SCIENCE FOCUS 科言

Issue 009, 2016

The Mysterious Honeyguide
神秘的響蜜鴷

Stress and Resilience – Why are some better at it than others?
抗逆力 – 爲什麼有些人更擅於處理壓力？

Interviews with Prof. Dennis, Lo Yuk Ming and Prof. Tony Wyss-Coray
盧煜明教授 與 東尼·衛斯哥利教授專訪

School of 理學院 Science

香港科技大學 THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

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Science Focus Issue 009, 2016

Message from the Editor-in-Chief 主編話語

Dear Readers,

Welcome back to *Science Focus*! I trust that all of you are well into your semester of the new school year. School and studying are of utmost importance, but it is also essential to relax, take a break and breathe in this crisp autumn air. Let us help you de-stress! In this issue, we have several exciting new developments to share with you.

In our past issues, we have prepared guides and tips for students wanting to study abroad in universities all around the world. We're temporarily shelving our Global Education Hub section for a new section called *Science in History*. Much of science is built upon earlier discoveries that evolve over time and we get a glimpse of what the world was like before science and technology gave us modern conveniences. We hope that you will find this new section interesting and thought-provoking. However, check out our archived issues at *http://sciencefocus.ust.hk if you are looking for application tips!*

Science Focus has been around for some time now and we want to know your opinions on how we're doing and where we could improve. If you are a student, please fill out our survey at *http://sciencefocus.ust.hk/survey_students/* to tell us what you think. **By filling out this survey, you will be entered for a lucky draw to win a Commercial Press coupon valued at HK$500.**

Thank you and enjoy your *Science Focus*!

Yours faithfully,

Prof. Yung Hou Wong
Editor-in-Chief

親愛的讀者：

歡迎各位回到「科言」！相信你們已經適應新學年。學習固然非常重要，但適當地放鬆也是必要的。不妨稍作休息，呼吸秋日清爽的空氣，讓「科言」幫助你舒緩壓力！今期，我們將與你分享一些令人振奮的新發展。

在過去幾期，我們為有意到海外升學的同學，提供了世界各地大學的入學指南。從本期開始，我們暫時擱置「環球教育」，加入新欄目「昔日科學」。今日的科學大多是從過往的發現演變而來，讓我們回顧一下，在科技帶來種種便利之前的世界是什麼模樣。希望你會覺得這欄目有趣，對你有所啟發。若果你需要留學指引，可以到 *http://sciencefocus.ust.hk*，查看「科言」存檔。

「科言」面世已有一段時間。我們想知道你對本刊的意見和建議。如果你是學生，希望你能參與網上調查：*http://sciencefocus.ust.hk/survey_students/*，告訴我們你的想法。**完成問卷便可參加抽獎，有機會得到價值港幣500元的商務印書館現金卷一張。**

多謝支持。請享讀本期「科言」！

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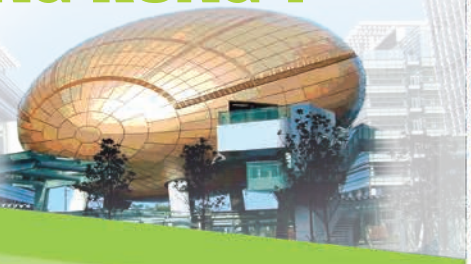
WHAT'S HAPPENING IN HONG KONG ?

By Thomas Lee 李浩賢



Science Explorer at HKSTP

At Science Park, discover cutting-edge inventions that are shaping the modern world and gather knowledge about career prospects from successful tech companies. Are you more hands-on? Roll up your sleeves to participate in the Robo Workshop, where you can learn more about the mathematics, engineering, physics and coding that go into creating robots.

Individuals and groups are welcome!

To book a tour, please visit *https://sciencexplorer.hkstp.org/en/booking_tc.html*

香港科技園科學探索行

在香港科學園內，你可以認識塑造現代世界的先進創新發明，及了解科技行業的就業前景。喜歡動動手的你，更可參與機械人工作坊，學習如何融匯數學、工程、物理及編程等知識，創造機械人。

歡迎個人或團體報名參觀！

預約請登入*https://sciencexplorer.hkstp.org/tc/booking_tc.html*

Roving Exhibition

The roving exhibition aims to enhance the public's awareness and understanding of climate change. What is the government doing to combat these changes and what do we need to do as a society? Learn more at the exhibitions available at:

Hong Kong Science and Technology Parks from 29 Oct to 6 Nov, 10:00 AM – 7:00 PM or

Yatsumoto International Academic Park, CUHK from 8 Nov to 20 Nov, 9:30 AM – 7:30 PM.

Visit *http://www.science.gov.hk/exhib2016/index.htm* for more information.

「科學為民」十週年巡迴展覽 —「回應・氣候展」

展覽目的是增強公眾對氣候變化的了解，展示政府部門的應對策略，及促使社會反思如何回應。巡迴展覽場地包括：

香港科學園：10月29日至11月6日，10:00AM - 7:00PM；及

香港中文大學康本國際學術園：11月8日至11月20日，9:30AM - 7:30PM。

有關詳情，請瀏覽: *http://www.science.gov.hk/exhib2016/index_uc.htm*

WWF Volunteering

Volunteering is an excellent way to contribute to society as well as to build your resume. WWF's recent ventures include "Discovering Biodiversity in Hong Kong Wetlands" and the "Coastal Watch programme", in an effort to conserve our environment. To volunteer for WWF, fill out their application form at *http://www.wwf.org.hk/en/your_support/be_our_volunteer/* and start doing your part in society!

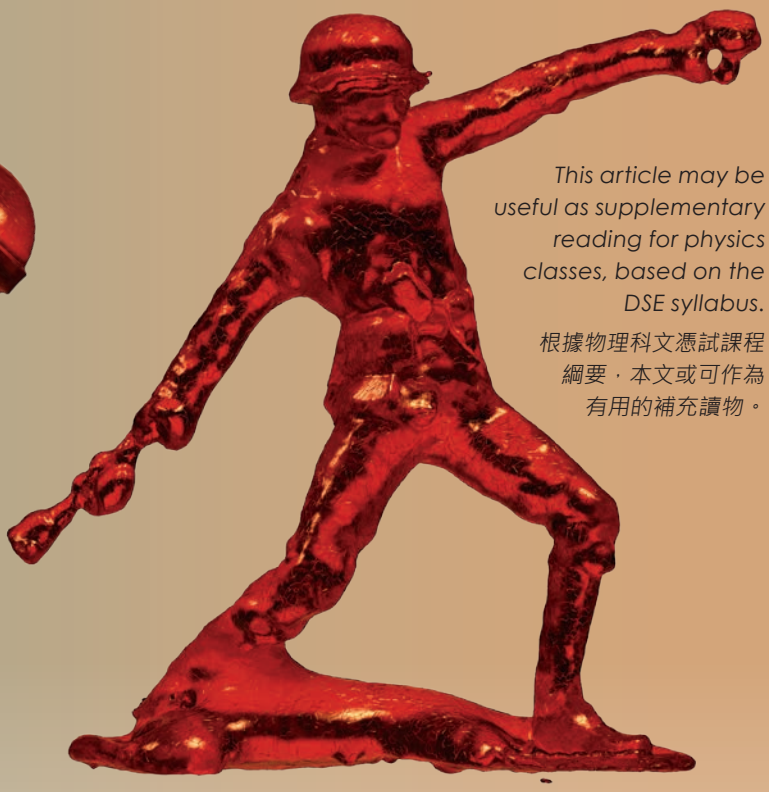
世界自然基金會義工

積極參與義工活動不只有助建立簡歷，更是貢獻社會的最佳途徑。世界自然基金會近期推出的環保計劃，包括「香港濕地生物多樣性普查」和「育養海岸」等。要成為該會義工，為本地保育出力，可從網頁*http://www.wwf.org.hk/your_support/be_our_volunteer/*下載表格。

香港科技活動

THE ACCIDENTAL DISCOVERY OF THE MICROWAVE

意外的發現 — 微波爐



This article may be useful as supplementary reading for physics classes, based on the DSE syllabus.

根據物理科文憑試課程綱要，本文或可作為有用的補充讀物。

By Jason Long Him Cheung 張朗謙

Many modern inventions, such as the airplane or the computer, were painstakingly honed and refined to work as intended. Others were encountered upon by mere happenstance. Arguably one of the most ubiquitous kitchen appliances, the microwave oven, was invented by accident during World War II – a period that pressured the creative geniuses of the world to match the demands of weaponry, espionage technology and vehicles. Some of these were inadvertently translated into practical equipment that made their way into mainstream consumerism.

Most of us are familiar with the microwave oven. Convenient to heat up food in a matter of minutes and safe to use, the microwave is both a staple of every kitchen and a revolution to food preparation in the dining industry. Life without the microwave is hard to imagine. But it wasn't until 1946 when the first microwave was sold, and 1967 when it was initially introduced into consumer markets for home use.

The man of the hour was Percy Spencer. A leading expert in radar technology in World War II, he was responsible for developing combat radar equipment that detected and tracked increasingly dangerous enemy aircrafts for hundreds of miles, even when cloaked in darkness. A tube known as a magnetron was used to generate short wavelength microwaves. It involved a high-powered vacuum that imposed an interaction between a stream of electrons and a magnetic field.

At the time, Spencer worked on the maintenance of short wavelength radars in cold weather. He just so happened to reach into his pocket for a candy bar, and noticed that it had melted even in the cold temperatures, concluding that microwaves were responsible for the heat generated. He then proceeded to heat up popcorn and an egg, the latter of which exploded under the unreleased pressure. Spencer found that by trapping microwaves in a metal box, temperatures in the box increased significantly and heated up food.

Microwaves are made of an ensemble of relatively short electromagnetic wavelengths ranging from 1 m to 1 mm, and have frequencies of 300 MHz to 300 GHz. The microwave oven (not to be confused with the electromagnetic microwave), makes use of the frequency of 2.45 GHz. Working primarily on dipole water molecules in food, the electromagnetic field forces the water molecules to realign themselves with the changing polarity. The friction of

the constantly vacillating water molecules creates the heat energy required to heat up the rest of the food via radiation.

Spencer and his colleagues were able to file a patent for this novel device by October 1945. In 1947, the microwave oven was available for commercial use but was 1.8 m in height and came with a hefty price tag of USD$5,000. Adjust that for inflation and you would purchase one of these bad boys for USD$53,000 – hardly affordable for a simple kitchen device. Improvements to streamline the cost for commercialisation eventually arrived in the 70s. The microwave we know today is present in most households and comes with different functions and power outputs, but who knew this common household appliance rooted from World War II research?

