SCIENCE FOCUS 科言

Issue 008, 2016

The Great Emu War
鴯鶓大戰爭

Mosquito-Zapping Lasers
激光殺牠死

Interview with
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Fingerprints:
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香港科技大學
THE HONG KONG UNIVERSITY OF
SCIENCE AND TECHNOLOGY

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Science Focus Issue 008, 2016

Message from the Editor-in-Chief 主編話語

Dear Readers,

Yet again, we have arrived at the end of the school year. I trust that everyone has put in countless hours of hard work for their examinations and is looking forward to a summer vacation filled with relaxation and fun. Science Focus offers a balance of intellectually stimulating articles depicting technology at the forefront of innovation and interesting information designed to challenge you and make you think.

I would also like to take this opportunity to congratulate our newest Science Focus Article Submission Competition winner, Christopher Peng Cheng of Chinese International School (S6), for his well-researched article on the science behind the human fingerprint. You can read his winning article on page 22. If science and writing fall within your forte, send us your submission to our next Science Focus Article Competition for the potential to win an iPad Air and to have your article published in our magazine. Visit our website for more details at *http://sciencefocus.ust.hk*.

Enjoy your summer holidays!

Prof. Yung Hou Wong
Editor-in-Chief

親愛的讀者：

又是告別學年的時候。我相信各位同學為了考試而辛勤多時，正期待著悠閒而充滿樂趣的暑假。「科言」提供了多篇介紹前沿科技的益智文章和趣味資訊，希望有助啓發你們思想。

我也想借此機會祝賀漢基國際學校 S6 的程鵬同學，成為「科言」徵文比賽最新的得獎者。得獎作品講述人類指紋背後的科學，內容經過精心考究，刊登在第 22 頁。若果科學和寫作都是你所擅長的領域，請投稿參加新一輪的「科言」徵文比賽，有機會贏得蘋果 iPad Air 乙部，並在本刊登出你的作品。若想了解詳細信息，請瀏覽「科言」網站：*http://sciencefocus.ust.hk*。

祝各位暑假愉快！

主編 王殷厚教授
敬上

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What is HAPPENING in HONG KONG?

By Jacqueline Aw
歐婷梅

The annual JSSE is back again, showcasing innovative inventions from secondary school students. With this year's theme *Connection*, students are challenged to create solutions that bridge modern communication barriers unique to this technology-savvy era. The winners and qualified teams will display their projects at the Hong Kong Central Library Exhibition Gallery from **August 19** to **August 25**. As the largest secondary-school-student-run exhibition in Hong Kong, it is definitely worth a visit!

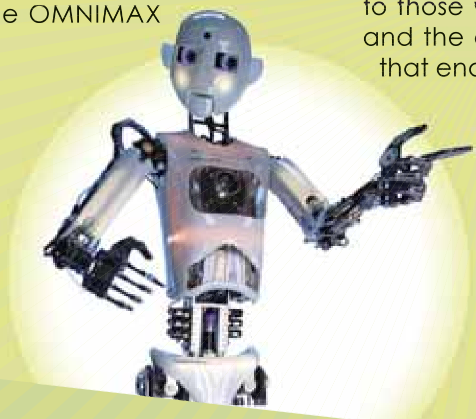
每年一度展示中學生創意發明的聯校科學展覽又回來了。今年的主題是「連繫」，挑戰學生以創意和科學知識，打破這科技發達的年代所特有的溝通屏障。獲獎者和入圍團隊將於**8月19日至25日**於香港銅鑼灣中央圖書館展覽廳展示作品。這是由中學生籌備全港最大型的展覽，絕對值得參觀！

49th Joint School Science Exhibition
第四十九屆聯校科學展覽

Space Theatre Shows
香港太空館天象廳節目

This summer, catch these informative shows at the Hong Kong Space Museum.

Does the idea of getting a machine to do your work appeal to you? Until **August 31**, catch the OMNIMAX Show "Robots", where the robot RoboThespian will introduce you to the fascinating world of robotics. Learn about the different kinds of robots that cater to different needs, from robots who look like us to those whose abilities surpass us, and the cutting edge technology that enables their development.



Please visit the following link for the show schedules:

http://www.lcsd.gov.hk/ce/Museum/Space/en_US/web/spm/info/generalinfo_showschedule.html

今年夏天，不要錯過在香港太空館天象廳播放的精彩資訊節目。

你可有興趣讓機械人為你代勞？由即日起至**8月31日**，天象廳放映全天域電影「機械智友」。片中機械人RoboThespain將會帶領你進入奇妙的機械人世界。你會遇到不同用途的機械人：從貌似人類的到能力超越我們的都有。該片還會介紹機械人工程學的最尖端科技。節目詳情請瀏覽：

http://www.lcsd.gov.hk/ce/Museum/Space/zh_TW/web/spm/info/generalinfo_showschedule.html

Novel Nano-Medicine Exhibition 新納米藥物展覽

The challenges in drug delivery development are to ensure effective cellular uptake and sustained release. A feasible solution to these problems is by using nanoparticle carrier based nano-medicine, which has the added advantage of serving as multifunctional carriers that enable targeted drug delivery. The Hong Kong Science Museum special exhibition is proudly featuring a novel nanoparticle-drug system locally developed by the Chinese University of Hong Kong. This drug system has the ability to self-decompose after drug release, allowing easy excretion and reduced side effects. To increase efficacy, the system also allows control over the drug release. Interested in knowing more? Make a trip to the Science Museum! This exhibition will be available until **August 31**.

