work reliably and intelligently in the natural environment, like human beings,' he said.

Taking Snapshots of the Future

Dennis Lo navigates the seas of plasma DNA



Prof. Dennis Lo
Li Ka Shing Professor of Medicine

Prof. **Dennis Lo** is perhaps best known for his discovery that the DNA of an unborn fetus could be found in the blood plasma of its pregnant mother. He went on to develop a new method for the prenatal testing of Down syndrome which averted the risk of miscarriage inherent in traditional invasive methods. His pioneering work has made possible a new generation of non-invasive tests.

In collaboration with Prof. **Rossa Chiu** and Prof. **Allen Chan**, he made a breakthrough by showing that the entire fetal genome is represented in maternal plasma. The next step of devising a non-invasive fetal genome scan was challenging, as fetal DNA molecules, which account for only about 10% of the DNA in the maternal plasma, are highly fragmented. Constructing the fetus's genetic profile from these fragments would be tantamount to assembling a million-piece jigsaw puzzle. Professor Lo said, 'To make matters worse, these fetal DNA molecules in the mother's blood plasma are drifting in an ocean of maternal DNA molecules. This is like adding in tens of millions of pieces from another jigsaw puzzle and then trying to re-assemble the first one.'

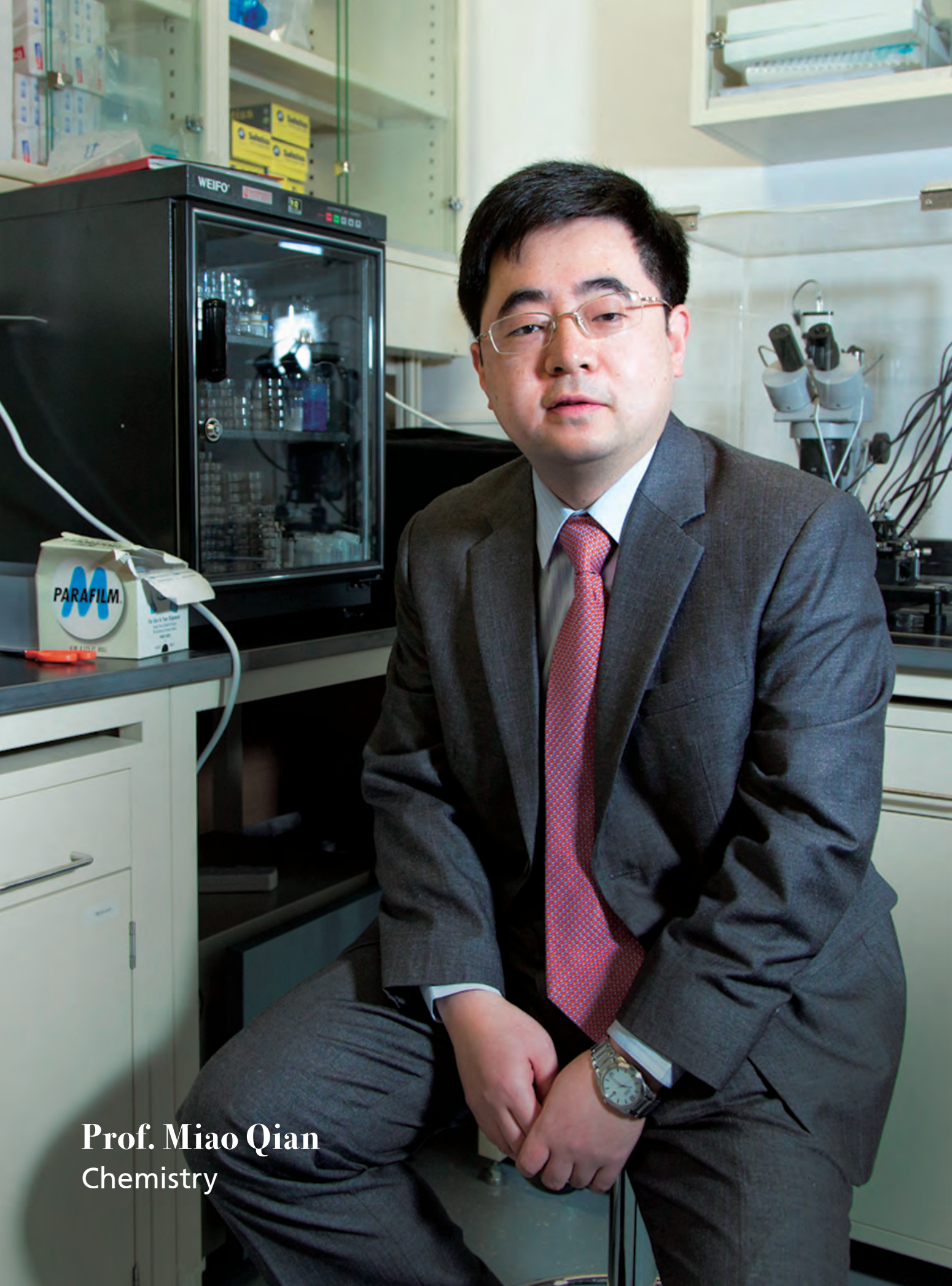
To overcome this, the CUHK research team sequenced nearly four billion DNA fragments from a maternal blood sample, which was equivalent to some 65-fold coverage of the human genome. They then constructed separate genetic maps that the fetus had inherited from the father and from the mother. By combining the paternally-inherited and maternally-inherited genetic maps, they were able to arrive at a genomic map of the fetus. They then used this map to confirm that, in the test case in point, the fetus was a

carrier of beta-thalassaemia from the father's side, which should not cause any serious postnatal problems.

By carefully sequencing the maternal plasma DNA, Professor Lo's team has been able to reveal the genome-wide genetic and mutational profile of the fetus. The implication of this ground-breaking research is that by analysing a blood sample from the pregnant woman the entire genome of the fetus can be deduced and screened for many possible genetic disorders in one go.

The plasma DNA analysis can not only be applied in prenatal tests but also cancer screening. In 2013–2016, Professor Lo and his team conducted a study of screening nasopharyngeal carcinoma (NPC) using plasma DNA analysis and the result is promising. By detecting the Epstein-Barr virus DNA, which is released by NPC tumour cells into the patient's plasma, early diagnosis of NPC can be achieved. Professor Lo's study involved 20,174 Chinese males aged between 40 and 60 without NPC symptoms. Among them, 309 participants had tested positive on the initial and follow-up blood tests and 34 were diagnosed with NPC. The predictive value is 11%, higher than the average of 3% of normal cancer screenings. The research was selected by *The New England Journal of Medicine* as one of the 'Notable Articles of 2017'.

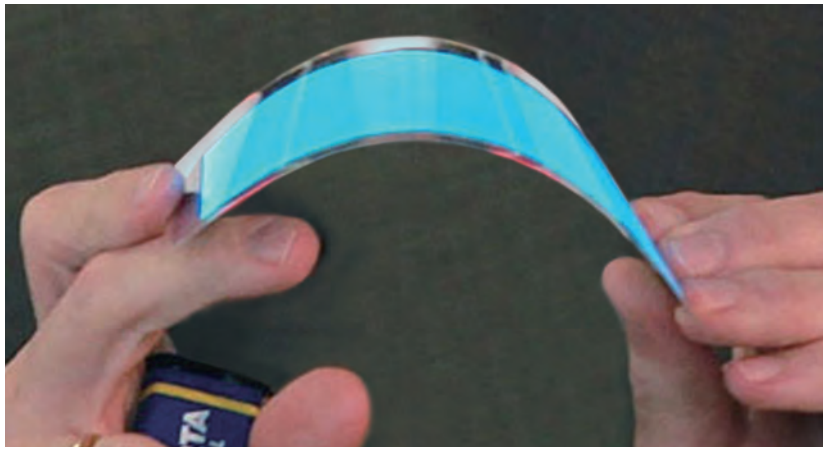
What Professor Lo is doing is to reveal the mystery of diseases and deficiencies in ever-increasing numbers of pixels which will enhance prevention and even treatment. He takes aim at the present for possible answers to the future. The future for patients who would benefit from Professor Lo's scientific innovations is indeed bright.



Prof. Miao Qian
Chemistry

Mobile and Malleable

Miao Qian's work on organic semiconductors



▲ *A flexible OLED display* (Source: Armin Kübelbeck, CC-BY-SA, Wikimedia Commons)

Thanks to the development of organic semiconductors by chemists such as Prof. **Miao Qian**, we will likely soon benefit from products like mobile-phone screens that bend in our pockets and never crack, sensors that can alert inspectors to gas leaks, and wearable medical devices.

Professor Miao and his research team have been experimenting with organic rather than inorganic materials in the fabrication of thin film transistors, a fundamental device in electronic circuits used for many applications.

He sees plenty of applications for his work. The most common semiconductor at the moment is silicon, which is inorganic. But its production requires high temperatures and therefore lots of energy, with many steps necessary to turn sand into silicon.