許多現代發明如飛機或電腦，都是要經過千錘百煉才能得到，有些卻是出於偶然。微波爐可以說是最普及的廚房電器之一，也是二次世界大戰時的意外發明。當時全世界的創作天才施展渾身解數，應付來自軍事、間諜、運輸等方面的需求。有些發明就在無意間轉化為實用的主流消費品。

相信大家對微波爐都相當熟悉。它能在短短幾分鐘內將食物加熱，既方便又安全，已成為廚房必備的器具，也徹底改變了業界製備食物的過程。你能想像沒有微波爐的生活嗎？但其實在1946年才有第一台微波爐出售；直至1967年，微波爐才出現在家用市場。

培西·史賓賽是這故事的主角。他是二戰時期的頂尖雷達技術專家，負責研究即使在黑暗中，亦能探測及追蹤數百英里之外敵方戰機的軍用雷達，所以會用到磁控管。磁控管是讓電子在真空與磁場相互作用，產生較短波長的微波。

當時培西在寒冷的天氣維修短波雷達，偶然伸手入袋取糖果，發現糖果竟然在低溫下融化了。培西推斷是由微波產生熱能，並嘗試以微波加熱爆谷及雞蛋，後者竟因內壓過大而爆炸。培西更發現把微波困在金屬箱中，可以提高箱內溫度加熱食物。

微波是波長1 mm至1 m之間的短波電磁波的統稱，頻率介於300 MHz至300 GHz。微波爐所用的電磁波頻率是2.45 GHz，主要是針對食物中的偶極水分子。水分子隨著電磁場的極性變化而轉換方向，不斷搖擺和摩擦產生熱能，擴散到食物其他部分。

培西和夥伴在1945年10月就這項發明申請了專利。商用微波爐在1947年面世，高1.8 m，售價高達5,000美元。若將通脹計算在內，就相當於今日的53,000美元。這並不是一般人可以負擔的廚房設備。經過一番努力控制成本，微波爐終於在70年代成為大眾普及的商品。我們今天所看到的微波爐，幾乎是每家必備，而且有不同的功能和輸出功率。又有誰知道這平凡的家庭電器，竟是從二戰研究中衍生出來呢?

Further Reading 延伸閱讀

http://news.psu.edu/story/141277/2005/11/28/research/probing-question-how-do-microwaves-cook-food

DID YOU KNOW? 你知道嗎？

The microwave oven is often misunderstood to cause cancer or is hazardous to health due to the word “radiation”. It is important to distinguish the different types of radiation. Microwave radiation is non-ionising, which means that it does not have enough energy to remove an electron from an atom. This type of low energy wave will not be able to change the chemistry of biological cells and thus will not cause cancer or other types of radiation sickness. On the other hand, ionising radiation has a shorter wavelength, carries much more energy and can cause serious illnesses. X-rays and gamma rays are some examples.

微波爐和輻射扯上關係，所以往往被人誤會，以為可以致癌或對身體有害。要知道有不同類形的輻射。微波爐的輻射是「非遊離輻射」，能量不足以把電子從原子分離。這類低能量的輻射是不會引起細胞的化學改變，更不會誘發癌症或其他輻射病。至於X射線、伽瑪射線等屬於較短波的「遊離輻射」，帶有高能量，可以導致嚴重的疾病。

ADAPTING SEA CRITTERS

Since the dawn of the industrial revolution, human activities have caused a surge in the amount of carbon dioxide (CO_2) released into the atmosphere. Each year, the ocean absorbs approximately 25% of atmospheric CO_2. As atmospheric CO_2 levels increase, the ocean's CO_2 concentration follows suit. This dissolution alternate carbonate chemistry in surface water leads to a drop in its surface pH. The phenomenon is known as ocean acidification [1].

Ocean acidification has led to a drop in the pH of surface ocean waters by about 0.1 pH units since the 1950s. While this number appears to be insignificant, recall that the pH scale is logarithmic. The minute change belies a 30% increase in acidity [1]. Fluctuations in the ocean's CO_2 levels are a direct threat to the growth and development of marine life. Marine critters rely on the calcium carbonate in seawater to build their exoskeletons, but carbonate ions become less available with increased acidity. As a result, scientists are studying how well organisms such as molluscs, crustaceans, and corals are able to adapt to the increasingly acidic conditions.

Marine biologist, Gretchen Hofmann, and her group have been observing the adaptability of sea urchins to increasing ocean acidification. Sea urchins exhibit spherical-shaped bodies, covered in needle-like protrusions, and are found ubiquitously in the world's oceans. Considered as a keystone species, any changes in the population size of sea urchins would directly influence other marine organisms [2].

The size of sea urchin larvae is critical to its ability to swim and the amount of food it can obtain. In her preliminary studies, Hofmann exposed sea urchin larvae to water containing high CO_2 levels and compared their sizes to sea urchins grown in less acidic conditions. While most larvae were unable to reach their full potential sizes, some of them seemed surprisingly unaffected by the acidity. This prompted her and her colleague – evolutionary biologist Morgan Kelly, to investigate whether sea urchins that hail from a coastal area naturally exposed to higher water acidity, had any evolutionary advantage over other sea urchins in coping with acidification.

Their results showed that organisms in Northern California, a region with higher ocean acidity due to coastal upwelling, displayed a different genetic profile from their relatives in other coastal regions. The profile showed robust genetic variance for larvae sizes, suggesting that sea urchins may have hope in adapting to future conditions, particularly when reared from urchins from different regions. In other words, mating the hardy northern male sea urchins with the southern females revealed

References 參考資料

[1] Ocean Acidification: The Other Carbon Dioxide Problem. PMEL Carbon Program, National Oceanic and Atmospheric Administration. Retrieved from *http://www.pmel.noaa.gov/co2/story/Ocean+Acidification*

[2] Staff Reporter. Sea Urchins Adapting to Increased Oceanic Acidifcation (2013). Nature World News. Retrieved from *http://www.natureworldnews.com/articles/2431/20130613/sea-urchins-adapting-increased-oceanic-acidification.htm*

[3] Welch, C. Sea Change – Can Sea Life Adapt? (2013) The Seattle Times. Retrieved from *http://apps.seattletimes.com/reports/sea-change/2013/nov/2/can-sea-life-adapt/*

適應海洋變化的小傢伙

By Jacqueline Aw 歐婷梅

This article may be useful as supplementary reading for biology classes, based on the DSE syllabus.
根據生物科文憑試課程綱要，本文或可作為有用的補充讀物。

that the resistance to acidity in water was able to be passed onto their offspring, showing potential evidence of evolution and adaptation [3]. However, the data for larval sea urchins may not apply to adult urchins, and further study is required.

With natural selection on their side, the future for marine creatures may not be as dire as once predicted. However, ocean acidification is not the sole threat to their survival. Ocean warming is believed to occur simultaneously, which may also pose indirect threat by altering the food web. The key is to determine whether the rate of adaptation is adequate to keep up with the rapid changes in their habitat. Furthermore, this study is limited to sea urchins alone; other sea creatures may be less able to cope with elevated ocean temperatures and acidity, warranting a more comprehensive study.

自工業革命以來，釋放到大氣的二氧化碳量因人類活動而激增。每年，大氣中的二氧化碳約有25%會被海洋吸收。大氣中二氧化碳的含量上升，海洋的二氧化碳濃度亦隨之而增高。海洋表層的碳酸鹽化學特性因此而改變，導致pH值下降，這現象稱為海洋酸化 [1]。

從50年代至今，海洋酸化已令表層海水的pH值下降了0.1。雖然這數字看似微不足道，但別忘記pH值是以對數增長的，這微小變化其實意味著海水的酸度已經提高了30% [1]。海洋中二氧化碳含量的波動直接危害海洋生物的生長和發育。海洋小動物依賴海水提供碳酸鈣來構建外骨骼，但碳酸根離子濃度卻因酸度增加而下降。科學家因此在研究軟體動物、甲殼類動物及珊瑚等不同生物，如何適應日漸酸化的環境。

海洋生物學家格雷琴．霍夫曼和她的團隊一直在觀察海膽適應海洋酸化的能力。海膽呈球體，體表佈滿棘刺，在世界各地的海洋中都能找到。海膽是一種關鍵物種，族群的大小出現變化，就會直接影響其他海洋生物 [2]。

海膽幼蟲的體型對其游泳能力及可覓得的食物量有重要影響。霍夫曼在初步研究中，把海膽幼蟲放在高含量二氧化碳的水中養殖，然後與在酸性較低的環境中生長的海膽比較。雖然大多數幼蟲不能生長至正常大小，但令人驚訝的是有些幼蟲似乎不受酸度影響。這發現促使她和進化生物學家凱利摩根，開始探討究竟在水酸度較高的沿海地區生長的海膽，是否比同類更有進化優勢，可以應對酸化過程。

他們的研究結果指出，在受沿岸湧升流影響，海洋酸度較高的加州北部生長的海膽，與其他沿海地區的親戚有著不同的基因圖譜。與幼蟲體形有關的基因差異穩定，反映出海膽，尤其是來自不同地區的海膽交配所生的後代，有可能適應未來的環境。換句話說，把北方耐力較強的雄性海膽與南方雌性交配後，耐酸的特質可以遺傳到後代，這或許可以證明進化和適應已出現 [3]。然而，海膽幼蟲的數據未必適用於成年海膽，還需要進一步的研究才能確認。

得益於物競天擇，海洋生物的未來未必會像預測般可怕。然而，海洋酸化並不是唯一的威脅；一般相信海洋暖化也在同時發生，可能會改變食物網，構成間接威脅。重點是物種適應的速度能否跟上棲息地的快速變化。另外，此研究只局限於海膽，其他海洋生物適應海洋溫度及酸度上升的能力可能不及海膽，需要更全面的研究才能下結論。

「暗能量」和「暗物質」暗藏玄機？

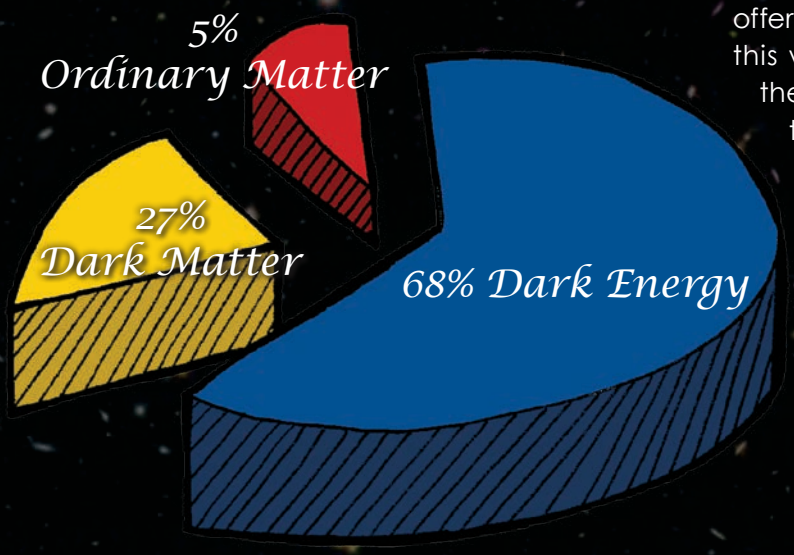
Dark Energy and Dark Matter

Why Do They Matter?