Please visit *http://hk.science.museum/en_US/web/scm/se/snc.html*

藥物傳輸技術發展的方向是要讓藥物持續釋出及有效地被細胞吸收。以納米粒子作為載體的納米藥物，可以滿足這方面要求，還能成為多功能載體，用於標靶藥物傳輸。香港科學館的專題展覽展出香港中文大學研發的納米載藥系統。此系統在釋放藥物後自行分解，方便排出體外，減少副作用。藥物還會在受控的情況下釋出，療效得以提高。若有興趣了解更多，可到香港科學館看看，展出日期至**2016年8月31日**。詳情請瀏覽：*http://hk.science.museum/zh_TW/web/scm/se/snc.html*

Most people think studying abroad means going to the US, UK or Australia, but many are now turning to countries closer to home to pursue their tertiary education. Universities in Japan and Korea are also renowned, and are repeatedly ranked in the top 50 universities in Asia. Kyoto University, University of Tokyo and Osaka University are among the top universities in Japan, whereas Seoul National University, Yonsei University and Korea University are consistently ranked highly in Korea.

GLOBAL EDUCATION HUBS

Guide to University Applications: Japan & Korea

Educational System in Korea

Under the influence of Korean popular culture, more and more students are pursuing their undergraduate studies in South Korea. With the emphasis of education as 'the second economy' of Korea, the Korean government has invested lavishly to further advance their tertiary educational system and to provide quality education.

Similar to the Japanese Tertiary Education System, the Korean system also includes universities, specialised colleges and integrated colleges. General university degrees require a 4 year commitment, excluding medicine and dentistry.

Application Requirements

Applicants are expected to have had at least 12 years of education as well as a high school diploma before applying for any aforementioned institutions. Students can choose to sit the Test of Proficiency in Korean (TOPIK) at level 3 or supplement their university courses with Korean language courses. Foreign students must apply for the student visa (D-2) by providing the following documents: admission letter, proof of financial resources, study plan and certificates of highest education.

Entrance Exams

Students are required to sit for the Test of Proficiency in Korean, held every March to April and October to November and obtain at least level 3 prior to application.

韓國高等教育制度

除了留學日本，受韓流影響，留學韓國亦成為了一個新的趨勢。韓國政府視教育為「第二經濟」，全力支持其發展，不斷提升質素。

韓國的高等教育體系與日本相似，包括：大學、專科大學、教育大學、綜合大學。不計醫科和牙科，一般大學課程需要4年完成。

申請資格

申請人須完成最少12年教育並持有高中畢業證書。學生亦須具有韓國語能力考試(TOPIK)3級合格成績，否則必須就讀韓國語言學校。本科留學生須要申請長期學生簽證(D-2)，所須文件為：入學許可書、財產證明、學習計劃書及最終學歷證明。

入學考試

學生在申請入學前，須要參加每年3至4月及10至11月期間舉行的韓國語能力考試(TOPIK)，並至少獲得3級水平。

Comparing Korean Universities
韓國大學比較

	Seoul National University 首爾大學	Korea University 高麗大學	Yonsei University 延世大學
Ranking 排名	World 85th, 6th in Asia (Times, 2015) 泰晤士高等教育世界大學排名 世界第85, 亞洲第6	World 251st-300th, 26th in Asia (Times, 2015) 泰晤士高等教育世界大學排名 亞洲第26, 世界第251-300	World 301st-350th, 28th in Asia (Times, 2015) 泰晤士高等教育世界大學排名 亞洲第28, 世界第301-350
Tuition fee 學費	Varies among majors 依學系而定	Approx. 約 KRW 4,600,000 (HK$31,000)	Approx. 約 KRW 5,000,000 (HK$33,000)
Application Period 入學申請日期	Spring Semester: June – July Fall Semester: January – February 春季：每年六月至七月 秋季：每年一月至二月	Spring semester: October – November Fall semester: March – May 春季：每年十月至十一月 秋季：每年三月至五月	Spring Semester: June – December Fall Semester: March – April 春季：每年七月至十二月 秋季：每年三月至四月

多數人以為出國留學就是到英、美、澳洲，但有許多學生也會考慮到離家較近的國家升讀大學。日本及韓國的大學都享有盛名，長期列入亞洲前50名。日本頂尖的大學包括京都大學、東京大學和大阪大學；至於韓國，國立首爾大學、延世大學和高麗大學排名一直都很高。

留學日韓知多點

By Man Hing Wong 黃雯馨

The Japanese Tertiary Education System

The tertiary education system in Japan is comprised of universities, junior colleges and special vocational training institutions offering programmes of various lengths and specialisations. A bachelor degree typically requires four years to complete. A six year structure is adopted among departments of medicine, pharmacy, dentistry or veterinary science.