Organic semiconductors can be fabricated with a simple printing technique at room temperature. They have several other advantages. They are flexible, unlike their inorganic counterparts, and can produce devices that are both lightweight and very large. That would allow for malleable screens that would, for instance, allow a robotic hand to sense whatever it touches through an 'eSkin.'

High-grade silicon has very rapid charge transport, which is necessary in an application such as the contents of a computer's central-processing unit. But for a comparatively simple product such as a computer or television screen, low-grade silicon is sufficient, something an organic semiconductor can replace.

Organic semiconductors are inherently more flexible than silicon. Professor Miao is also attempting to detect if gas is leaking from a device by using an organic semiconductor in a transistor that amplifies electrical signals, interacting with other molecules to provide feedback in the form of an alert.

Professor Miao considers the creation of an n-type organic semiconductor based on nitrogen-containing pentacene to be the most significant discovery that he has made in the field so far. By experimenting with the chemical structures of organic semiconductors, he discovered that replacing carbon atoms in the well-known p-type semiconductor based on pentacene with four nitrogen atoms converted the material into a high-performance n-type semiconductor.

The combination of p-type semiconductors, such as pentacene consisting only of carbon and hydrogen, and n-type semiconductors containing nitrogen atoms in the fabrication of electronic circuits allows easy fabrication of efficient circuits.

'The development of n-type organic semiconductors is slower than that of p-type semiconductors,' Professor Miao explained.

The p-type pentacene contains 22 carbon atoms in its five-ring framework. Professor Miao and his team began experimenting with substituting various numbers of those atoms with nitrogen, replacing two atoms, then six, before settling on four as the best combination.

'The speed of charge transport is the best for solution-processed n-type organic semiconductors,' he explained. What's more, the production begins with cheap starting materials, diaminobenzene and benzoquinone, which are both readily available.

One of the key challenges now is figuring out how to create the organic semiconductors in a simple way. At first, Professor Miao's best n-type semiconductor was processed in a high vacuum, which is expensive to achieve. 'That is not good enough,' Professor Miao said.

He has since managed to produce the semiconductor film from a solution by surface modification, a simpler and cheaper method that was recently patented. He is working with a mechanical engineer to fabricate electronic circuits for large-area sensing applications. 'We want to make the devices in a much cheaper, simpler way.'

Taking Aim at a Deadly Enemy

Tony Mok personalizes lung cancer treatment

Prof. Tony Mok

Li Shu Fan Medical Foundation
Professor of Clinical Oncology

It is through the emerging field of personalized medicine that CUHK professor and oncologist **Tony Mok** has been improving the treatment and lives of lung-cancer patients. As the lead investigator on two landmark studies, he has helped to establish new approaches to the treatment of lung cancer that can extend the lives of people afflicted by the disease.

Professor Mok has been tracking patients with what is known as the epidermal growth factor receptor (EGFR) mutation, an oncogene that can cause normal cells to become tumorous and that results in thousands of lung-cancer cases every year. He has established that it can be more effective to treat advanced lung cancer caused by the EGFR mutation with a pill that a patient can take once a day, without the need for chemotherapy, which is more toxic.

In the EGFR mutation, a genetic defect on the receptor causes a malfunction, providing a continuous growth signal to the cancer cell, which then grows uncontrollably. The drug gefitninib, marketed under the name Iressa by AstraZeneca, inhibits an enzyme, tyrosine kinase, which acts as the 'on' and 'off' switch for the signal. It binds with the tyrosine kinase, and inhibits the enzyme, meaning the signal is no longer sent.

Professor Mok oversaw the Iressa Pan-Asia Study, or IPASS, the study that first established the foundation for using personalized, gene-based medicine to treat lung cancer. All patients with adenocarcinoma are now mandated to be tested for the EGFR mutation.

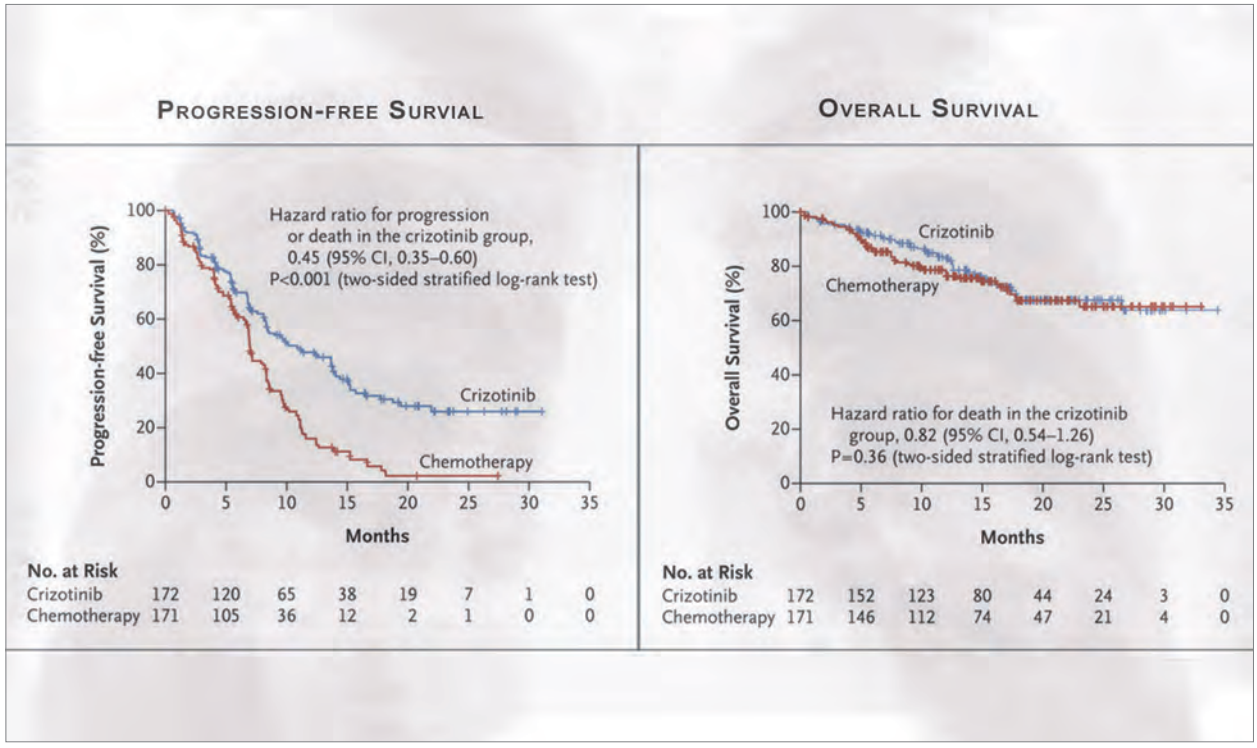
The paper from the multinational study led by Professor Mok—'Osimertinib or Platinum-Pemetrexed in EGFR T790M–Positive Lung Cancer'—was selected by *The New England Journal of Medicine* as one of the 'Notable Articles of 2017'.

Following another ground-breaking discovery in Japan, that the re-arrangement of an enzyme known as anaplastic lymphoma kinase or ALK can also cause lung cancer, Professor Mok launched another major study known as PROFILE 1014. Again, the ALK abnormality can be traced through genetic testing.

PROFILE 1014 looked into the use of another drug, crizotinib, that inhibits the ALK. The study, conducted with Prof. **Benjamin Solomon** at the Peter MacCallum Cancer Centre in Melbourne, confirmed the superiority of crizotinib over chemotherapy, findings that came out in the *New England Journal of Medicine* in 2014.

Unlike EGFR, ALK is not a mutation but instead involves the translocation of chromosome 2. What used to be an

▲ *Professor Mok: 'The whole objective is to convert a fatal lung cancer into a chronic illness.'*



▲ *Comparison of survival rates with treatment of crizotinib and with chemotherapy in a study published by Professor Mok and others* (Source: *N Engl J Med* 2014; 371:2167–2177)

'indolent' gene causing little or no harm suddenly becomes a fusion protein that makes the ALK active. Treatment with crizotinib showed substantially better results than chemotherapy in terms of extending the patients' lives (see the graphs above).

His results show that all patients with advanced-stage lung cancer should be tested for the EGFR mutation and ALK rearrangement. They can then receive the appropriate drug. Thanks to this work, such personalized medicine is now a universal standard, allowing for individualized plans of treatment based on each person's genetic makeup.

'The whole objective is to convert a fatal lung cancer into a chronic illness,' Professor Mok said. 'We are not curing the patients with advanced-stage lung cancer. But people can take one pill a day, and they live like a normal person for a substantial portion of time.'

Prof. Edward Ng

Yao Ling Sun Professor of Architecture

Taking Temperature of a Fevered City

Edward Ng's tips on staying cool

During the summer in Hong Kong, temperatures in the urban areas can reach feverish levels. Prof. **Edward Ng** is particularly interested in urban climatology and sustainable architecture. Through research and tests, he provides concrete data to help the government improve its environmental planning, and finds antidotes to Hong Kong's 'fever' by creating a more comfortable and healthy living environment.