By Raphaella So 蘇韋霖

"Seeing is believing" is an often heard phrase people use to justify their disbelief (or belief) in ghosts or religion. While a good portion of science can be proven with the tangible and evidential, much of it also relies on theories and models. The abstruse mysteries of the Universe, in particular, requires an imaginative mind to decipher, leaving many questions answered speculatively and creating even more in the process. Such is the case with dark energy and dark matter.

Back in the 90s, an intriguing observation puzzled physicists. We know that the universe is made up of matter, and all matter has gravity. For a while, there was a general consensus that gravity would slow, or even stop the Universe from expanding. However, all observations captured by the Hubble Space Telescope in 1998 pointed to a Universe that not only continued to expand, but that expanded at an accelerated rate. The mismatch between expectation and reality instigated a look into what became coined as dark energy. The net amount of visible matter that existed in space, on the other hand, was believed to not possess enough gravity to hold the Universe together. Hence, the discrepancy in matter was coined as dark matter.



The Planck Space Mission, launched in 2009 to create a detailed map of the Universe by scanning for cosmic microwaves, revealed that 68% of the Universe is made up of dark energy, while 27% is dark matter. "Regular" matter that is observable only occupies about 5% of the Universe, begging the question of whether normal matter should be referred to as "normal" in the first place.

Scientists have yet to agree on how to explain dark energy. There are several schools of thought. The initial hypothesis was derived from a version of Albert Einstein's theory of relativity, stating that what we consider as empty space is not in fact empty, thus it would also possess energy. This ensures that the Universe would not be diluted as it expands, and is known as the cosmological constant. The energy would then cause the Universe's expansion rate to increase, therefore explaining the Hubble Space Telescope observations. A second plausible hypothesis is that there is a new type of energy that has an opposite effect on the Universe's expansion than normal matter and energy. Finally, some have offered to debunk Einstein's theory of relativity, but this would misplace everything we know about the Solar System and the Universe would need to be re-examined. All we know for relative certainty is that dark energy is responsible for accelerating the expansion of the Universe.

Dark matter is just as elusive. We know what it isn't, but have little idea of what it is. Dark matter is anything in the Universe that we are unable to directly observe, unlike visible stars or planets. We can also separate it from antimatter, which reacts with "regular" matter to produce gamma

rays. Lastly, dark matter does not refer to black holes, the latter of which cannot be scattered (whereas dark matter can be). So, if we are unable to observe dark matter directly, how do we know that it exists? In layman's terms, there is so much gravity in the Universe that is unaccounted for based on the matter that we can observe, so the remainder "stuff" is defined as dark matter.

There is much we have yet to find out about the Universe and with each step toward uncovering these mysteries more questions are revealed in the process. But this process is what drives science forward, the curiosity to push the boundaries of the known and the perseverance to piece the unending puzzle of the Universe into a picture that we can understand.

常聽聞人們以「眼觀為實」作為自己懷疑(或相信)鬼神或宗教的理據。部份科學確實是可以通過「眼觀」和證據得到證實,但大部份還得依靠理論和模型。至於宇宙的奧義,更是需要豐富的想像力才能破譯,有許多問題只能憑臆測作答,且由此產生更多的問題。「暗能量」和「暗物質」就是這類情況。

早在90年代,就有一個有趣的觀察讓物理學家費解。眾所週知宇宙是由物質組成的,而所有物質都具有引力。曾幾何時,普遍認為引力拉扯會減慢、甚至停止宇宙的膨脹。然而,哈勃太空望遠鏡在1998年取得的觀測結果指出:宇宙不僅繼續擴大,而且在加速進行。這意外發現挑起對被稱為「暗能量」的神秘能量的研究。另一方面,單憑太空中可見的物質,實在不能提供足夠的引力維繫宇宙,應該還有所謂「暗物質」存在。

普朗克太空任務於2009年展開,目標是要掃描宇宙微波背景,製作詳細的宇宙地圖。結果揭示「暗能量」佔宇宙68%,而「暗物質」則佔27%。可見的「常規」物質其實只佔宇宙約5%,讓人反思是否應該視「正常」物質為正常。

科學家之間還未有共識如何解釋「暗能量」。目前有幾家學說。第一個假設來自愛因斯坦關於引力的其中一套理論,指出我們以為是虛空的太空其實擁有能量,確保宇宙即使膨脹也不會被攤薄。這概念被稱為宇宙常數。這種能量可能導致宇宙加速膨脹,解釋了哈勃太空望遠鏡的觀測。第二個可能的假設是有一種新型能量,對宇宙膨脹有著與正常的物質和能量相反的效果。最後,有人建議撇開愛因斯坦的引力理論;如此一來,就會推翻我們對太陽系的一切認知,重新審視宇宙。目前我們唯一比較肯定的是,「暗能量」造成宇宙膨脹加速。

「暗物質」也同樣是難以捉摸。我們只能分辨什麼不是「暗物質」,對「暗物質」的本質知之甚少。與可見的星體不同,我們無法直接觀察到「暗物質」。暗物質也有別於反物質,反物質會與正常物質發生反應,產生伽馬射線。最後,「暗物質」亦不是黑洞,後者不像「暗物質」可以被散射。既然我們無法直接觀察到「暗物質」,又如何知道它的存在?簡單而言,宇宙間存在的引力不能全歸因於可見的物質,其它物質就被稱為「暗物質」。

宇宙有許多未解之謎,有待我們去偵破。每當前行一步,又會出現更多的問題。不過,正因為有開拓新知的好奇心,以及將宇宙種種謎團拼湊全貌的毅力,科學才能不斷進步。

Further Reading 延伸閱讀

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費曼的小抄 — 原子儲存

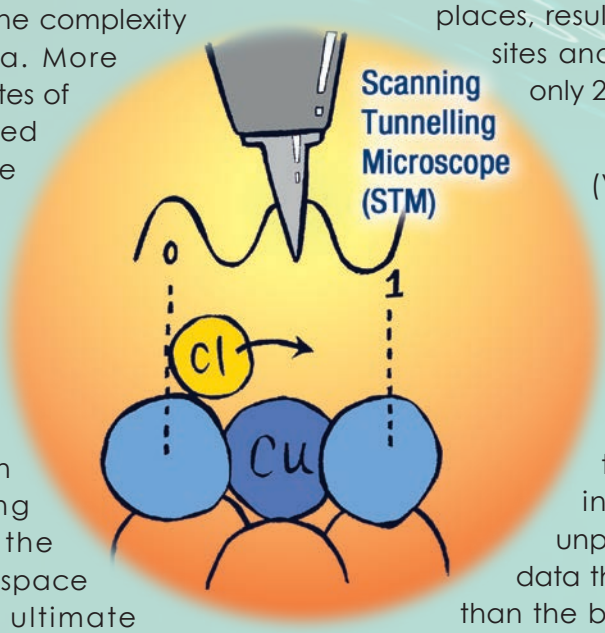
Feynman's Cheat Sheet – Atomic Storage

By David Iu 姚誠鵠

YOU are taking a test tomorrow. Your teacher was generous enough to allow you to bring a cheat-sheet, but only on one side of an A4 paper. How would you arrange the overwhelming amount of information you need to know and pack them in a space so limited? Naturally, you would miniaturise your writings, compress your equations and facts and cram in as much as you can. Still, eventually you would reach the edges of the paper, no longer able to smuggle those last few equations into the exam hall.

And this, indeed, is the million-dollar question of our information age.

The advent of the digital age has seen explosive growth in the complexity and variety of data. More than a billion gigabytes of new data are created each day [1], a pace unmatched by the advances in information systems. Data centres and servers take up large spaces and consume even more energy each year. Thus, ensuring each bit takes up the minimal amount of space is paramount. The ultimate solution? Coding information at the atomic level, as Feynman envisioned nearly 60 years ago.

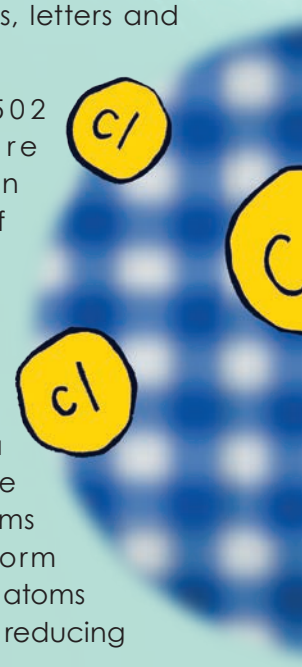


Scientists at Delft University have approached the physical limit by reducing each bit to single atoms. By arranging individual chlorine atoms in an exactly ordered pattern, the research team built a memory of 8000 bits (1 kilobyte) on an area as small as 100 nm wide [2]. The hard drive was assembled by coating a chlorine atom lattice on a copper surface in ultrahigh vacuum, with the precise locations of each individual atom manipulated by injecting an electric current using a Scanning Tunnelling Microscope. The presence of a current allows the chlorine atoms to switch places, resulting in a pattern of coupled vacant sites and occupied sites. Each vacant site is only 20 to 30 pm deep.

> ***Why can't we write the entire 24 volumes of the Encycolpaedia Brittanica on the head of a pin?***
>
> *— Richard Feynman,*
> *"There's Plenty of Space at the Bottom", 1959*

These combinations of vacant sites (V) and occupied sites (Cl) come in two distinct configurations, V-Cl and Cl-V. Translated into binary, they can be represented as "0" and "1", for different numbers, letters and symbols of data.

A density of 502 terabits per square inch was achieved, an unprecedented density of data that is 500 times higher than the best commercial hard disk available on the market [1]. To put that into perspective, the entirety of the US library of Congress can be stored within a 0.1 mm wide cube. Furthermore, the atomic-scale device employs atoms by removing them from a uniform surface as opposed to employing atoms in an additive manner, profoundly reducing errors.



Nonetheless, whilst the atomic hard disk offers impressive improvements in thermal stability and data density, there is still ample room for improvement until it finds its way into data centres or servers, let alone households. The codes only have several hours of lifetime at -196 °C, a temperature too low to be practically and economically maintained. Moreover, reading a block of memory – which codes for just 8 characters – takes up to 10 minutes.

Still, the future is full of promises. By creating several thousands of single-atom bits, this pioneering research represents a significant step toward miniature electronics. With the discovery of new materials and the development of tools for atomic manipulation, Feynman shall eventually get his cheat sheet containing all the knowledge known to mankind. After all, *there is plenty of room at the bottom*.