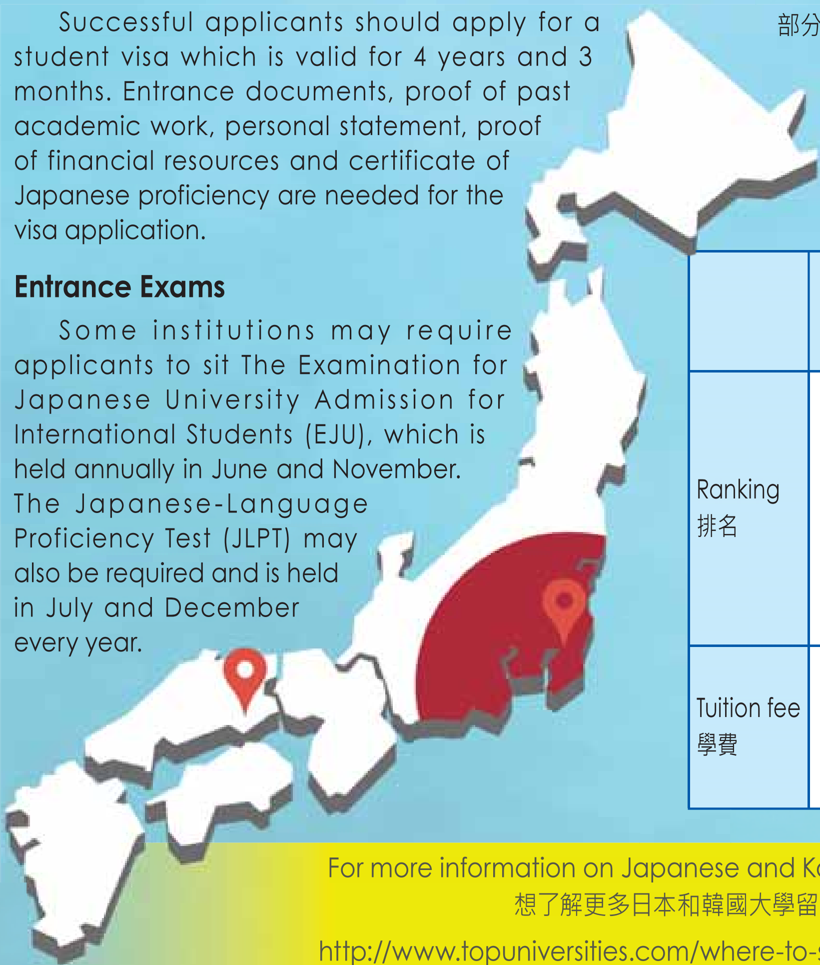
Application Requirements

To apply for any of the aforementioned institutions, applicants are required to have had at least 12 years of education and have completed secondary school. Moreover, students should hold an examination certificate equivalent to Japan college entrance exam, such as HKDSE or IB. N1 and N2 level of Japanese proficiency is a must.

Successful applicants should apply for a student visa which is valid for 4 years and 3 months. Entrance documents, proof of past academic work, personal statement, proof of financial resources and certificate of Japanese proficiency are needed for the visa application.

Entrance Exams

Some institutions may require applicants to sit The Examination for Japanese University Admission for International Students (EJU), which is held annually in June and November. The Japanese-Language Proficiency Test (JLPT) may also be required and is held in July and December every year.



日本高等教育制度

日本的高等教育機構有大學、短期大學和專門學校，提供不同年期和學科的課程。大學為4年制課程，著重理論性的學術傳授，學生完成學位後可獲學士資格。修讀專科如醫學、藥劑、牙醫以及獸醫等學系，則須6年時間。

申請資格

上述機構均要求申請人完成最少12年教育，以及具備高中或同等學歷。另外，申請人應持有相等於日本高考的考試合格證明，例如：香港中學文憑試、國際文憑等。申請人的日語能力必須達到N1及N2水平。

錄取之後就要申請留學簽證，最長逗留年期為4年3個月。所須文件包括：入學許可書、學歷證明、個人陳述、經濟來源證明和日語能力證書。

入學考試

部分院校會要求申請人參加每年6月及11月舉行的日本留學試驗（EJU），以及在每年7月及12月舉行的日本語能力試驗（JLPT）。

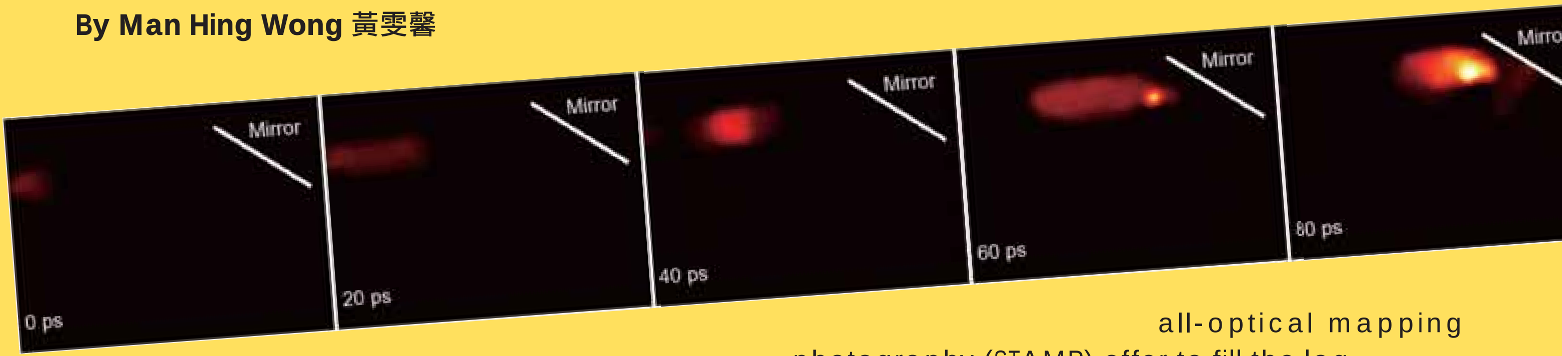
Comparing Japan Universities
日本大學比較

	The University of Tokyo 東京大學	Kyoto University 京都大學	Osaka University 大阪大學
Ranking 排名	World 43th, 1st in Asia (Times, 2015) 泰晤士高等教育世界大學排名 世界第43，亞洲第1	World 88th, 9th in Asia (Times, 2015) 泰晤士高等教育世界大學排名 世界第88，亞洲第9	World 251st-300th, 18th in Asia (Times, 2015) 泰晤士高等教育世界大學排名 世界第251至300，亞洲第18
Tuition fee 學費	Admission fee 入學費用：Approx. 約 282,000円 (HK$19,700) Tuition fee (annual) 全年學費：Approx. 約535,800円 (HK$37,500)		

For more information on Japanese and Korean universities, please visit
想了解更多日本和韓國大學留學資料，請瀏覽
http://www.topuniversities.com/where-to-study/asia/japan/guide
http://www.topuniversities.com/where-to-study/asia/south-korea/guide

Capturing the Breeze : HIGH-SPEED Photography

By Man Hing Wong 黃雯馨



History's earliest surviving photograph, circa 1826, was little more than a rudimentary sketch, requiring several days of exposure. By 1838, daguerreotype photography had shortened exposure time significantly, to the length of around ten to twelve minutes. Since then, the development of photography and videography has taken off at an exponential rate, with standard cameras being able to capture motion more rapidly than can be detected by the naked eye. Recent research has taken this to an entirely new level with high-speed photography.