'If the temperature is higher than 28ºC at night, our bodies cannot rest properly. It's like we haven't slept at all,' said Professor Ng. His research findings indicate that in Hong Kong, 'very hot nights' have jumped from 20 a year in the past to 127 or a third of the year now. Further research, conducted by Professor Ng in collaboration with Prof. **Emily Chan** of CUHK's School of Public Health and Primary Care, revealed that when the temperature rises by one degree in summer, the mortality rate rises in tandem by 1.6%. So reducing the temperature of the city is not just essential to improving general living conditions, but also to saving lives.

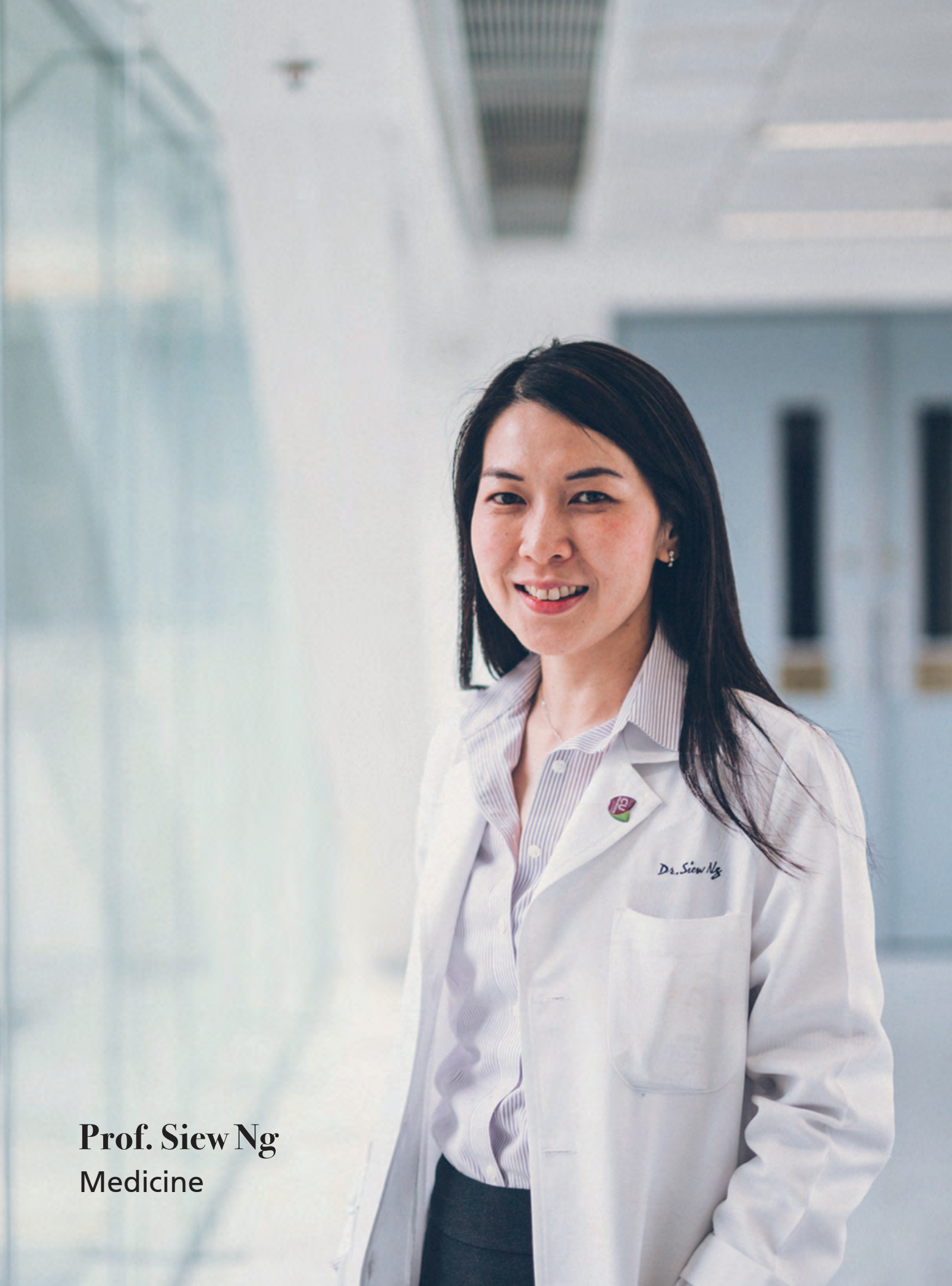
When the built-up areas of a city are significantly warmer than the surrounding rural areas due to the retained heat caused by urban development, this creates a phenomenon called an Urban Heat Island (UHI). During the summer, Hong Kong's average temperature is 28.3ºC. But due to UHI, the temperature in major built-up areas such as Mongkok, Yaumatei, Tsimshatsui and Causeway Bay can reach 33ºC.

Six major factors influence whether people feel comfortable in the summer: air temperature, humidity, solar radiation, wind speed, clothing and individual behaviour. These factors can be put together in a formula and presented as an indicator called Physiological Equivalent Temperature (PET). By adjusting these factors, we will be able to create more comfortable summer living conditions for the population.

According to Professor Ng, there's nothing we can do about humidity. But we can do something about the other three through good urban planning. We can find appropriate locations for both horizontal and vertical greening to reduce air temperature, establish bodies of water to reduce the impact of radiation, clear away obstacles to improve air flow, improve the choice of building materials, and paint buildings a lighter tone to reflect the sun's rays.

Choice of clothing and individual behaviour and habits are internal factors. Wearing lighter clothing allows us to stay cool and reduce the use of air-conditioning which pumps warm air out into the city. Professor Ng's outfit does not include a tie. 'Usually an air-conditioned office should remain at around 25.5ºC,' he said. 'But here in my office I am comfortable at 27.5ºC. The way we dress affects our response to temperature. If you put on a tie, you will feel two degrees warmer. A bow tie will make you feel 2.5 degrees warmer!'

Solving the problem of UHI is not just the responsibility of Government alone, but also of each individual citizen and organization. It will also take various measures, including promotion and educational efforts, to raise awareness among the public in reducing energy use and lowering the heat in the city by changing behaviour.



Prof. Siew Ng
Medicine

So Much to Stomach

Siew Ng: why an inflammatory bowel? why Asia?

The West imports plenty of goods from Asia. But there's one transfer in the other direction that is very negative indeed. It's the job of CUHK gastroenterologist **Siew Ng** to stop that flow.

Two decades ago, inflammatory bowel disease was virtually unheard of in Asia. The two main forms, Crohn's disease and ulcerative colitis, were viewed as a 'Western disease' that affected Caucasians, and Caucasians alone.

Hong Kong has seen a 30-fold increase in the disease since then. The mainland has experienced an especially pronounced pickup, and is likely to have more than 1.5 million cases of inflammatory bowel disease by the year 2025. That will likely equal or exceed the total in the Western world.

Changing diets are a major factor. High levels of fat, meat, sugar, food additives, fast food and carbohydrates trigger the condition. High levels of fibre may prevent it.

The condition is rarely life-threatening, but it is debilitating, and mostly affects the young. Patients are in and out of hospital, suffer through multiple operations, have internal bleeding and pain, and often can't stomach, literally, going to school or managing a family.

Professor Ng's first step was to study the epidemiology of the disease, and find out how common it truly is. She discovered that the incidence in Hong Kong had expanded from 0.1 to 3 cases per 100,000 people over the last two decades.

The rapid change demonstrates to Professor Ng that genetic changes alone have not accounted for the spread of the disease. However, there are more than 200 genetic loci—essentially 200 genes—that indicate a propensity to develop inflammatory bowel disease.

She has also discovered that people who were breast-fed as babies have at least a 90% lower chance of having the disease. Interestingly, exposure to pets is also a protective factor—exposure to parasites boosts the immune system, Professor Ng has proved in Asia.