明天就要考試了。老師容許你攜帶一張小抄 (即俗稱「貓紙」) ，但限定只能是單面 A4 紙。你會如何將所需的大量資訊塞進如此小的空間呢？很自然地，你會縮小字體，盡你所能將濃縮了的方程式和事實填滿小抄。即便如此，到了紙張邊緣就要停止，無法把最後幾條方程式帶進試場。

這正正是資訊年代價值連城的一大難題。

隨著數碼年代的到來，數據的複雜性和多樣性均有爆炸性的增長。人類每天生產超過 10 億 GB 的新數據 [1] ，遠遠拋離資訊系統發展的速度。數據中心和伺服器佔用龐大空間，並且耗用大量能源，因此有需要確保每個位元佔用最小的空間。費曼在差不多 60 年前所預想的原子資訊編碼，成為終極的解決方案。

荷蘭代爾夫特理工大學的科學家把位元佔用的空間縮小至一顆原子，接近物理極限。他們利用整齊排列的氯原子，成功造出 100nm 寬，能容納 8,000 位元 (即 1,000 位元組) 的記憶體 [2]。硬盤是在超高真空環境下組裝，將氯原子鋪排在銅板上，再以掃描穿隧式顯微鏡注入電流，操控每顆原子的精確位置。氯原子隨電流切換位置，形成相聯結的空穴與氯原子點，每個空穴只有 20 至 30pm 深。

這些空穴 (V) 跟氯原子點 (Cl) 的組合可以分為 V-Cl 和 Cl-V 兩類，代表二進位編碼中的 0 和 1，組成不同的數字、字母和符號。

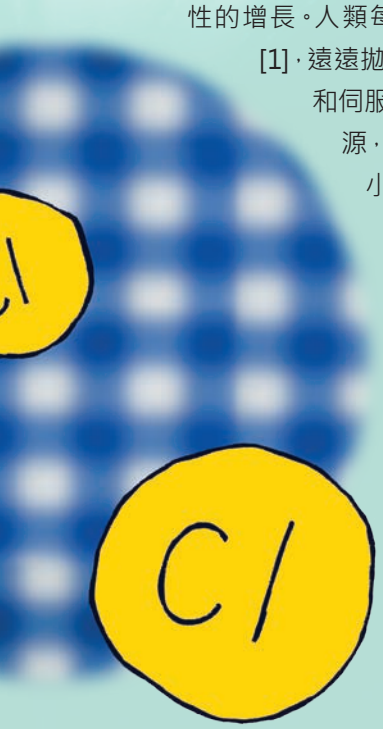
這硬盤的數據密度達到前所未有的每平方英吋 502 TB，比目前市面上最好的硬盤還要高 500 倍 [1]。整個美國國會圖書館的館藏可以儲存在 0.1mm 寬的立方體。另外，這個原子硬盤是從均勻的表面去掉原子，而非增加原子，大大減少誤差。

為什麼我們不能把整套24冊大英百科全書寫在針頭上？

—理查·費曼，
"底下的空間還大的很"，1959年

雖然這原子硬盤在耐熱程度和資訊密度均有出色表現，但還需要多方改進才有可能被數據中心或伺服器採用，家居應用更是遙不可及。硬盤的原子編碼在 -196°C 下只有數小時壽命，在實際應用中是難以維持這樣低的溫度。此外，要讀取只有 8 個字元代碼的記憶體也得耗上 10 分鐘。

即便如此，原子存訊技術的未來絕對是充滿希望的。代爾夫特團隊製造了幾千個單原子位元，為微電子產品的發展踏出了一大步。當我們發現和發明更多的物料和工具讓我們可以更容易地操控原子時，費曼就會拿到那張包含人類所有知識的小抄。畢竟，*底下的空間還大得很*。



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神秘的響蜜鴷

The Mysterious Honeyguide

By David Ren 任大偉

Commonly found in the forests of sub-Saharan Africa, the greater honeyguide (Latin name *Indicator indicator*) is one of the few birds that can digest beeswax. Their diet extends to the remaining contents of bee colonies, such as bee eggs, larvae and pupae [1], and they are particularly adept at seeking beehives to secure their prey. Avoiding bees and their stings, however, prove too difficult for these relatively defenceless small birds. Instead, they enlist the help of honey hunters of the Yao people in Northern Mozambique.

Honey hunters summon nearby honeyguides with a loud brr-hmm noise, often referred to as the trill-grunt. The birds respond by chirping and flying toward the beehive. In a harmony of calls and responses, the honey hunter and the honeyguide repeat in reaffirmation to seek their common goal. Once identified, human hunters will envelop the hive with smoke and fire to disorient the bees to mask any attack pheromones. The hive is then cracked open to retrieve the honey. The entire process is no easy feat – beehives tend to be

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located far out of reach within the trunks of trees and far above the ground. To reward the bird, the Yao people leave behind wax ceremonially on a bed of leaves. After all, the birds have earned it; with a honeyguide's help, honey hunters are able to triple the chance of locating hives [2].

Initial Western reports of this phenomenon appeared in the 16th century, when a Portuguese missionary noted that a small bird pecked at the candlesticks in his church and could guide seekers to beehives. For centuries, it had been dismissed as myth, until the 1980s when Isack and Reyer showed that the Boran people of Kenya were purposefully following the honeyguide. Unlike the Yao, the Boran summoned honeyguides with sharp whistle-like sounds. With the help of the honeyguide, the Boran are able to cut down search time from nine hours to three [3].

The mutualistic behaviour – describing two parties both benefitting from a shared relationship – is frequently observed in the natural world. Plants and pollinators depend on each other, as do gut bacteria and humans. The Hadza people of Tanzania also follow honeyguides to locate honey, but their relationship moves from a mutualistic one to a manipulative one, where one party acts in a way that is beneficial to them but costly to the other party [5]. The Hadza people manipulate honeyguides by destroying the wax that they find – burning, burying or hiding, to deliberately deprive honeyguides of their reward. According to Hadza tradition, this behaviour keeps honeyguides hungry and motivated to find more hives.

Even with the promise of reward, the origin of honey guiding is called into question. The birds are not trained or domesticated, and are wild by every definition. Yet, they voluntarily engage with humans to establish a mutualistic relationship. Honeyguides themselves, however, are guilty of their own manipulative behaviour toward other birds. In fact, they are oftentimes referred to as 'African cuckoos' for its cuckoo-esque parasitism. Female honeyguides are unable to build their own nests and thus, sneak into the underground nests of bee-eating birds, pierce the host's eggs and supplant their own eggs in the nest. The host bird is often unaware of the switch, and obliviously incubates the new clutch [5].

Competition between female honeyguides is also fierce; around one third of parasitised nests contain eggs from two or more females and bee-eater hosts are only able to provide so many insects. To gain the evolutionary edge, honeyguide eggs very much resemble host eggs in size. Unlike in the case of the cuckoo bird, however, the honeyguide's mimicry aims to fool other honeyguides instead of the host.

在非洲撒哈拉沙漠以南的森林中常見的黑喉響蜜鴷（拉丁學名：*Indicator indicator*），是能夠消化蜂蠟的少數鳥類之一。牠們還會進食蜂窩內的其他東西，如：蜂卵、幼蟲和蜂蛹等 [1]，所以特別擅於尋找蜂窩。不過，對於這些手無寸鐵的小鳥來說，要躲避蜂蜇是有一定的難度，要借助於莫桑比克北部的堯族採蜜人。

採蜜人以嘹亮的顫音 — 呼嚕聲，召喚附近的響蜜鴷。響蜜鴷會報以鳴聲並飛向蜂窩。在唱和聲中，人鳥重複互認，尋找共同目標。一旦發現蜂窩，採蜜人會以煙火包圍蜂窩，讓蜜蜂無法分辨進攻源頭，然後破開蜂窩取走蜂蜜。整個過程一點都不簡單，因為蜂窩往往位於不能觸及的樹幹之內或高處。堯族人會特意在一堆樹葉上留下蜂蠟，作爲對小鳥的獎勵。畢竟，這是響蜜鴷應得的酬金。在牠們幫助之下，採蜜人找到蜂窩的機會是平常的三倍 [2]。

最早關於這現象的西方報導，出現在16世紀。當時一位葡萄牙傳教士，記錄了有一隻小鳥啄食他教堂內的蠟燭，還為尋找蜂窩者引路。幾個世紀以來，人們視之為神話。直到80年代，Isack 和 Reyer 證實肯尼亞的波拉納人故意跟隨響蜜鴷。不過，波拉納人使用的叫聲像口哨般較為尖銳。有了小鳥的幫助，波拉納人就能把搜索時間由9小時減至3小時 [3]。

這種雙方都能受益的互惠行為在自然界中甚為普遍，例如：植物和傳粉者彼此依賴，腸道細菌和人類亦如是。坦桑尼亞的哈紮人也會跟蹤響蜜鴷尋找蜂窩，不過兩者的關係從互惠變成了操控，以致一方得益而另一方受損 [5]。哈紮人的操控手段是銷毀、掩埋或者隱匿找到的蜂蠟，故意剝削響蜜鴷的酬勞。按照哈紮傳統，這種行為是要讓響蜜鴷飢餓，迫使牠們尋找更多的蜂窩。

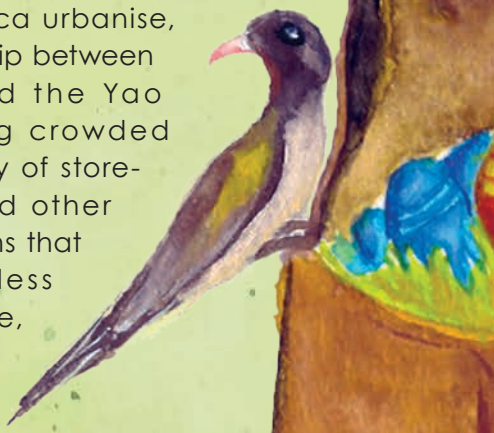
雖然可以得到獎勵，這種「導蜜」行為的起源還是讓人費解。響蜜鴷既沒有經過培訓亦不是家養，肯定是野生動物；卻自願地與人類建立互惠的關係。不過響蜜鴷本身，也會對其他鳥類作出操縱行為。

Experiments have shown that bee-eating hosts are oblivious to the size of the eggs and blithely incubate eggs that are significantly larger than their own. Researchers put this theory to test by placing a conspicuously foreign egg into a bee-eater nest and waited until a female honeyguide approached to lay her egg. They observed that every egg in the nest was punctured, but the foreign egg was particularly severely pierced, concluding that these anomalous eggs were mistaken as rival honeyguide eggs [6].