According to the Society of Motion Picture and Television Engineers (SMPTE), high-speed photography is categorised as photographs that can be taken at a rate of over 128 frames per second. To capture a photograph, the camera must receive light reflected from the surface of an object. Objects in rapid motion must be sequentially recorded with high precision, which is virtually impossible for ordinary cameras due to the unavoidable delay of the shutter. Pump-probe technology and sequentially timed all-optical mapping photography (STAMP) offer to fill the lag.

In pump-probe photography, the "probe" and "pump" lasers are adopted to eliminate time lapse due to a light shutter. To photograph the response of an object such as a collection of atoms, an initial beam of 'pump' laser radiates the object to an excited state of heightened energy, and a precisely delayed beam of 'probe' light is applied to take an image of the object. An issue associated with pump-probe photography, however, is that it requires repetitive measurements to compile the final movie.

Scientists from Keio University and University of Tokyo have invented a means of capturing single-shot images at a rate of 4.4 trillion frames per second at a resolution of up to 450 x 450 pixels using STAMP, also known as femto-photography. To put this into perspective of what this means, STAMP can potentially capture the conduction of heat (which moves at a speed nearly a sixth of the speed of light), vibrations of atoms in their crystal states (lattice vibrations), and plasma dynamics.

The technique involves shooting an ultra-short laser pulse at the photographed object. A set up of mirrors and careful orientation of cameras surround the object so that all angles are

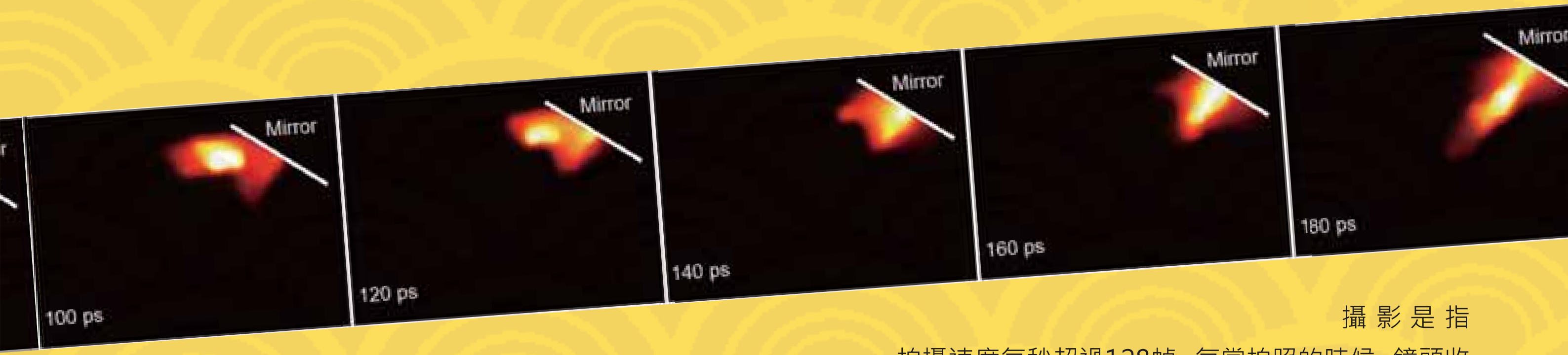
Further Reading 延伸閱讀

- Pump-probe technique, *https://www.youtube.com/watch?v=Vy71bJJ9EnU*
- Sequentially Timed All-optical Mapping Photography, *https://www.youtube.com/watch?v=TtXzrlXxCkM&spfreload=10*

References 參考資料

Nakagawa, K., Iwasaki, A., Oishi, Y., Horisaki, R., Tsukamoto, A., Nakamura, A., Sakuma, I. (2014). Sequentially timed all-optical mapping photography (STAMP). Nature Photonics Nature Photon, 8(9), 695-700.

捕風捉影：淺談高速攝影



encompassed.

The pulse is then divided into distinct pulses at different spectral bands, capturing the object as sequential flashes and then combined to form movie frames. In addition to breaking all previous records in number of frames per second, STAMP also eschews the need for repetitive measurements required in pump-probe photography, and is able to map an object's spatial profile.

The benefits from the application of high speed photography are endless. Researchers are now focusing their attention on shrinking the camera for a wider scope of applications – it is currently at a size of about one square metre – including the synthesis of semiconductors or applications in the medical field. Our need to capture instances in time has transitioned from the macro to the nanoscale, satiating humanity's curiosity for the very building blocks of physics, biology and chemistry. For now, we can enjoy the entertainment offered to us by current commercial high speed cameras. Bursting water balloons, anyone?

史上最早的一幀相片大概可追溯至1826年，跟簡樸的素描圖像相差無幾，曝光時間卻要數天。直至1838年，銀版攝影法的發明大大縮短曝光時間到10至12分鐘。自此之後，攝影與錄影技術迅速發展，標準鏡頭能夠比肉眼更快地捕捉每一個動作。近日更有研究將高速攝影推向新境界。