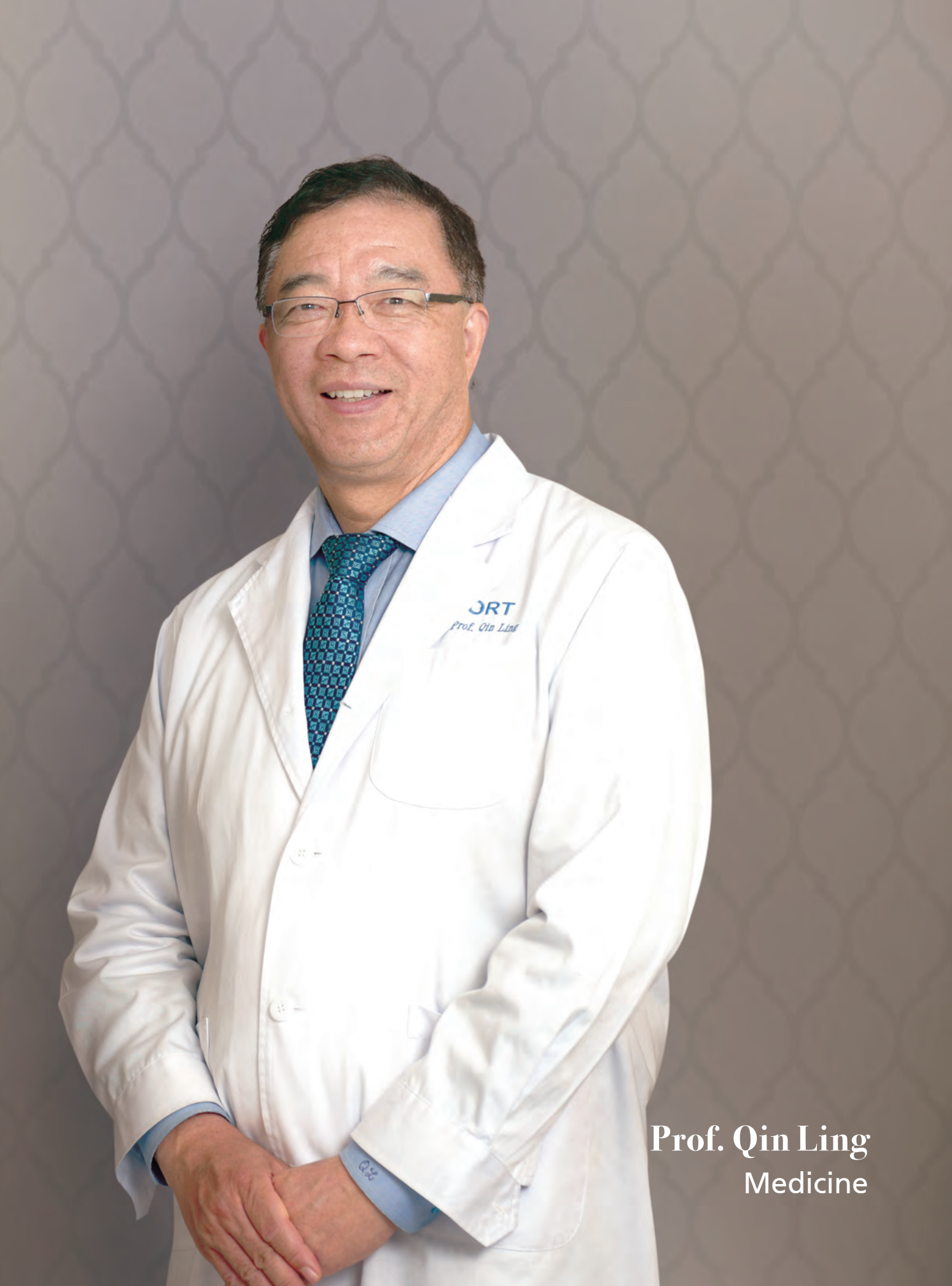
The use of antibiotics early in life can raise your chances of contracting Crohn's, depending on the type and dose. Antibiotics are routinely overprescribed in China, especially to children.

Professor Ng is working on introducing fecal microbiota from the faeces of a healthy person into an affected patient, aiming to introduce 'healthy' bacteria that can fight the disease.

Professor Ng's group established the Asia Pacific Crohn's and Colitis Epidemiology Study group, or ACCESS, which has expanded to cover 15 countries in the Asia-Pacific region. It has tracked more than 3,000 new cases in the area.

Northern China has lower incidence, while Guangzhou in the south has the highest. 'We don't know why, but that is really fascinating for me,' Professor Ng said, 'and an area for further study.' Urbanization and the Westernization of diets may both play a part.

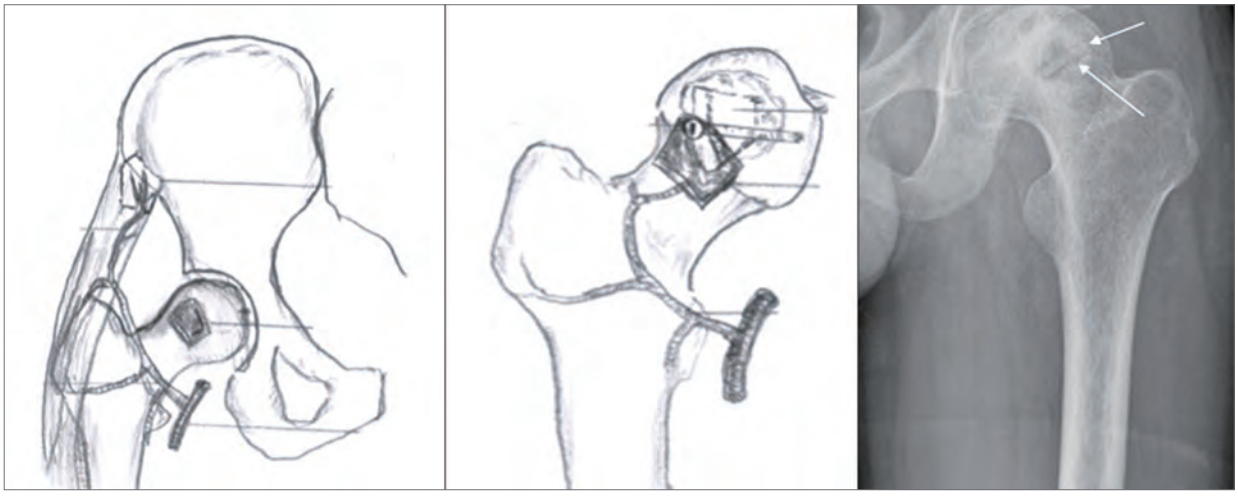
Ng's team has been coordinating with laboratories and clinics in Beijing, Shanghai, Guangzhou and Xian to study the disease on the mainland, in the hope of uncovering how environmental factors lead to Crohn's disease. Ultimately, the aim is to encourage dietary changes and modify gut bacteria to treat the disease, two steps on the path to finding a cure.



Prof. Qin Ling
Medicine

Fixing a Loose Screw

Qin Ling experiments with bioactive implants



▲ *Professor Qin's team develops a magnesium screw that dissolves entirely, aiding in the bone formation around the join site in the process* (Source: Zhao DW, et al. *Biomaterials* 2016)

Titanium plates or screws are normally used to fix difficult fractures and they remain permanent in the body. But Prof. **Qin Ling**'s experimental implants simply dissolve within the body, reducing the risk of infection or the need for removal. That's because they are made of magnesium rather than the hard metal that's currently used.

Magnesium is a micronutrient that the body needs to consume regularly, and is present in our diet. So as well as dissolving naturally, the new orthopedic implants have a secondary benefit in that they serve as a supplement of sorts to the body's natural function. Magnesium is a 'bioactive' implant, whereas titanium or steel are 'bioinert.'

Magnesium does not have the strength of permanent metallic implants such as titanium. That actually proves an advantage since the bones involved gradually strengthen around the join site. With a titanium implant, the body learns to rely on the metal for stabilization, and the bone does not regrow as well.

Magnesium is also a co-factor in around 300 enzyme reactions in the body. Found in green and leafy vegetables, nuts such as almonds and cashews, soy milk and whole grains, the metal leads to better bone strength in those that consume it, as well as helping with muscle growth and to protect the nervous system.

Working with hip injuries in particular, Professor Qin's team has developed a magnesium screw that dissolves entirely within two years, aiding in the bone formation around the join site in the process. They had reported those findings in the journal *Nature Medicine*. His paper demonstrating good results in the fixation of magnesium screws to prevent joint collapse has appeared in *Biomaterials*, another top journal.

Besides hip injuries, which are particularly dangerous for older patients since the patients often develop complications from other infections while in hospital, Professor Qin has also experimented with the use of magnesium implants to help heal tears of the anterior cruciate ligament.

ACL tears are particularly common with younger patients, between the ages of 15 and 25. It's difficult to suture the ligament back into place, often requiring doctors to drill a hole into the knee to fix a graft in place. With a normal metal screw, there is the risk that the constant wear and tear of the knee eventually results in the widening of its insertion tunnel. A magnesium screw, by contrast, stimulates bone growth around its insertion site, eventually dissolving in place.

Professor Qin has already established the efficacy of magnesium implants in rats, rabbits and goats. Together with a collaborator at a hospital in Dalian in northern China, they have now successfully introduced magnesium screws in some 200 human patients, in a single-centre trial.

The bipedal stance of humans creates different load-bearing issues in humans compared with quadrupeds. Other doctors are also using the same implants in experimental treatments in Europe. Such technology will contribute to the research and development of orthopaedic devices in Hong Kong.

'Magnesium is not a new material, but we have found a new application on the medical side,' Professor Qin explained. 'It's a material that is good for the body, and it's part of the body.'

Prof. Catherine So
Educational Psychology

Teaching the Autistic to Articulate

Friendly gestures from Catherine So

Gestures sometimes speak louder than words. Prof. **So Wing-chee Catherine** devotes most of her efforts to the study of gestures. In one of her studies, she found that children aged six to 12 years old with autism spectrum disorders (ASD) produced fewer gestures than typically developing children.

Most people gesture when they talk. And babies communicate through gestures well before they use speech. 'We can say that gestures are a precursor to language ability,' said Professor So.