Aside from the honeyguide, natural cases of cooperation between humans and wild animals are rare, but not unheard of. Fishermen in Laguna, Brazil, collaborate with local dolphins to catch fish. Every autumn, local bottlenose dolphins (*Tursiops truncates*) herd schools of mullet toward a line of waiting fishermen. These helpful creatures then use specific head and tail slaps to signal the fishermen to cast their nets. What exactly the dolphins derive from this action is a mystery; the pod may be leveraging the chaos to catch larger mullet with less effort. The benefit to fishermen, however, is much more obvious. Analogous to honeyguides, cooperative fishing increases the frequency of net casting, the volume of fish in each catch, as well as the average size of the fish brought to shore [7].

Dolphins are well-known to be highly social and intelligent creatures. Those in Laguna may be mimicking learned cooperative behaviour from each other and their parents. Mother dolphins are often observed pushing their young toward the fish as encouragement. In turn, the fishermen impart their fishing knowledge to their children as a means to continue the tradition.

As areas in Africa urbanise, the fruitful relationship between honeyguides and the Yao people are being crowded out. The availability of store-bought honey and other sugary goods means that people depend less on the honeyguide, and the practice of guiding is slowly becoming obsolete. The race is on to uncover the evolutionary mysteries of this peculiar mutualistic interaction before it is too late [8].



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嚮蜜鴷又被稱為「非洲杜鵑」，因為牠們跟杜鵑一樣是巢寄生鳥。雌鳥自己無法築巢，會潛入蜂虎鳥在地底的巢穴，刺破宿主巢內的鳥卵，以自己的卵取代。宿主往往毫不察覺，繼續孵化嚮蜜鴷卵 [6]。

雌鳥之間的競爭極為激烈。在被寄生的巢中，約有三分之一是被兩隻或以上的雌鳥寄生產卵。可是宿主只能供應有限的昆蟲。為了奪得進化優勢，嚮蜜鴷卵和宿主卵大小相若。不過，和杜鵑鳥不同，嚮蜜鴷偽裝的目的是要欺騙其他嚮蜜鴷，而不是宿主鳥。實驗證明，蜂虎鳥宿主並不在意卵的大小，樂意孵化比宿主卵大得多的鳥卵。為了測試這個理論，研究人員將一隻顯然有異的外來鳥卵放在宿主巢內，直到嚮蜜鴷到來產卵。之後，他們發現巢內每顆卵都被刺破，外來卵更是嚴重受創。由此得出結論，這些外來卵被誤認為是其他同類競爭者留下 [6]。

The Mysterious Honeyguide

神秘的嚮蜜鴷

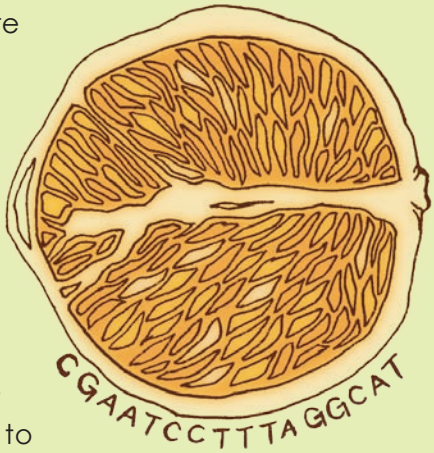
除了嚮蜜鴷，人類與野生動物在自然情況下合作，是比較罕見，但並非聞所未聞。巴西拉古納的漁民和當地的海豚合作捕魚。每到秋天，當地的瓶鼻海豚（*Tursiops truncates*）把魚群趕往列隊恭候的漁民。這些好幫手用頭和尾巴拍打水面，發出信號讓漁民撒網。究竟海豚可以從中得到什麼益處還是一個謎，可能是想趁亂輕鬆地捕捉更大的魚。不過，漁民的得益就很明顯。就跟嚮蜜鴷相似，合作捕魚可以增加撒網頻率、漁獲量及捕獲的魚類體積 [7]。

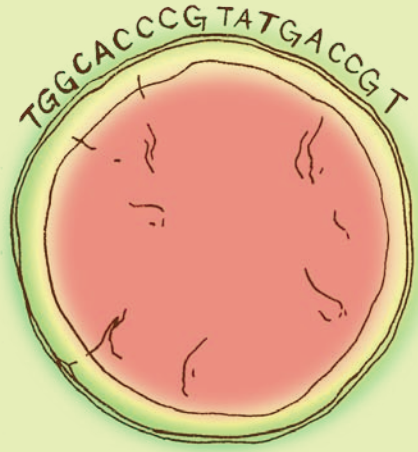
眾所周知，海豚是社會性和智商很高的動物。拉古納海豚的合作行為有可能是在模仿彼此和父母。母海豚經常會將自己的幼崽推向魚群以表示鼓勵。漁民也會將自己的捕魚知識傳授給子女以延續傳統。

非洲地區逐步城市化，漸漸不能容納嚮蜜鴷和堯族人之間的互利關係。人們可以在商店找到蜂蜜和其他糖類製品，就不用依賴嚮蜜鴷，「導蜜」慢慢地變得過時。要趕在這種奇特的互惠互動消失之前，解開相關的進化奧秘，這實在是刻不容緩 [8]。

Nothing offers more relief than the bite of a cold juicy cut of watermelon on a hot summer's day. Yet, James Kennedy, a chemist from Australia, claims that what appears to be both natural and fresh in a watermelon, could not be farther from the truth. The watermelon that we have all come to know and love, has been changed so significantly over the years, that it has now arguably become a different fruit entirely [1]. Such alterations are not unique to watermelons; in fact, most modern fruits have been manipulated and domesticated to suit our tastes.

Farmers have selectively bred desirable fruit traits for many centuries. Fruits are essentially the protective vehicle for seed development and dispersal. However, unpredictable changes in weather can significantly vary the amount of harvest [2]. Thus, selectivity helps to maintain harvest, in addition to the obvious result of breeding the sweetest and largest fruits. Farmers may also want to control the production of the fruit breed without introducing genetic variation, so as to ensure consistent quality in their products.





Selectivity is achieved through parthenocarpy, which refers to the production of fruit without fertilisation of ovules, leading to seedless fruits. Killing two birds with one stone, it is also a desirable alternative method for producing fruits that naturally contain hard seeds, such as grapes, oranges and bananas, for easier consumption.

Occasionally, parthenocarpy occurs from natural mutation. When this serendipitous act of nature occurs, farmers can propagate the mutated plant by cutting or grafting. After cutting a section of the plant, the ends are dipped in root hormone and grown into a new plant. Alternatively, grafting involves cutting a part of the plant and growing it on top of the living roots of another plant [3]. Parthenocarpy can also be artificially induced using incompatible pollen for fertilisation, such as the crossing of a diploid with a tetraploid parent. The resulting offspring has an imbalanced chromosome number, making it sterile and unable to produce seeds [4].

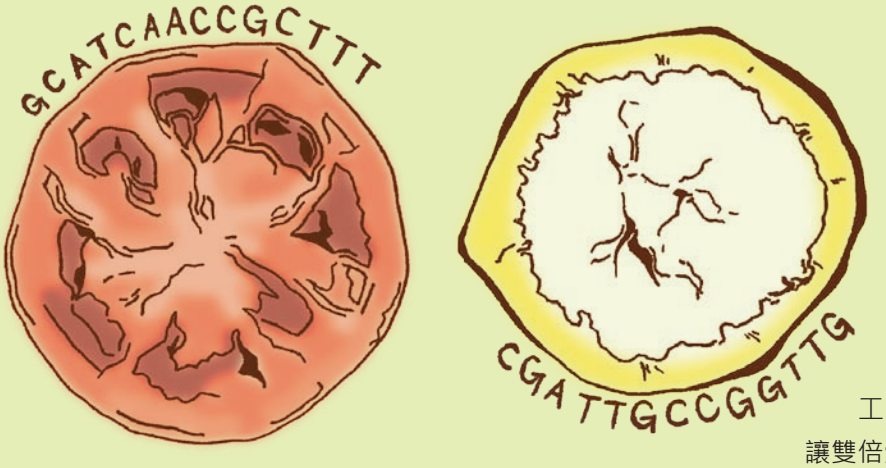
The major disadvantage to breeding seedless fruits is the reduction in the diversity of cultivated fruits, leading to a higher susceptibility to pests or diseases, which could wipe out all of these genetically identical clones. Such was the case in 1965, when the fungal Panama disease infected most of the world's commercial banana plantations that grew a common banana species. The banana industry rapidly scrambled to replace the infected species with an alternative, Cavendish cultivar, which was immune to the disease. However, in 1990, a new strain of disease emerged in Asia and had spread to the African continent, threatening local African banana varieties, including the Cavendish banana [5]. The Food and Agriculture Organisation of the United Nations (FAO) is urging a global effort in raising awareness of the disease among banana farmers and implementing preventative measures to keep its spread in check.

It has been argued that fruit seeds possess the highest nutritious value, and consumers are losing out on nutrients. For instance, sprouted watermelon seeds are packed with protein, vitamin B, magnesium and healthy fats [1]. In any case, it is fair to say that while science makes our lives more convenient, tinkering with Mother Nature often has its consequences, whether it is in the form of diseases or fewer nutrients. Science just has to evolve alongside it.

細說無籽水果

The Modern Seedless Fruit

By Jacqueline Aw
歐婷梅



沒有什麼比一口清涼多汁的西瓜更能消暑降溫。不過，澳洲化學家占士甘乃迪認為，貌似清新自然的西瓜絕不天然。我們現在所熟悉、所喜愛的西瓜，經過多年改造，已可說是完全不同的水果了[1]。不單是西瓜，還有許多現代水果都是經過改造以迎合大眾口味。

多個世紀以來，果農挑選繁殖帶有理想性狀的果實品種。果實原是要保護種子的發育傳播，不過人類另有打算。難以捉摸的天氣變化，會大大影響收成[2]。因此，除了要得到最大、最甜的果實，篩選目的還包括要維持產量。果農也會謀求控制品種，不讓基因變動出現，以確保作物品質穩定。

要做到選擇性產果，就要採用單性結實技術，指的是使胚珠不經受精而結出無籽果實。這方法還有一個好處，就是讓天然帶硬籽的水果，例如葡萄、橙和香蕉等，變得無籽而易於進食。單性結實偶然會因突變而自然出現，果農就會把握時機，以扦插法或嫁接法繁殖變種植物。扦插法是指切下部分植物，把一端浸泡在根激素中，生長成為新株；嫁接法則是把切除的部分，接合到另一植物的根系[3]。也可以人工誘發單性結實，用不相容的花粉進行授精。例如讓雙倍體和四倍體植物交配，下一代的染色體不平均，就會失去生殖能力，無法產生種子[4]。

生產無籽水果的主要弊端是減少品種的多樣性，基因相同的作物較容易受蟲害和病害威脅，甚至可能會被消滅殆盡。這正是1965年香蕉瘟疫的情況：當時真菌感染引起的黃葉病，如野火般席捲全世界的香蕉養殖場，蕉農匆匆改種能抵禦黃葉病的香芽蕉。然而，到了1990年，新真菌株在亞洲出現，並且擴散至非洲，危害包括香芽蕉在內的當地品種[5]。聯合國糧食及農業組織正在敦促各國加強蕉農對疾病的認識和實行預防措施，力求遏止黃葉病蔓延。

此外，有人認為果籽的營養價值最高，所以無籽水果其實是令消費者攝取較少的營養。舉例來說，發芽後的西瓜種子含有豐富的蛋白質、維他命B、鎂和有益的脂肪[1]。科學無疑是讓我們生活更加便利，但擺弄大自然卻往往會招來疾病、低營養等等不同形式的後果。科學與自然是要並軌前行。

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STRESS AND RESILIENCE – WHY ARE SOME BETTER AT IT THAN OTHERS?