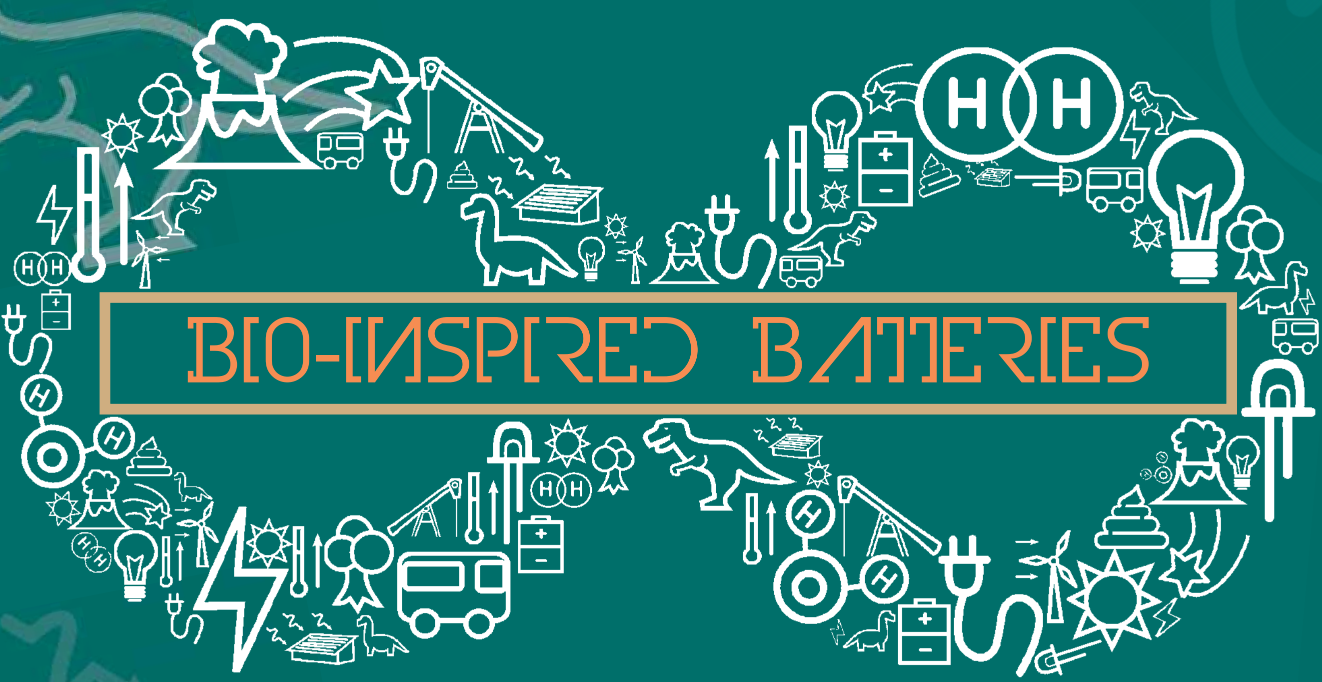
根據電影電視工程師協會(SMPTE)的定義，高速攝影是指拍攝速度每秒超過128幀。每當拍照的時候，鏡頭收集物件反射出來的光。由於快門會出現時間誤差，普通鏡頭無法精確地順序捕捉迅速移動物件的影像。泵浦技術以及STAMP（連續定時全光學映射攝影）技術的面世解決了上述的問題。

泵浦攝影技術利用「浦鐳射」以及「泵鐳射」去消除快門的時間誤差。以拍攝一組原子的反應為例，可先以泵鐳射提高拍攝對象的能量至激發態，然後以浦鐳射在精確控制的延遲時刻進行拍照。不過，美中不足的是，泵浦技術需要重複量度才能夠重建一連串的動作畫面。

慶應義塾大學以及東京大學的科學家用STAMP相機進行飛秒攝影，可以每秒4.4兆的幀率捕捉一連串畫面，解析度高達450 x 450 像素。STAMP可以捕捉熱傳導(速度是光傳遞的六分之一) 、晶體原子的振動（晶格振動）和等離子動態，可見其重要。

STAMP技術利用超短鐳射脈衝射向拍攝對象。物件被多面鏡子及經精心調較位置的相機環繞，確保所有角度均在覆蓋範圍之內。脈衝分化成不同光譜帶的脈衝閃爍，依次照射拍攝對象，然後結合重構整個畫面。STAMP技術具有破記錄的高幀率，而沒有泵浦技術需要重複測量的缺點，同時亦能勾畫出物件空間分佈的變化。

高速攝影技術可以帶來無窮的好處。科學家正在研究怎樣能夠縮小佔地約1平方米的相機，以求擴大其應用範疇，例如：半導體生產以及醫療用途。人類為了滿足好奇心，探求物理學、生物學和化學的根本，需要捕捉的時段也逐漸趨向以納米計算。現在，且先讓我們以市面上的高速攝影機留住動人一刻！



BIO-INSPIRED BATTERIES

仿效生物的電池

By Thomas Lee 李浩賢

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

根據化學科文憑試課程綱要，本文或可作為有用的補充讀物。

A typical battery is composed of two electrodes, an anode and a cathode, which are immersed in a vial of electrolyte solution. Commonly used lithium-ion batteries use lithium ions as the electrolyte, which migrate to the anode during recharging. Most anodes in lithium-ion batteries today are composed of graphite, for its superior electric conductivity. However, the production cost of graphite anodes has seen a significant increase recently due to the high cost of purification, reduced flake graphite production, and higher tax rates imposed on the commodity.

Graphite's superior conductivity is a result of its bonding structure. Its stacks of planar sheets of delocalised electrons, similar to a metal, allow free electrons to move and conduct electricity. With an anticipated surge in the demand of batteries for electronics, numerous attempts have been made to develop alternatives to graphite electrodes but which match the conductivity. Engineers and scientists are turning to the diverse and unique microstructures of feedstock, such as certain pollens and mushrooms, and are exploring the use of carbon microarchitecture in biomass as material to create anodes.

Hard carbon structures derived from bee pollen or bulrush pollen has been found to have potential for anode applications in energy storage devices [1]. In a process known as pyrolysis, pollen is treated with argon gas under high temperatures to form porous carbon structures. The research found that the porosity of the unique microstructures (the samples contained high levels of oxygen content) maximised the energy storage capacities, instilling potential anode applications to this clean and renewable technology.

Engineers at UC Riverside have created yet another type of lithium-ion battery anode using the skin of portabella mushrooms caps [2]. Known to be highly porous, the nano-ribbon-like architectures in the cap skins not only contain plenty of small apertures for liquid or gas to pass through, but they also create more chambers for energy storage and transfer upon heat treatment. These chambers are essential for improving battery performance. In a similar process to the previously mentioned pollen processing, the cap skin tissue also undergoes pyrolysis to create the desired carbon morphologies. As blind pores in the carbon structure can be activated after numerous charges, future electronics may see an increase, as opposed to a decrease, in energy capacity.