Professor So's study is the first one that has analyzed gestural communication in children with ASD in the age range of elementary school (aged six to 12). Her research team recruited children with ASD and typically developing children from local family organizations and primary schools, and engaged them in experimental tasks. In one of the tasks, the researchers gave these children a farm blocks play set to play with and asked their caregivers to interact with them naturally. The researchers videotaped the interaction between the children and caregivers, transcribed their conversations, coded their gestures, and compared the amount and types of gesture used by the two groups of subjects.

'The children with ASD are unable to produce a particular type of gestures we call *markers*', said Professor So. Markers are gestures with culture-specific meaning. For example, a thumbs-up signifies praise; a head nod signifies agreement. She added, 'We found that the number of this type of gestures produced by them was less than one third of that produced by typically developing children.'

Researchers divide gestures into four types. In addition to markers, there are iconic, deictic and beat gestures. Iconic gestures bear a resemblance to the objects they represent or the actions associated with those objects (e.g., flapping two hands to represent a bird, or placing a closed fist with the thumb and pinkie outstretched near the ear to represent the action of making phone calls). Deictic gestures are generally understood as 'pointing gestures' that indicate real or imaginary persons, objects, directions. Beat gestures do not carry any meaning. They are simple motions with the hand or fingers that follow the rhythm of the speech.

▲ *With the help of NAO, children are trained to recognize commonly used gestures, including certain markers and iconic gestures* (Source: Aldebaran)

Professor So's study shows that children with ASD produced comparable numbers of iconic and deictic gestures to typically developing children, but they produced markedly fewer markers. 'Markers are conventionally or culturally defined,' said Professor So, 'and they are important for regulating interaction. When we shake our heads or give the thumbs-up sign, people understand us without any words. Children with ASD failing to produce markers have a serious deficiency in social interaction.'

To help children with ASD to understand gestures better and to use them more proficiently in social settings, Professor So and her team are offering an online gestural training programme for school-aged children with ASD. In this programme, gestures are produced by an animated robot called NAO. NAO does not have human facial features and expressions to cause sensory overstimulation and distractions to children with ASD. Incorporated into social stories, gestural movements performed by NAO can be understood and learned relatively easily by these children.

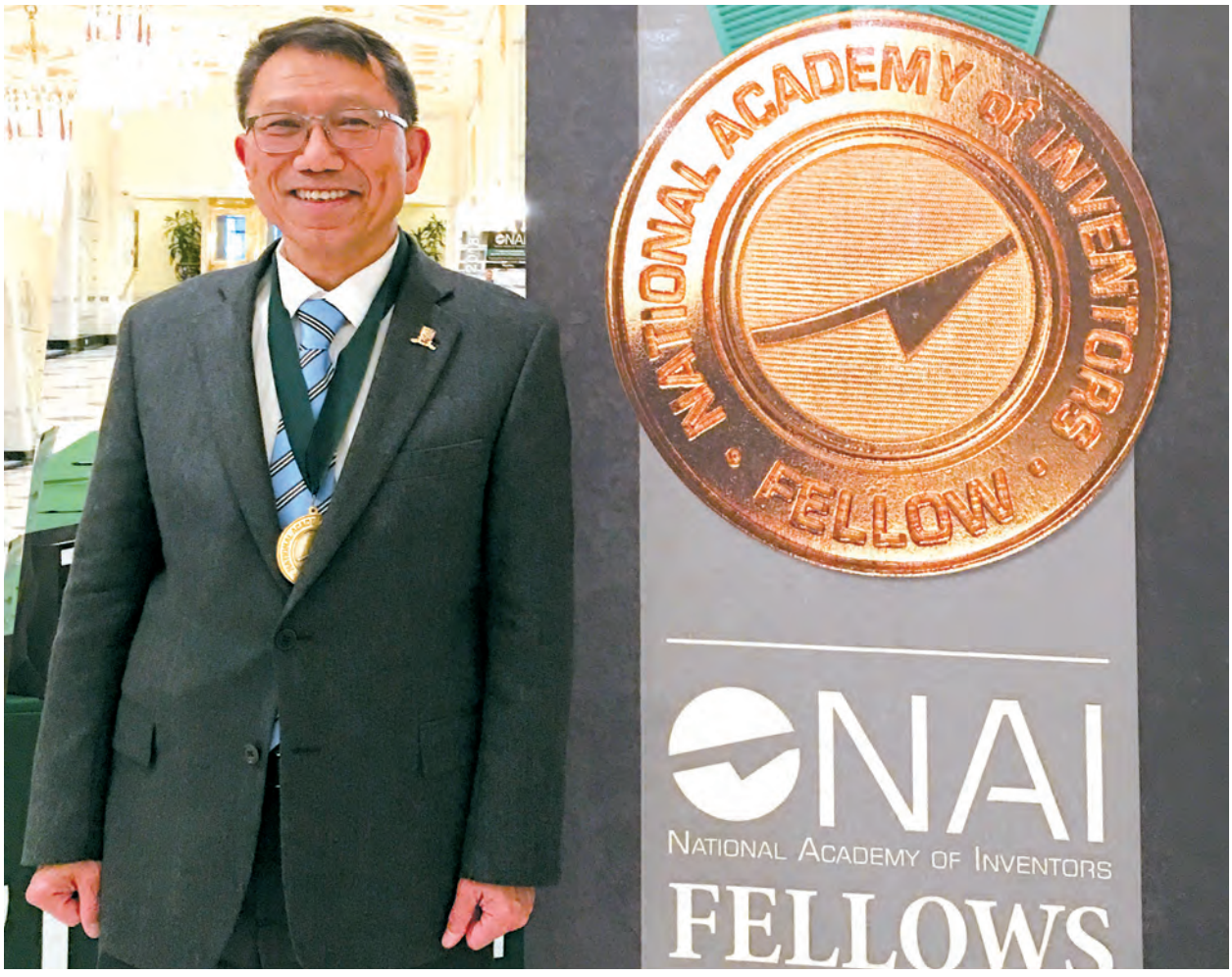
Professor So explained, 'The whole online gestural training programme consists of three phases. In the first phase, with the help of NAO, which is programmed to demonstrate the 20 most commonly used gestures, we train children with ASD to recognize these gestures, including certain markers and iconic gestures. In the second phase, we ask the children to make those gestures by imitating the robot's movements. In the last phase, we teach them how to use those gestures appropriately in social situations.'

What's Bred in the Bone

Rocky Tuan innovates and regenerates

Prof. Rocky Tuan

Vice-Chancellor and President,
Lee Quo Wei and Lee Yick Hoi Lun
Professor of Tissue Engineering
and Regenerative Medicine



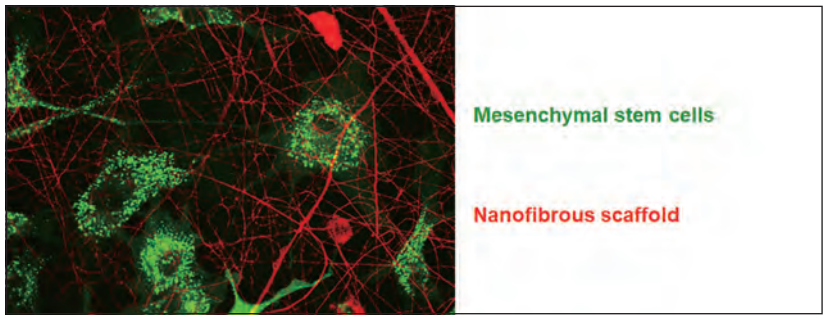
Regenerative medicine is the branch of modern biomedical technology that aims to repair or regenerate diseased or damaged tissues or organs of the human body. It encompasses the development of medical devices or artificial organs, tissue engineering, biomaterials, cellular therapies, and clinical translation.

Prof. **Rocky Tuan** is a world-renowned biomedical scientist specializing in musculoskeletal biology and tissue regeneration. His seminal work on musculoskeletal tissues has scripted an important chapter in the big book of regenerative medicine.

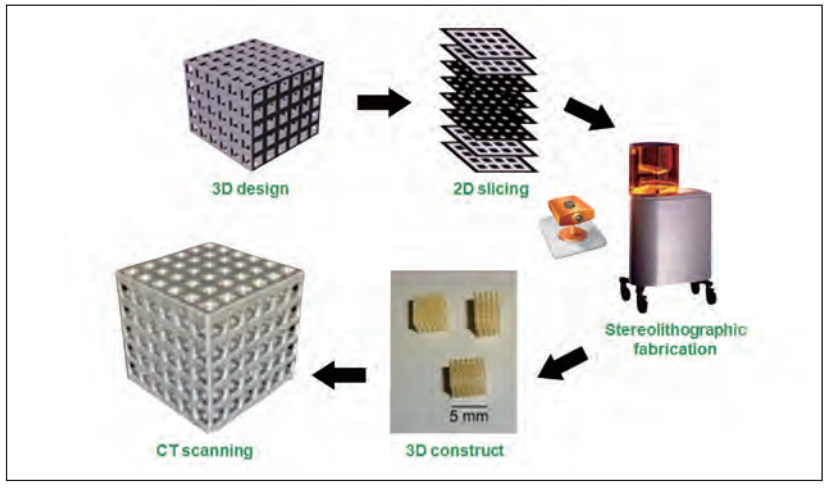
There are over 200 bones in a human adult. They serve two major functions, namely, weight-bearing and locomotion. The proper functioning of the bones and the joints ensures that human beings can carry on with their daily activities. Bones and joints, however, get damaged through injuries or degenerate with age, and the process is irreversible. Take osteoarthritis, for example. The disease, which results in the breakdown of the joint cartilage and the underlying bone, affects 10% to 15% of the population over 60. It is estimated that 130 million people worldwide would be affected by osteoarthritis by 2050. And there's no cure for it.