By Raphaella So 蘇韋霖

Stress and anxiety are unfortunately integrated into the lives of students and the working population in Hong Kong. It does not take a scientist to notice that certain students handle stress a lot better than others. There are, in fact, biological reasons for this and methods by which one can improve their resilience to stress.

Resilience refers to a positive stress-coping ability. A person is resilient to stress if they are immune to the negative symptoms that stress brings about, or are able to cope by recovering quickly from traumatic experiences [1]. Resilience is largely a product of one's brain architecture and its associated signalling pathways. Depending on the effects exerted on the brain, stress can be split into two categories: tolerable stress and toxic stress. Tolerable stress is defined by stress that one has resources to cope with and is easier to adapt to and overcome. Toxic stress, on the other hand, is overwhelming and can result in residual psychological disorders such as depression or post-traumatic stress disorder.

Brain cells have receptors for insulin and insulin-like growth factor (IGF-1). Type II diabetes patients whose cells have impaired response to insulin, experience similar structural changes as do people who are stressed. While structural changes in the brain can be reversed following a stress-free recovery period, chronic activation of the stress response can overload the system, deteriorating the brain's resilience to future stressful events. The stress pathway is also interconnected with the inflammatory and metabolic systems, which means that chronically stressed individuals are at risk of developing secondary disorders such as chronic inflammation, cardiovascular disease and dementia.

Early childhood experience determines one's ability to cope with stress. In rats, lack of maternal care impairs proper brain development, leading to aversive behaviour in later life. Rhesus monkeys that were raised by anxious mothers have been documented to mimic chronic anxiety as well. In humans, those from a lower socioeconomic class, which generally increases the chances of experiencing stressors, correlate with greater emotional reactions when presented with stressful images. They are also more likely to be diagnosed with depression – consistent with the hypothesis that they are less resilient.

In line with environmental factors, epigenetics have been shown to influence one's stress-coping skills. Epigenetics refer to the changes in the responsiveness of genes to external factors that

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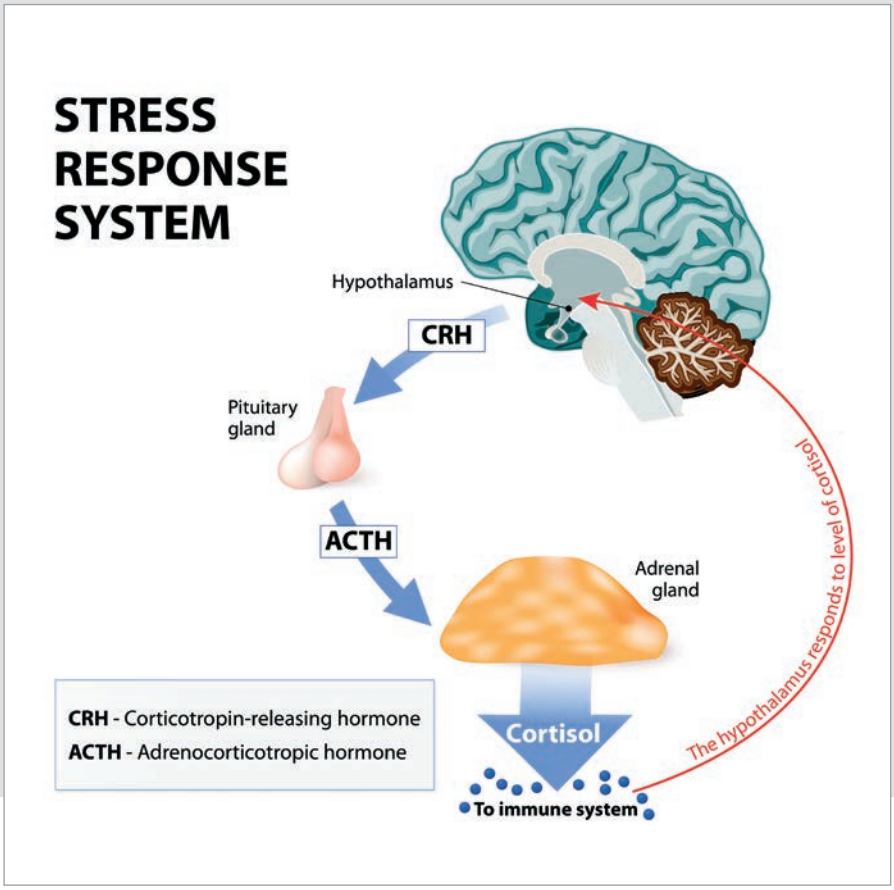
抗逆力
—為什麼有些人更擅於處理壓力？

壓力與焦慮已不幸地成為香港學生與在職人士生活的一部分。不用是科學家也能發現，有些同學更懂得處理壓力。這背後其實是有生理因素，而且有方法可以提高自己的抗逆能力。

抗逆力是指以正面態度應對壓力的能力。可以抵抗壓力所帶來的負面影響，或是從創傷中快速復原，就是有抗逆能力 [1]。抗逆力很大程度上是大腦結構及相關的信號傳導途徑的產物。壓力可以按其對腦部的影響分為兩類：可容忍壓力和毒型壓力。可容忍壓力是指個人有足夠的資源應對，較容易適應和克服的壓力。毒型壓力卻可以把人壓垮，造成後遺心理病，例如：抑鬱症或創傷後應激障礙。

腦細胞帶有胰島素和胰島素樣生長因子 (IGF-1) 的受體。二型糖尿病患者的胰島素反應受損，腦部結構產生變化，與人受壓力後的反應相似。這些結構性變化在壓力消除後可以還原，但長期的壓力反應會讓系統不勝負荷，削弱大腦日後的抗逆力。應力信號通路與炎症和代謝系統互連，所以長期處於受壓狀態的人比較容易出現續發性疾病，例如慢性炎症，心血管疾病和癡呆症。

早期童年經歷決定了個人應對壓力的能力。缺乏母性關懷的大鼠腦部發育受損，以後會出現厭惡行為。有報導指由焦慮母親撫養的獼猴會模仿長期焦慮症狀。低社經地位者有更大機會面對壓力源，對包含壓力的意象有較強的情緒反應。他們患上抑鬱症的機會也更高，符合長期受壓者有較低抗逆力的假設。



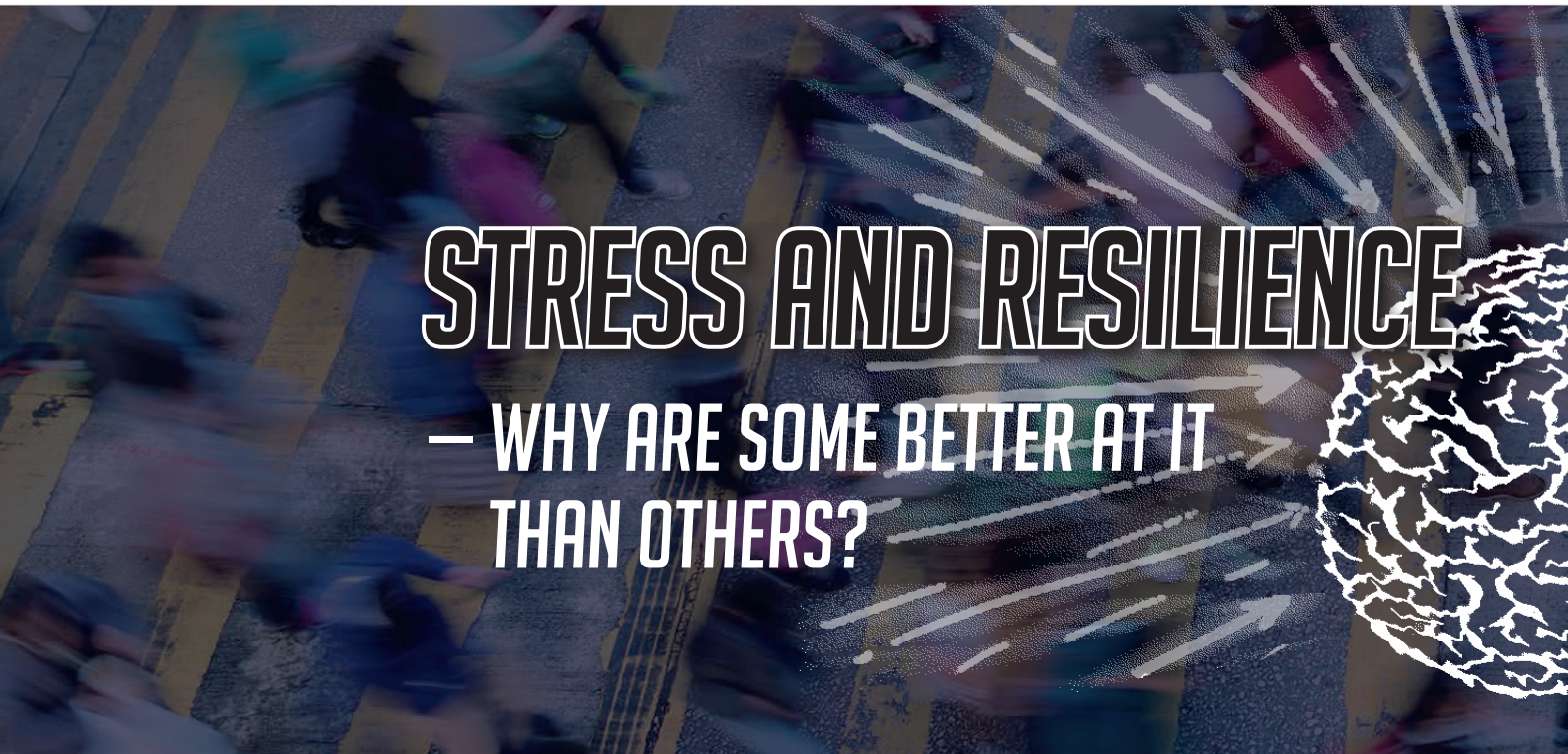
affect the way cells express genes. Such changes can be incurred by maternal care or dietary choices. Sometimes, certain repressive epigenetic markers render stress-coping genes to be unresponsive to environmental factors, causing the individual to be more vulnerable to future stressors. However, in others, epigenetic markers can cause the release of a natural antidepressant, providing mental protection to the individual from stress.