As an alternative to lithium-ion batteries, German scientists are investigating sodium-ion batteries with bio-waste-derived hard carbon as the anode [3]. Sodium-ion batteries allow for stationary energy storage, and are attractive to scientists and investors because of its abundance, great accessibility, and low cost. Organic waste (which is carbon-based), such as apple cores, has the application of anodes in sodium-ion batteries. The cathode consists of multiple layers of sodium oxides, which replace cobalt in conventional lithium-ion batteries. While, both sodium-ion and lithium-ion battery cathodes are similar in efficiency, the former offers an eco-friendly method of harvesting biomass and recycling agricultural wastage.

An unprecedented increase in the demand of energy storage for electronics is currently exhausting our natural resources. Innovative ideas that incorporate recyclability and the use of naturally available resources to create these technologies mark a great leap towards the development of inexpensive and eco-friendly batteries. The science exists, but the next step is to commercialise these technologies in real-life applications by cutting costs and enhancing efficiency as well as power output.

電池是由浸在電解質溶液中的正極和負極組成。在常用的鋰離子電池中，鋰離子在充電時移向負極。現今多數鋰離子電池的負極是由具有強導電性的石墨碳材製成。近年，由於石墨的提純成本提高，石墨片產量下降，加上商品稅率提高，導致石墨負極的生產成本大幅飆升。

石墨的超強導電性源於其結構，層層的遊離電子可以像金屬電子般移動及導電。有見於市場對電子產品用電池的需求將會激增，各方正嘗試開發導電性可與石墨電極比美的替代品。工程師和科學家看中花粉和蘑菇等生物原料的多樣而獨特的微結構，正在探索如何利用生物質中的碳微體系結構來生產負極材料。

他們發現從蜂花粉和蒲黃花粉取得的硬碳結構有可能製成儲能負極材料[1]。花粉經氬氣高溫處理後，熱解形成多孔碳結構。研究顯示這些獨特微結構（樣品含大量氧氣）的孔隙率，讓能量存儲量達到頂點，因此這種清潔可再生能源技術可以應用於開發負極材料。

另一方面，加州大學河濱分校的工程師們利用褐菇帽的皮製成另一類負極材料[2]。褐菇帽皮加熱後形成類似碳納米帶的結構，有大量小孔讓液體或氣體通過，亦會提供空間儲存和轉移能量。這些微孔是提高電池性能的關鍵。通過類似花粉處理的過程，褐菇帽皮組織也可以熱解成為所需的碳形態。碳架構中更有許多孔隙會隨著充電次數增加而被啟動，未來電子產品經長期使用後，電容量可能是增加而非減少。

德國科學家正在研究以鈉離子電池，配上從生物垃圾衍生的硬碳所製成的負極材料，作為鋰離子電池的替代品[3]。鈉離子電池可以成為固定儲能設備，而且優點眾多，如：原料供應充足、提取容易、成本低，所以吸引不少科學家和投資者青睞。有機廢物（碳基）如蘋果核，可以用作鈉離子電池的負極。正極則由多層鈉氧化物組成，取代傳統鋰離子電池所用的鈷。雖然兩者的效能不相伯仲，鈉離子電池可以額外提供回收生物質和循環再用農業廢料的環保途徑。

電子產品所衍生的儲能需求空前增加，消耗我們的自然資源。以上所介紹的種種方案，既有融入循環概念的創新思路，亦有運用自然可得資源的新技術，標示著在廉價環保電池的研發方面，已取得飛躍進展。下一步就要考慮削減成本和提高效率，以及提高輸出功率，務求將這些技術商化應用於現實生活中。

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Malaria, dengue fever and the recently much-discussed, Zika virus, are only a few of the life-threatening diseases that pesky mosquitoes have a hand in spreading to humans. To curb the number of these flying disease incubators, we have classically employed the use of an eclectic selection of creative contraptions. From the basic mosquito glue trap to the more systematic annihilation of these insects by means of pesticides and genetically modified mosquitoes that are unable to reproduce, we've tried them all. Extermination has, however, reached a new level of innovation – laser zapping. That's right, light sabers are not only limited to fighting galactic wars.

Two companies have made it their mission to destroy mosquitoes efficiently and with extra style points. The setup is composed of photonic fences that are tasked with detecting and locating mosquitoes. Functioning like radars, infra-red signals are altered when an object crosses the fence, triggering detection. A low-energy laser is then shot toward the target to further analyse the size, shape, speed and wing-batting frequency for further confirmation of a mosquito. The system is precise enough to distinguish mosquitoes by their gender – only female mosquitoes bite. Female mosquitoes are also larger in size with lower wing-batting frequency. Once identified, the system shoots a high-energy laser that eliminates the wings.

Instead of outright killing them, the laser only burns off their wings. While small and seemingly squishy to humans, mosquitoes are actually protected with a hard exoskeleton made of chitin, a long chain of polysaccharides that is made of the same material characteristic to that of the exoskeletons of crustaceans. A very powerful laser would be required to penetrate this outer layer of protection, neither efficient nor safe. Alternatively, a much lower powered infra-red laser is sufficient to vaporise fragile mosquito wings, which has the added benefit of being invisible to the naked eye.

Scientists may have finally found a viable solution for mosquito-transduced disease outbreaks endemic to developing countries,

Mosquito-

激光殺牠死

討厭的蚊子傳播許多威脅人類生命的疾病，其中包括瘧疾、登革熱以及近期熱話的茲卡病毒。我們出盡法寶克制這些會飛的疾病孵化器，用過的方法五花八門，有基本的蚊子膠黏陷阱，也有系統性的滅蟲手段，如殺蟲劑、不育的轉基因蚊子等等，創意不斷，最近更發展到一個新水平，以激光擊殺蚊子。激光劍已不再侷限於銀河格鬥！

有兩家公司致力以高效率、高格調的方式來消滅蚊蟲。他們的設計包括能夠探測蚊蟲位置的光子網，功能類似雷達。當有物體進入光網時，紅外線信號就會改變，觸動系統，發出低能量激光分析目標的大小、形狀、速度和翅膀拍

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where a reliable and convenient source of electricity is scarce. Low-energy infra-red lasers can be maintained and operated by a steady stream of solar energy stored in batteries, readily available in these countries. As well as being renewable and clean, solar energy is also relatively cheap when it comes to powering small contraptions.