To mend the damaged joint, like repairing a pothole in the ground which requires concrete or asphalt as the filling material, the first step is to develop the material to replace the lost or damaged cartilage. In this case, the first raw material is human stem cells which can be found in many parts of the human body, such as bone marrow, fat tissue, muscle, placenta, and even baby teeth. Stem cells represent an ideal regenerative material because they have self-renewing power and the potential, when planted in a new tissue environment, to develop into cells that display the properties or functions relevant in that tissue. It is preferable that the stem cells for regenerative application come from the same person who is in need of a repaired or renewed tissue.

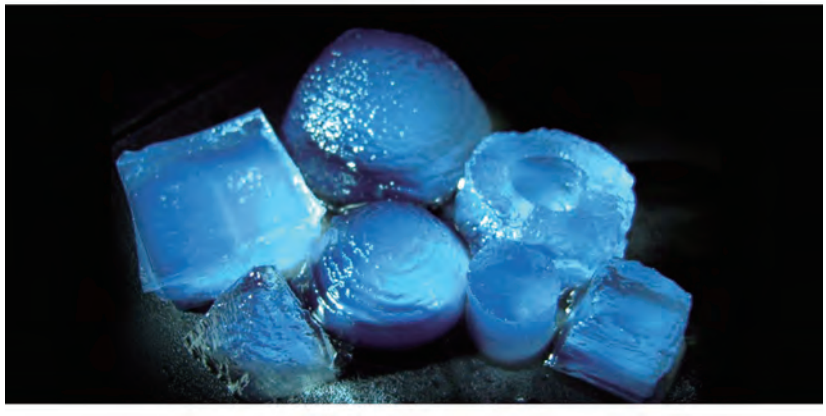
Second, a scaffold or matrix is needed as a carrier for the cells to grow and develop into a reparative tissue. Professor Tuan has pioneered two



▲ *Cells adhere to nanofibrous scaffold*



▲ *Projection Stereolithography (PSL) 3D printing*



▲ *Hydrogel Fabricated by PSL*

▲ *Microbioreactor for microJoint chip—first prototype*

types of such biomimetic scaffold. The first is electrospun nanofibres which are made by spraying a polymer solution, consisting of FDA-approved resorbable biomaterials, in a high electric field, to produce noodle-like threads, though with nano-scale dimensions. The stem cells are then seeded into a scaffold of such nanofibres. The cells would cling to and interact with this nanofibrous biomaterial scaffold, developing into an engineered tissue.

The second method is to seed the stem cells into a polymer solution that can be crosslinked with light to produce a hydrogel structure with the use of Projection Stereolithography (PSL) 3D printing technique. This method has the advantage that the cells are readily embedded inside the hydrogel structures which may be custom-fabricated to different shapes and sizes.

Lastly, the stem cell-seeded scaffold is placed in a bioreactor, much like an oven or incubator, into which nutrients are fed to simulate the inside of a living organism. The substance incubated in a horizontal axis rotating bioreactor for seven weeks results in a tissue structure that resembles natural joint cartilage, with 75% of its hardness.

The replacement cartilage thus engineered has been successfully tested on animals such as rabbits, pigs, goats. To further exploit the technology and extend its application on human beings, Professor Tuan has developed the first ‘microJoint’, a 3D replica of the human joint using a microbioreactor platform to cultivate multiple tissues that make up the joint, which can be used to study and screen for potential therapeutic agents for osteoarthritis. This approach significantly enhances the prospect of identifying and developing drugs and treatment for osteoarthritis.

Prof. Wang Xiaogang
Electronic Engineering

Reading Laughter and Tears

Wang Xiaogang perfects 'deep learning' for computers

◀ *A well-trained computer system can recognize what a person is doing in an image—laughing, eating, talking on a phone, etc.*

Computer scientist **Wang Xiaogang** has improved the way that machines sort images to the point where they are able to match the human ability to recognize faces. He is taking that expertise and expanding on it so that computers will be better equipped to detect and identify objects and actions—including what people are doing. The computer can report that data without requiring a human to sift through millions of images.

Professor Wang is using a technique known as Deep Learning to mimic the processes of the mind. Deep Learning is a method of structuring computer networks that uses parallel computing to pass information between millions of computation units to simulate the way the neural networks of the human mind work. Once under way, the interaction between the units helps them to 'learn' the increasing complexity of millions of parameters without a human being having to keep programming different instructions.

Professor Wang's group has been the first to apply Deep Learning to the detection of certain parts of the face, as well as the alignment of a face and the segmentation of the body. He has also trained his computer systems to recognize what a person is doing in an image—laughing, eating, talking on a phone—and estimate what kind of pose somebody is in.

After developing a new facial-recognition system, Professor Wang tested it against a data set known as 'Labeled Faces in the Wild,' a database of thousands of faces collected from the Internet. He has also tackled the problem of 'occlusion'—identifying a person in a crowd, or when only part of him or her shows in an image. Through Deep Learning, his hierarchical computer system can also figure out what parts of a person are in an image, and what position he or she is in.

Humans can recognize the similarity between two cropped faces 97.5% of the time, and the accuracy increases to 99.2% when they're shown a complete picture. Prior to the introduction of Deep Learning, the most-advanced computers were pitching at 96.3%. But Professor Wang has been able to boost performance to 99.15%—a breakthrough in that computers now have essentially the same success rate as humans.

The improvement comes from increasing the 'depth' of Deep Learning by introducing more layers of analysis, as well as getting those multiple layers to share information and re-use components.

Professor Wang has been able to outperform other scientists in facial-recognition tests, including those at Facebook, something he attributes to experience and a willingness to share information.

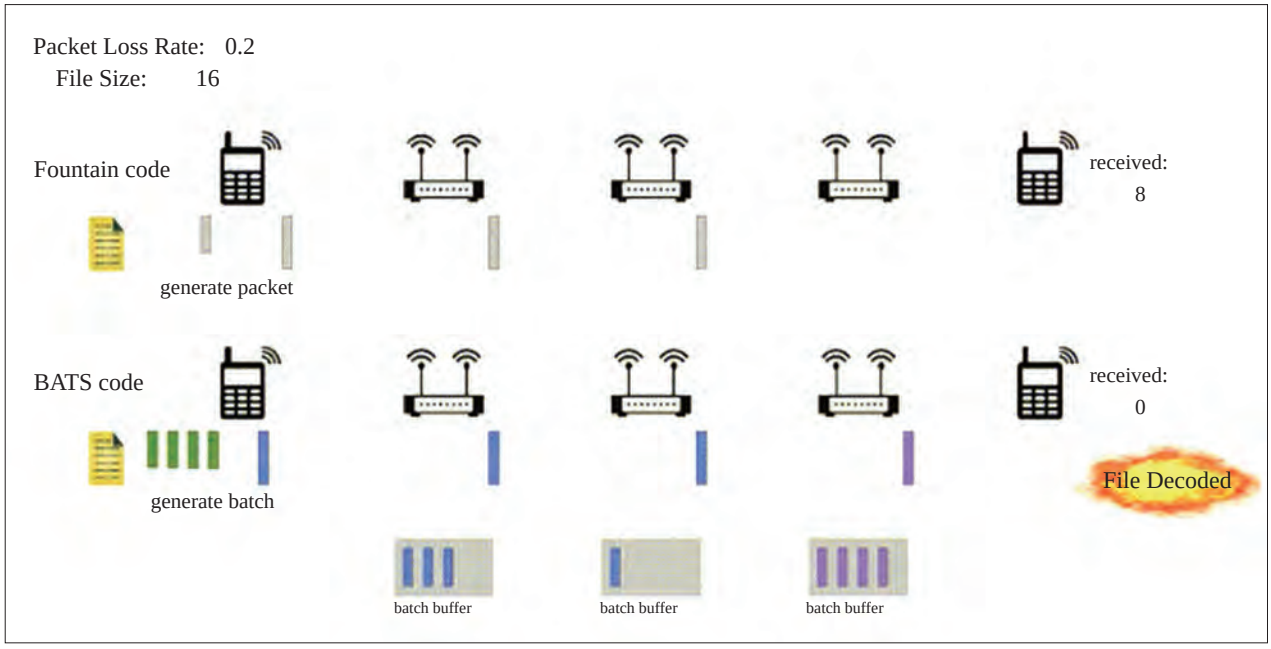
'Many computer scientists treat Deep Learning as a black box,' Professor Wang said, using their own image database and keeping it in house. 'We will open this box and carefully design this internal structure, by incorporating our research into computer vision conducted over the last 10 years.'