On the other side of the nature versus nurture debate, genetics play a significant role in determining one's stress-coping ability. Gender, which is both genetic and hormonal, also has an impact. Male rats and female rats, for example, display different neuronal changes in response to chronic stress. Application of an acute tail shock, which is a stressor for rodent models, causes male performance in a behavioural test to improve and female performance to decline. Research into human gender differences in dealing with stress has shown that male and females approach stressors using different strategies due to subtle distinctions in brain structures.

Given the potential psychological and physiological consequences of poor stress resilience, one would be curious as to whether the effects of stress on the brain's architecture is reversible. To some extent the structure can be restored to resemble its original state after a recovery period. Yet even after such a recovery, there remain subtle but undeniable differences between the stressed and unstressed brain. Thus, stress-induced changes can be permanent; later treatments only introduce compensatory changes to induce a healthy cognitive state. Certain changes in gene expression may be irreversible. Thus, it would be wise for one to take preventive measures instead.

To improve stress-coping abilities and to guard against toxic stress, certain activities known in the literature as "top down" therapy, as opposed to pharmacologic therapy could be adopted. Regular exercise has been shown to improve prefrontal cortex blood flow and increase hippocampal volume, both of which are excellent stress-copers. There is, in fact, a molecular explanation for this phenomenon. As mentioned, hippocampal neurons respond to insulin-like growth factors (IGF1), which is triggered during exercise. IGF1 exerts neurogenesis-promotion by activating signalling pathways in the cell. A related method is brain exercise – or intense learning sessions. Training the cognitive system has also been shown to increase hippocampal volume in humans. Finally, positive social interaction and having purpose in life also produce similar stress-coping benefits to regular physical activity.

Stress is an inevitable component of life. Whether we can cope with it in a positive manner is largely determined at birth and early childhood. However, there are strategies with which we can improve our resilience, therefore preventing chronic stress from creating permanent footprints on our mental and physical health.



從環境因素方面來看，表觀遺傳學也能影響應對壓力技能。表觀遺傳學是指基因行為受外在因素影響而改變，以致基因表達的模式發生變化。這些因素可以是產婦護理或是飲食選擇。某些抑製性表觀遺傳標記，有時會讓壓力應對基因不能對環境因素作出反應，以後面對壓力源就招架不住。不過，有些表觀遺傳標記卻能釋放天然抗抑鬱劑，可以抵禦壓力，保護精神健康。

不管是先天還是後天，個人應對壓力的能力主要還是由遺傳決定。性別同時涉及了遺傳與荷爾蒙，所以亦有一定影響。例如雄性和雌性大鼠的神經系統，就會因應長期壓力而有不同的變化。電擊鼠尾法證明雄鼠受壓後，會在行為測試中有更好表現，雌鼠卻會有退步表現。有研究探討人類兩性在處理壓力時的差異，結果是男女因大腦結構稍有不同，會以不同策略應對壓力源。

既然抗逆力不足會有心理和生理後果，不免要問：腦部結構受壓力影響後能否還原？答案是經過一段時期，大腦結構可以在某程度上恢復原狀，但仍是有微小差異，所以壓力引起的變化是永久性的。治療只能帶來代償性改變，誘導健康認知狀態，某些基因表達的變化或許是不能逆轉。因此，採取預防措施是較明智的做法。

有些活動可以提高應對壓力的能力和對抗毒型壓力。這類方法被稱為「自上而下」療法，以別於藥物治療。定期運動已被證實可以改善前額葉皮質血流量和增加海馬體積，有效對抗壓力。這種現象的分子機制與前文提及的IGF-1有關。運動可以增加IGF-1，啟動細胞內的信號通路，促進海馬神經元生長。另一個方法可能會被厭學的學生所痛恨，就是「腦部運動」或「密集式學習」。鍛練認知系統可以增加人類海馬區的體積，這也是得到證實的。最後，正向的社會互動和有目標的人生，也跟定期的體能活動相似，有助於應對壓力。

壓力是生活中不可避免的部分，能否積極面對，其實早在出生和幼兒時期已有定數。不過，還是有些方法可以提升抗逆力，幫助我們免因長期受壓而在身心健康留下永久烙印。

抗逆力

——為什麼有些人更擅於處理壓力？

NATURE'S LEFTIES

In a society where 9 out of 10 people are right-handed, the pain of being a lefty using scissors catered toward the majority falls on deaf ears. Rumours about lefties being brainier or better artists are offset by the hypothesis that they are more likely to be isolated or to suffer from psychological disorders. In some societies, left-handed individuals have even been historically shunned, and believed to be malicious. While a majority of humans are right-handed, handedness in animals is a lot less studied. Other than a myth about polar bears being left-handed (they're not), it appears that aside from primates, the only other animal with handedness is kangaroos. But how exactly is handedness shaped in nature and why does it exist?

Tracing back to our closest natural relatives, primatologists confirmed that hand preference exists in primates. For example, prosimians (a type of primitive primate) tend to be left-handed. Primates are close to us genetically and are approximately 30 percent southpaws (left-handed) [1]. While reasons for these patterns have yet to be identified, left-handedness has undoubtedly been found in nature.

Explaining human preference for handedness is complex. For instance, genetic makeup is not the sole determinant of handedness. Identical twins with the same genetic makeup have been documented to have different preference for the dominant hand, explained by differences in foetal positioning in the womb [2]. Another explanation suggests that preference is formed and influenced by parents when they teach us how to use different tools.

Our ancestors' preference for handedness is a question that requires more probing. Daniel Abrams, Associate Professor in Engineering Sciences and Applied Mathematics at Northwestern University, suggests that aside from genetics, on an evolutionary standpoint, handedness is shaped by two types of pressure – competitive and cooperative, and is responsible for the 9:1 equilibrium between righties and lefties. Lefties have an advantage over righties when it comes to competitive sports or combat. Since they are the minority, they instigate the surprise factor and would be more prepared against opponents who are right-handed. Evolutionarily, the group holding an advantage would typically increase in numbers until the advantage balances out, known as competitive pressure. However, Abrams explains that "human evolution has been shaped by cooperation, as well as competition", as seen in tool-sharing, where tools are created catered toward the majority – right-handers. This is known as cooperative pressure [3].

Handedness in animals is much less common. However, recent studies have shown that kangaroos and wallabies were found to exhibit handedness in comparison with other marsupial animals (animals found in Australia such as koalas). They suggest that animals which walk on four legs require both "hands" to execute daily actions, whereas kangaroos and wallabies are bipedal, much like humans [4].

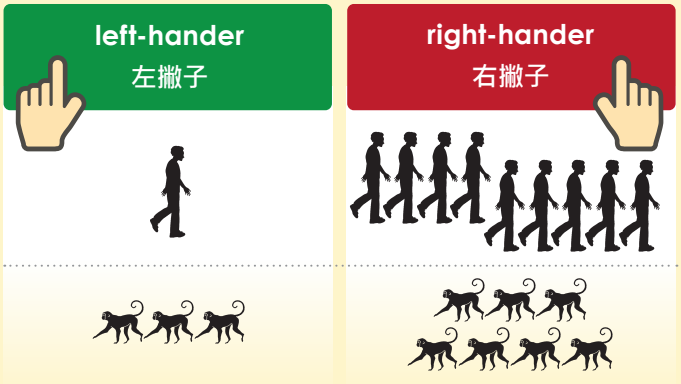
While handedness exists prominently in humans, and much less so in animals, it should be noted that handedness is a spectrum. Most people have a preference for the left or right hand, but some are ambidextrous, and able to perform equally well with either hand for various activities. Further study into handedness has the potential to reveal the evolutionary secrets of the human race [4].

自然界的左撇子

By Thomas Lee 李浩賢

每10個人中就有9個是右撇子，無怪乎左撇子在使用一般剪刀時遇到的痛苦往往被忽略。雖有傳言說左撇子較為聰明或是更好的藝術家，卻也有說左撇子易被孤立或受心理障礙困擾。某些社會更曾經以左撇子為不祥而加以排斥。人類中以右撇子佔多數，其他動物的左右偏好還未有廣泛研究。傳說北極熊是左撇子(其實不是)，除此之外，似乎只有靈長類動物和袋鼠有偏好。那麼在自然界中，偏手性是如何形成？為什麼會有偏手性？

先看看最接近我們的自然界近親，靈長類動物學家已證實靈長類動物也有左右手偏好。例如，原猴類 (較為原始的靈長類動物) 偏向使用左手。與人類基因較接近的靈長類，約有30%是左撇子 [1]。目前還無法解釋這些模式，不過可以肯定的是在自然界中也有左撇子。



要解釋人類的偏手性並不簡單，起碼基因就不是唯一的決定因素。有報導指出同卵雙胞胎，雖然基因相同，卻有不同的用手偏好，這可能是因為胎兒在子宮內的位置不同 [2]。另一種解釋是用手偏好是在父母教導我們使用不同工具時，受父母影響而形成。

至於我們祖先的偏手性又是如何出現呢？這問題需要更多研究才能解答。西北大學工程科學與應用數學系副教授丹尼爾·艾布拉姆斯認為從進化的角度考慮，除了基因之外，偏手性還受到競爭與協同兩種壓力影響，造成右左偏好的平衡維持在 9:1 比例。由於左撇子屬少數，可以出奇制勝，應付慣用右手的對手，在競技或格鬥時較有優勢。擁有進化優勢的群組人數會增加，直至優勢被中和，這就是競爭壓力。不過，艾布拉姆斯解釋說：「人類的進化同樣受協同及競爭所左右。」例如在共用工具時，便會碰到協同壓力，因為工具是按照大多數人即右撇子的需要而製成 [3] 。

在動物界中難得發現左右偏好。最近的研究卻指出與其他有袋類動物 (樹袋熊等分佈在澳大利亞的動物) 相比，袋鼠和小袋鼠有使用左右爪的偏好。由此顯示以四足步行的動物需要「雙手」來進行日常活動，至於袋鼠和小袋鼠則可以像人類般以雙足步行 [4]。

人類普遍都有偏手性，這在動物界中卻不尋常。值得一提的是偏手性的程度是有差異的。多數人偏好使用左或右手，但有些人兩手俱利，可以同樣靈活地操作左右手。偏手性的進一步研究，或可有助揭露人類進化過程中的秘密 [4] 。

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見微知著

—盧煜明教授專訪

Finding the Straws in the Wind

– Interview with Professor Lo Yuk Ming, Dennis

Modern diagnoses have been made easy in a number of ways and Hong Kong's own scientists have made tremendous contributions. Prof. Lo Yuk Ming, Dennis, Director of the Li Ka Shing Institute of Health Sciences at the Chinese University of Hong Kong, is an expert in diagnostic applications of blood plasma. He developed a simple, non-invasive blood test that checks for a slew of prenatal diseases through examining foetal DNA in maternal blood plasma, as opposed to blood cells. The method boasts nearly 100% accuracy and is much safer compared to older methods.