The laser-shooting mechanism of mosquito control is on its way to being commercialised for widespread use. Some of the problems include the device's optimal functioning range of about 25 to 100 metres. Activity outside of this range becomes much more difficult to trace or target with precision. Nonetheless, when mobilised, this technology is not only limited to mosquito zapping and has the potential to see use in agricultural settings to eliminate harmful pests to crops. For now, it would be no exaggeration to claim that no one would be weeping for flightless mosquitoes.

-Zapping Lasers

By Long Him Cheung 張朗謙

動的速度，以確認物體是否蚊子。系統還可以精確區分蚊子的性別。叮咬人的是雌蚊，體形較大，翅膀拍打的頻率也比較低。一旦確定是雌蚊，系統就會射出高能量的激光，毀掉蚊蟲的翅膀。

系統激光只是燒掉蚊蟲的翅膀，而不是直接殺死牠們。蚊子細小而且看來軟綿綿的，其實是有一層外骨骼，由存在於甲殼類動物外殼的多醣類幾丁質組成，需要以非常強的激光才能穿透，這種滅蚊方法既無效率亦不安全。氣化脆弱的蚊子翅膀卻只需用人眼看不見、能量比較低的紅外激光就足夠了。

經蚊子傳播的疫病經常在發展中國家肆虐，這些地方缺乏可靠方便的電源，太陽能電池卻甚為普遍。低能量紅外激光可以靠這些電池維持操作，供電不成問題。太陽能作為可再生清潔能源，用於小裝置也是相對便宜。

激光滅蚊器正走向商品普及化。其中遇到的一個問題是裝置的最佳運作距離限於25至100米之內，難以精確追蹤或瞄準範圍之外的活動。儘管如此，一旦推廣成功，這技術將不僅可以消滅蚊子，也可能用於農業防治，消滅危害作物的害蟲。目前而言，相信沒有人會哭悼無翅的蚊蟲。

Gravitational Waves

重力波的預言

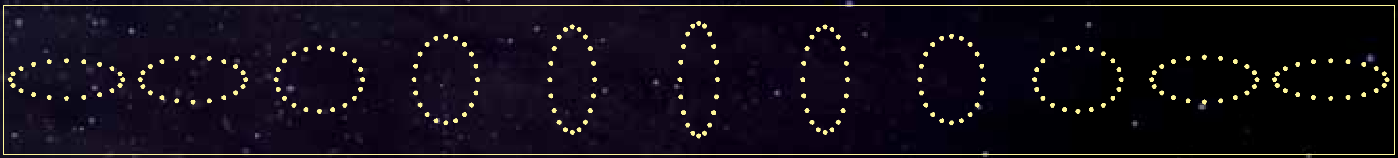
By Andy Cheung 張文康

Perhaps the most monumental science event of the year so far was the confirmation of the existence of gravitational waves. These mysterious ripples were first predicted by Albert Einstein exactly a century ago, but their detection has eluded scientists until recently. The excitement following this validation was almost palpable, drawing much attention from both laypeople and science aficionados alike. Dr. Tjonnie G. F. Li at The Chinese University of Hong Kong has been a member of the Laser Interferometer Gravitational-Wave Observatory (LIGO) Scientific Collaboration and has collaborated with other scientists in this important work. Their team deals primarily with the imperative work of distinguishing background noise from the minuscule signal of the waves, which is indispensable in gravitational wave detection and happens to be at the very forefront of this discovery.

In an apt analogy, he says "Imagine that the surface of a pond represents spacetime (the combination of space and time). When a rock is thrown into the pond, we observe ripples spreading outward from the centre. Similarly, cataclysmic events in the Universe can distort spacetime in such a manner that they produce waves in the fabric of spacetime itself. We call these gravitational waves". Similar to water waves, gravitational waves distort spacetime, momentarily altering our height and width but on a minute scale, only detectable with the most state-of-the-art technology. The LIGO interferometre, a cross-like structure measuring an arm-length of 4 km, detects gravitational ripples by measuring the changes in its width. These changes can be as small as 10^{-19} m.

Observing these infinitesimal differences requires researchers to identify and account for length changes while adjusting for error sources, such as expansion due to temperature change or background vibrations. Using special computer software, much of this involves analysing LIGO data and searching for bugs and methods to increase the interferometre's selectivity at the correct signal. Such a process requires months of devoted work, and a substantial amount of coding and debugging, making the fruits of their success particularly sweet.

As the final unobserved prediction of Einstein's theory of gravity, gravitational wave theory is, according to Dr. Li, "one of the pillars of modern physics". It opens a new avenue of understanding to the unlit parts of the Universe, shedding light on the areas where 'traditional' astronomy has trouble reaching. "Instead, gravitational waves are emitted by all massive things". Massive would be an understatement, because what is perhaps most remarkable about the detection of these gravitational waves is its source. Generated by a clash of two black holes almost 1.3 billion years ago and millions of galaxies away, the ripple effect was finally identified by LIGO's two detectors, the most sensitive measuring devices ever built.



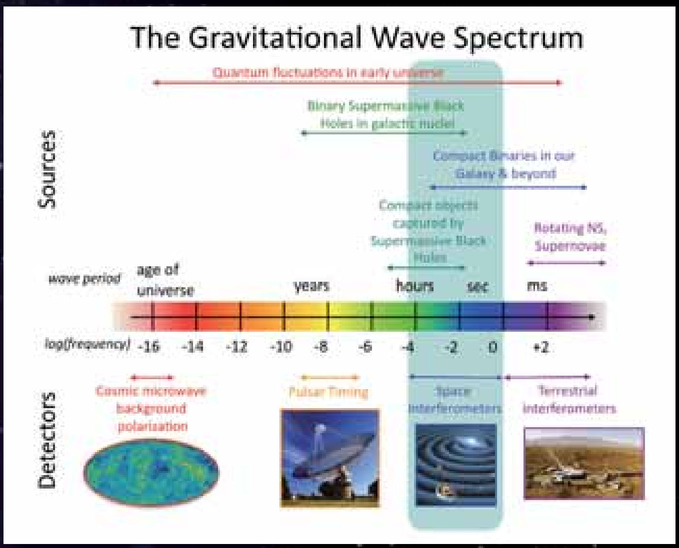
"I decided to pursue gravitational waves because I wanted to learn more about the force that dominates our understanding of the Universe, i.e. gravity." As a young achieving scientist, Dr. Li still has miles to traverse, as does the research on gravitational waves, uncovering the history of the University one secret at a time. "The real research has just started". The more we learn about our Universe, the less we seem to know.