Professor Wang's next challenge is to turn the attention of his machines to recognizing what people within crowds of thousands of pedestrians are doing, for instance. It's far more complex than facial recognition given the large number of people involved and the wide variety of ways they interact. Another challenge is to improve the sophistication of facial recognition so that, for instance, a computer could take a side view of a face and recreate a full-frontal image.

Prof. Raymond Yeung
Choh-ming Li Professor of Information Engineering

Special Delivery in a Smart City

Cities get smarter with Raymond Yeung's network-coding theory



Despite common misconception, data are not in fact a contiguous commodity. They can be broken apart, rearranged and transformed instead of being shipped 'all in one go.' The information is disseminated through the system, then reassembled, a more-efficient and more-reliable way of making sure it makes it to its ultimate destination.

Such a system of transmission is called BATS, or BATched Sparse code, developed by Prof. **Raymond Yeung** in 2011. It is a network-coding scheme that's practical and efficient to implement, and has subsequently been refined and developed for commercial applications. To use the mail analogy, he explored the ability of the nodes transmitting data not simply to forward packets along, but to open them and rearrange the contents into other packets, which could be recombined at the final destination.

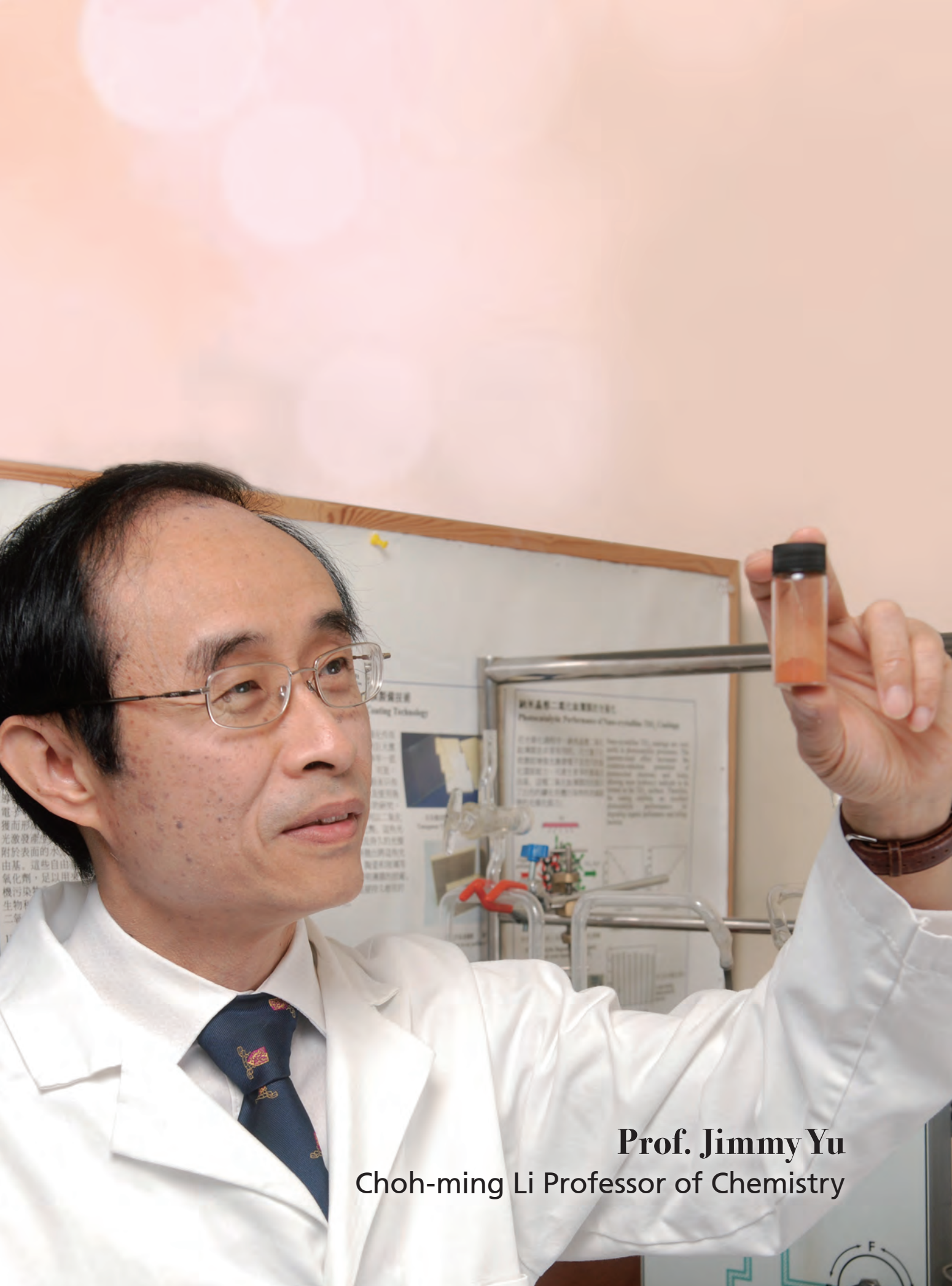
Hong Kong could benefit from his discovery with the development of 'smart lampposts'. These lampposts will, if all goes well, contain a multitude of sensors that could better coordinate the traffic light in the vicinity, detect environmental factors such as pollution, and gather analytics to allow for better city planning.

By becoming their own small signal-broadcast posts, lampposts could also allow for territory-wide WiFi coverage, as well as allowing autonomous cars to communicate with the system and with other cars.

The system could be a fast and efficient way of introducing 5G telecommunications to the city. The 5G technology is one order better in terms of bandwidth and latency than the existing 4G systems. But it operates at a very high frequency, meaning it is easily blocked by objects and barriers in its directional transmission. Having broadcast points throughout the city would allow for universal transmission.

Professor Yeung's BATS technology could allow for a small number of the lampposts to connect to the network by fibre, as nodes, while the others communicate to each other using BATS technology. By cutting data loss to negligible levels with BATS, large 'multi-hop' leaps are possible between posts communicating to each other, reducing the need for wired lampposts feeding into the network substantially.

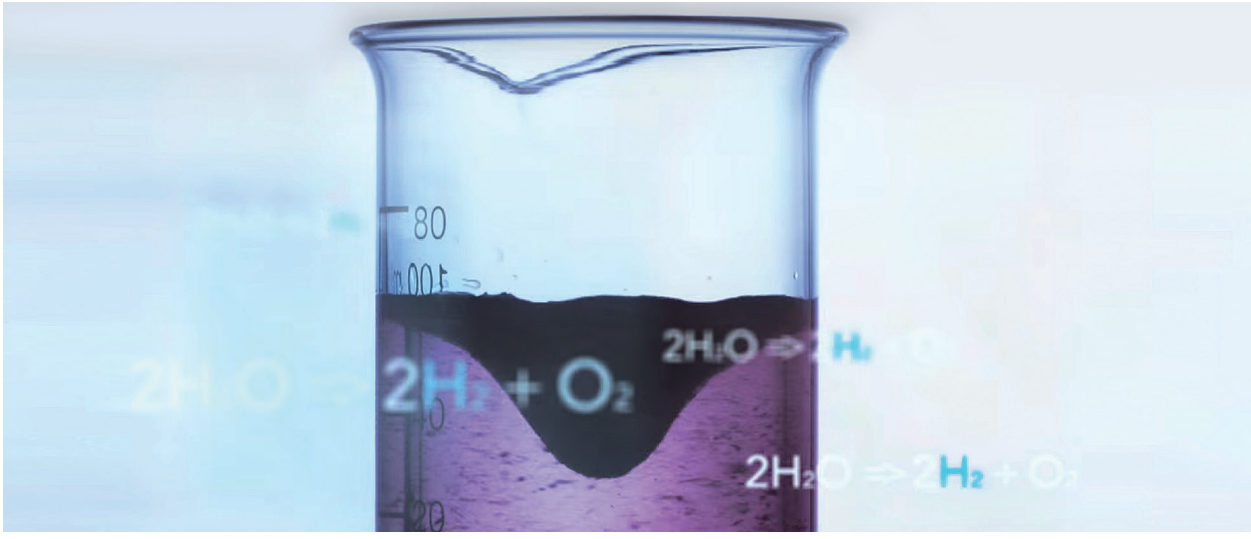
The government is planning a pilot project with 400 lampposts around the city. They will track weather, environmental data, transportation information and crowd flows. The idea is to equip them with WiFi and 5G capability, to improve communications service across the territory. They could also act as digital street signs, providing pedestrian and traffic directions, and indicate local parking conditions.



Prof. Jimmy Yu
Choh-ming Li Professor of Chemistry

Tapping Water and Sunlight

Jimmy Yu's quest for clean fuel



▲ *Under sunlight, red phosphorus breaks up water to generate bubbles of hydrogen*

The world is on a quest for clean energy, and it's one step closer to getting there, thanks to the work of chemist **Jimmy Yu**. A discovery by the CUHK chemist and his team has paved the way to creating energy simply by exposing water to sunlight.