The prenatal diagnostic was discovered when he found that a foetus will release DNA into the plasma of the mother. Previous scholars had suggested testing foetal DNA through blood cells, but Prof. Lo explained that blood plasma contains a significant proportion of foreign DNA – such as that from a foetus, placenta or even cancer. His idea was first proven by the discovery of DNA fragments of a male foetus in maternal plasma. By analysing the DNA fragments, the gender, blood type and abnormalities are able to be determined.

He believes that his successful career can be attributed to his ability to read between the lines and to make connections between seemingly unrelated matters.

"I have found that I could apply knowledge or skills obtained from one field and use them in another".

After reading papers that described the presence of cancer DNA in the plasma of patients, he realised that foetal DNA could likewise be present in maternal plasma. "I thought that a foetus growing inside the uterus of its mother has similarities to a tumour growing in a patient".

The impact of this technology has been far-reaching. Prof. Lo's test has been used on more than a million pregnant women through a simple, non-intrusive procedure of blood drawing. His commercial success is far and in between in Hong Kong's culture, which is not particularly conducive to the development of science and technology. However, Prof. Lo is confident that the local climate has been improving for technology start-ups, allowing for scientific research to reach the larger masses. With the support of infrastructure such as Hong Kong Science Park, he concluded:

"What we need now is a few success stories to show young people that Hong Kong indeed has a technology future,"

Prof. Lo and his team are currently working on the next step in diagnostics. Blood plasma can potentially be used to screen for cancer in patients who do not show symptoms. With cancer being the number one cause of death in many parts of the world, including Hong Kong, it goes without saying that this work is paramount. Moreover, the amount of cancer DNA and the death rate of the patient are closely correlated, providing a quantitative and more accurate method to peg the severity of the cancer. Detecting cancer early significantly improves the survival rate. The technology also has the potential to provide more accurate and appropriate administration of treatment.

現代醫學診斷方法要比以前容易，香港科學家在這方面作出了相當貢獻。現任香港中文大學李嘉誠健康科學研究所所長的盧煜明講座教授，就是血漿檢測方法的專家。他發明的簡易無創性測試，只憑檢驗母體血漿(不是血細胞)中胎兒的DNA，便能準確診斷出多種產前疾病。這方法的準確性接近100%，並且要比傳統方法更安全。

盧教授先是發現了胎兒的DNA能夠進入母體的血漿內。在這以前，很多學者都嘗試在母體血細胞內尋找胎兒的DNA。盧教授認為血漿含有相當多來自胎兒、胎盤、甚或是癌細胞的DNA。他在母親的血漿內找到男性胎兒的DNA片段，證明了他的想法。通過分析胎兒的DNA片段，便能判斷胎兒的性別、血型和潛在的異常狀況。

盧教授認為自己見微知著、舉一反三的能力，是成功的主要因素。

「我能把某一領域的知識或技術，應用到另一領域當中。」

當時有論文指出在病人的血漿中找到癌細胞DNA，盧教授意識到胎兒的DNA也可以存在於母親血漿之中。「我靈機一觸，想到胎兒在母親子宮內成長，跟腫瘤寄生在病人體內有相似之處。」

盧教授的發明影響十分深遠，過百萬的孕婦已經接受過這項檢測，過程中只需以簡單、無創傷性的方法抽取血液。在科研風氣不盛的香港，這樣的商業成功案例更見難得。儘管香港沒有深厚的科創文化，盧教授相信這個情況將會慢慢改變過來，讓科研成果得到普及。在香港科學園和大學的支持下，盧教授表示：

「我們現在所差的只是幾個成功故事，讓年輕人確信香港可以在科研界佔一席之地。」

盧教授的團隊正在開拓診斷新領域；其中一個可能是以血漿檢測方法篩查癌症，偵測沒有症狀的人士是否患癌。癌症是香港和世界許多地方的頭號殺手，所以這項應用將會幫助很多病人。此外，血漿內腫瘤DNA量和病人死亡率有密切關係，提供了更準確的量化方法，監測癌症的嚴重性。若能及早檢測癌症，將會大大提高病人的存活率。這技術亦能幫助醫生對症下藥，給與適切的治療。

Aging, one of life's inevitable certainties, has been a hot topic of research for a number of years. From the obvious fabled stories promising the elixir of life to the questionable anecdotes of individuals who swear by supplements or regimens, anti-aging has always appeared to be a wild goose chase. But now, scientists may be closer than they have ever been to identifying anti-aging agents. Stanford University's Prof. Tony Wyss-Coray has laid a milestone in the search by what is known as blood rejuvenation.

Prof. Wyss-Coray began his research career in 1993 at the prestigious Scripps Research Institute in La Jolla, California. His initial studies involved work on Alzheimer's and other dementia related diseases, which led to a faculty position at Stanford University. Prof. Wyss-Coray suspected that blood might hold the answer to diagnose Alzheimer's before it manifested its symptoms and the analysis produced interesting results in protein level discrepancies with aging, setting the premise for anti-aging blood treatment.

Although the idea sounds medieval, it is far from it. Elegant and straightforward, it involves treating old mice with young mice blood and vice versa via blood transfusion. In an initial attempt to identify blood-based protein biomarkers for Alzheimer's disease, Prof. Wyss-Coray and his research group found that the biggest fluctuations in proteins occurred due to aging, rather than to a specific disease. As a result, they demonstrated that old mice treated with young blood showed marked growth of brain cells from the hippocampus. More surprisingly, old mice blood on young mice also had effects of delaying their growth of brain cells, deeming them to be biologically older than they were in reality.

As humans age, the connections between neurons deteriorate, causing neurodegenerative diseases. Subsequent studies revealed that these proteins also participate in other biological pathways including inflammation and repair. Inspired by past research that showed blood rejuvenation could rejuvenate muscles and the pancreas, Professor Wyss-Coray turned to the brain, the most complex and important organ, ultimately showing that blood rejuvenation could produce the same rejuvenating effects on brains as on other organs.

Research in aging does not come without its difficulties. Their studies indisputably lie slightly outside of the box and garner a healthy amount of scepticism, meaning that the biggest challenge they have encountered is seeking funding. Any inkling of promising data that they have published has also been clamoured for by patients or people who wish to extend their lives. "Since we have no clinical evidence yet that our findings can be applied to humans, I keep having to tell these people that they have to wait for many more years until clinical trials show efficacy".

Tests done on mice could take years, let alone on humans. The entire process would begin from the breeding of lab mice for the specific studies and then waiting for them to be mature. A lab mouse's lifespan is typically between two to three years. Thus aging research takes much longer to obtain results than other types of research.

If their findings on the malleability of mice brains can be translated to humans, young plasma could have applications beyond aging, such as in wound healing. "For any of these, clinical studies would have to be done and those are expensive". The team is currently attempting to identify "rejuvenating factors" to understand which tissues produce them and their communication pathways with the brain.

"In the long term, we want to use fractions of plasma or find individual factors which could be more potent and treat more people,"
Professor Wyss-Coray said.

找尋長生不老的聖杯

— 東尼·衛斯哥利教授專訪

儘管人人都知道老化是人生難以避免的過程，可是自古以來還是有很多人前仆後繼，希望可以找到避免衰老的秘密。古代人以煉丹追求不老，現代人則嘗試各種偏方，可惜兩者都成效不彰。直到最近，史丹福大學的東尼·衛斯哥利教授成功試驗了「血液再生」的概念，科學家才可說是初步掌握了抗老化的機制。

1993年，衛斯哥利教授在位於加州的著名研究所Scripss展開他的研究生涯。他初期的研究涉及各種腦退化症疾病，更為他帶來斯坦福大學的教席。衛斯哥利教授當時懷疑早期的老年癡呆可以從血液分析作診斷。研究發現年輕和衰老血液中的蛋白質水平有差別，奠定血液抗衰老的基礎。

這個概念聽起來很像中世紀的血液療法，但是厲害多了。「血液再生」執行十分簡單，它只需要把年輕老鼠的血液輸入年老老鼠體內。最初，衛斯哥利教授的團隊根本不是想要研究抗老化，他只想在血液中找出能反映腦退化症嚴重程度的蛋白質。可是，他們發現該類蛋白質的多寡與疾病關係不大，反倒與年紀有顯著關係。經過更多深入研究，他們發現如果把年輕老鼠的血液送到年老老鼠的腦部，年老老鼠的海馬體長出了更多的腦細胞。更神奇的是，年輕老鼠接受了年老老鼠的血液，就好像變老了一般，牠們腦部的細胞生長減慢了。

隨著人類老化，神經元之間的連結會慢慢衰退，導致各種神經退化性疾病。研究揭示這些蛋白質也參與在炎症、損傷修復等途徑。之前早有研究證實，如果肌肉或是胰臟接受年輕的血液，就會出現再生的現象。有見及此，衛斯哥利教授就嘗試把類似方法應用到大腦。大腦不僅是最重要的器官，而且遠比肌肉和胰臟複雜。最終，衛斯哥利教授成功在大腦重現類似的再生現象，為抗老化科技的發展踏出重要一步。

研究抗老化技術從來都不容易。很多想法一開始看來荒誕不經，研究剛開始時也沒有足夠數據解答別人的質疑，使研究團隊很難獲得足夠資金開展研究。好不容易獲得資金開始研究，當他們發表了些許有潛力的成果時，人們又會蜂擁而至，希望獲得抗老化治療。「由於我們還沒有臨床證據，證實血液再生技術能應用在人類身上，我要不斷婉拒來求醫問藥的人。血液再生技術還要經過很多年的臨床實驗，才可證實它的療效。」

要把技術應用在老鼠身上，已經需要很多時間，更遑論應用在人類上。為了研究抗老化，研究人員需要觀察實驗對象的整個生命週期。老鼠生長、繁殖速度相對較快，只要兩三年便可以觀察它們的生長和衰老。可想而知，如果要研究人類的老化現象，便需要動輒數十年的時間了。

如果證實人類腦部跟老鼠的一樣可以「重塑」，年輕的血漿將可有抗老化以外的應用可能，例如傷口修復。「說到底，還是要經過大量昂貴的臨床實驗才可進入應用層面。」衛斯哥利教授的團隊正嘗試確定血漿中的「再生分子」，以確實了解它們修復腦部的機制。

「未來我們期望可以找到血漿的特定有效部分或分子，它們可能比血漿療效更好，使我們的科技可以幫助更多人。」
衛斯哥利教授如此總結。

The Holy Grail of Anti-Aging Technology

– Interview with Professor Tony Wyss-Coray

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