The secret ingredient is red phosphorus, the most stable and commonly found of three forms of that element. In the sun, it breaks up water to give off bubbles of hydrogen gas, a clean fuel.

That helps make it the world's simplest photocatalyst. 'Simple is beautiful,' Professor Yu said. 'This element is so abundant that it will never be used up.'

A photocatalyst operates much as chlorophyll does in a plant, absorbing energy from light and causing a chemical reaction. The process of photocatalysis is simply a form of artificial photosynthesis.

Red phosphorus is a common and widely produced substance that is used as a flame retardant and that gives matches their red colour. It is also used in fire-prevention materials and fireworks.

Professor Yu and his team were first examining a large group of elements that could act as semiconductors, a prerequisite for acting as a photocatalyst. They found that red phosphorus could act as a semiconductor, a property that other researchers had not recognized. The conventional wisdom was that red phosphorus was really only useful as an insulator.

Professor Yu and his team then experimented with various crystal forms of red phosphorus, since different crystals vary in their effectiveness in generating hydrogen.

Red phosphorus works across the spectrum of natural sunlight, making it ideal for use in the generation of clean power. The light acts as an irradiation source that stimulates the catalyst and induces chemical reactions.

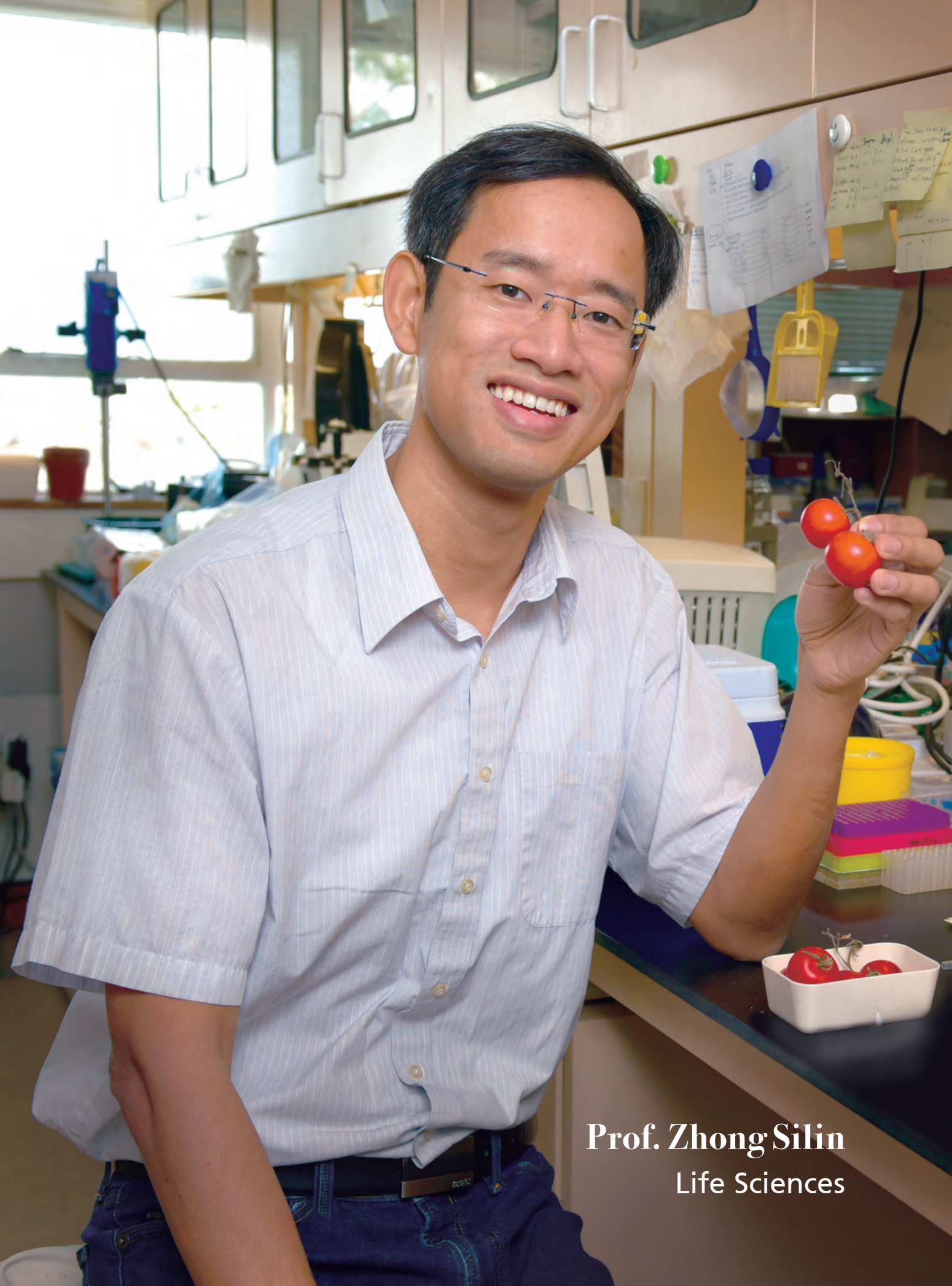
Professor Yu's water-splitting process functions at room temperature, with the phosphorus separating the individual elements in H_2O. Hydrogen has a very high fuel capacity, meaning it creates more energy than any other chemical fuel. Unlike petrol-based fuels, there's no greenhouse-gas byproduct when it burns, with only water left at the end of the reaction.

Professor Yu's research has been some of the most ground-breaking in the world, in terms of recognition by his peers. He made the ranks of Reuters's 'World's Most Influential Scientific Minds' in 2014.

Still, it will be some time before red phosphorus can be used to produce energy for commercial or industrial applications. The material is less efficient than traditional photocatalysts, and the amount of hydrogen it can produce is currently very small.

The prevalence of fossil fuels has negated the need for investing in the technology necessary to bring photocatalysts to a commercial scale. Even conventional solar power is considerably more efficient. But with a greater emphasis on the environmental degradation that traditional fuels cause, the thinking may change.

'The final goal is to develop an environmentally friendly way to generate clean fuel,' Professor Yu said. 'We hope to offer some possible solutions.'



Prof. Zhong Silin

Life Sciences

The Fruit Cracker

Zhong Silin decodes fruition in nature

Scientists have long wanted to fathom the mechanism which regulates the ripening of fleshy fruits. Like the gestation of a human foetus followed by labour, nature seems to have encoded when and under what conditions a fruit should ripen.

Prof. **Zhong Silin** leads an international team of scientists in the fruitENCODE project which aims to provide a comprehensive annotation of the functional elements in fleshy fruits in order to crack the mysterious process of fruit ripening.

The fruitENCODE team studied the genetic and epigenetic bases of the evolution of 11 fruits—apple, pear, melon, peach, papaya, banana, watermelon, grape, strawberry, tomato and cucumber. By means of large-scale profiling of gene expression data and DNA methylation, and mapping of histone modifications and accessible chromatin regions, the team was able to identify three types of positive feedback loop that govern their fruit ripening processes. Their findings were published in *Nature Plants*.

Apple, pear and tomato experienced recent whole genome duplication (doubling or even tripling their genome size) at the end of the Cretaceous period (145–66 million years ago). They evolved their fruits by using those duplicated floral organ identity genes (genes that specify the identity of the different organs of a flower) of their ancestors. In these fruits, a certain transcription factor (protein that controls if and when a gene gets activated) directly binds to genes that signal the production of ethylene, a kind of fruit hormone which facilitates ripening. The result further triggers other transcription factors which come full circle to bind with the original transcription factor and so on, thereby starting a positive feedback loop that enables and sustains ethylene synthesis.

Melon, peach and papaya did not have the luxury of whole genome duplication during the late Cretaceous, and therefore have not inherited the first group's ethylene-production kit. They instead synthesize ethylene by converting their existing gene controlling senescence (aging of the plant) to form a different positive feedback loop for the sustenance of ethylene synthesis.

The most eclectic of the bunch, banana, reaches ripening by a combination of the two: using both the floral organ identity and the senescence genes. The other fruits in the study—watermelon, cucumber, grape and strawberry—have developed their own system of ripening independent of ethylene.

What the team also found is that the epigenetic mark H3K27me3, which represses key developmental genes in animals, plays an important regulatory role in the ripening process of fruits, too. It acts as a braking device that targets key ripening genes in plants to prevent premature ripening which may be undesirable in terms of the survival of the seeds.

Marks similar to H3K27me3 are found in the ripening genes of the ancestral plant species, suggesting that in their evolution, fruits like tomato, peach and banana have not just inherited the type of positive feedback loop from their ancestors but also their epigenetic marks to regulate ripening.

By elucidating the genetic and epigenetic mechanism of fruit ripening, the team's findings could pave the way for a healthier and steadier food source in future. It is also possible to manipulate and engineer the regulatory components in gene expressions to enhance the fruits' nutritional value, consumer appeal and shelf life. This is good news to fruit-lovers across the globe.

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