要說到今年最重大的發現，重力波定必榜上有名。早在一百年前，愛因斯坦已預測到這些神秘漣漪的存在，但之前科學家一直未能窺見它的身影。現在得到確證，自然是振奮人心，受到廣泛關注。香港中文大學的黎冠峰博士亦有參與這項重大發現。他們的研究組加入鐳射干涉儀重力波觀測站（LIGO）合作組六年多，從事重力波物理研究，主要工作是要區分微小的重力波信號和背景雜訊，對探測重力波至關重要。

為了方便我們理解，黎博士用了一個恰當的比喻。「想像一下，池塘水面是時空（時間和空間）。把石頭拋入池塘，就會看到一圈圈的漣漪從中心向外擴散。同樣地，宇宙的劇烈活動也會扭曲時空，產生時空『漣漪』，我們稱之為重力波。」重力波像水波紋一樣會擾動我們的時空，瞬間改變物件的長寬，但變化十分短暫，只有世界頂尖的科技才能探測到。LIGO干涉儀的雙臂長度為4千米，可以測量重力波經過時帶來的寬度變化。這些變化小於10^{-19}米。

要探測如此微小的變化，首先要識別及調整因熱膨脹或背景振動等等原因而產生的誤差。黎博士和其他研究人員以特殊的電腦程式分析LIGO數據，找出程式的漏洞，提高干涉儀的選擇性。他們全力投入幾個月，作了大量編碼和偵錯工作，得到這成果自然倍覺甘甜。

愛因斯坦引力論所作出的預言中，最後被觀測到的就是重力波。黎博士認為重力波可說是「現代物理的支柱」，為探索未知宇宙開闢新路，讓我們可以觀察到以往天文學所不能探測的領域。「凡是大質量的東西，都會發出重力波。」這次探測到的重力波，源頭極具份量，是由距離地球13億光年及許多星系之外的兩個黑洞合併而產生，最終被LIGO兩個探測器，也是迄今為止最敏感的測量設備所發現。



「我決定研究重力波，是因為重力支配著我們所認識的宇宙，我想好好了解它。」重力波的研究才剛起步，宇宙起源還有許多秘密，有待年青有為的黎博士去逐步發掘。他說：「真正的研究才剛剛開始。」我們對宇宙認識的越多，就感到所知的越少。

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Tough, unpredictable and ravenous, the emu *(Dromaius novaehollandiae)* is an enemy as old as Australia itself (ironically, emus are the unofficial national birds of Australia, appearing on its coat-of-arms). The emu is the second-largest living bird on earth, standing six feet tall and weighing upwards of 100 pounds, its stature slightly smaller than its African cousin, the ostrich. Like ostriches, they are unable to fly, and are capable of sprinting up to an impressive 50 km/h. Their speed can be attributed to a set of powerful legs, which are amongst the strongest of any animal, capable of tearing down metal fences and fending off dingoes (their natural predators) by jumping and stamping them on their way down [1].

These gangling flightless birds are native to mid-western Australia, a habitat largely unperturbed by humanity. However, in times of dwindling food supply, emus have a tendency of travelling lengthy distances to reach alternative feeding areas, such as farms, which happened to be precisely the case in 1932.

In the aftermath of World War I, thousands of veterans returned to Australia, prompting the government to set up a “soldier settlement scheme”, allocating more than 5000 ex-soldiers to farms, where they cultivated wheat and sheep. These new settlements were built at the expense of emu habitats, naturally forcing them to begin feeding on crops. With their giant webbed feet and their duck-like black bills, emus trampled and sheared off crops right when the harvest was ready.

This, coupled with a nosedive in crop prices after the Great Depression, exacerbated the situation for the agricultural industry. Ravaged by hordes of these marauding intruders, numerous methods were used in attempts to contain the emu population. Poisoning, trapping and even shooting were met with limited success. Desperate, the farmers turned to the army for help.

And so, Australia declared war against its own national bird. Soldiers equipped with Lewis machine guns (capable of firing 500 rounds per minute and was used extensively during WWI) and a stockpile of 10,000 rounds of ammunition were used in an attempt to annihilate a good portion of the emu population. The leader, Major G. P. W. Meredith, was so confident that he brought along a cinematographer to capture his imminent success.

On Nov 2, Meredith and his men camped out in Campion, encountering a flock of 50 emus. Local settlers lured the herd towards the artillery, but the emus split into small groups and ran, rendering the barrage of machine guns ineffective. It soon became apparent that open warfare was useless, as the birds “employed guerrilla tactics” and were lightning-fast with their retreat. Worse still, their tough feathers and blind panic made them virtually immune to bullets – in

Did you know? 你知道嗎?

Emus belong to a family of flightless birds known as ratites, which also includes their distant cousins the ostrich and New Zealand’s kiwi. Ratites do not have the characteristic “keel” that provides the sternum anchor that allows for wing muscle movement, marking their inability to fly. Scientists have long believed that the ancestors of flightless birds were also flightless, but new uncovered DNA evidence has suggested that flightless birds may have actually evolved from independent flying ancestors, providing an explanation for how different ratites ended up in different areas of the Southern hemisphere.

鴯鶓大戰爭

The Great Emu War

By David Iu 姚誠鵠

以強悍、難以捉摸、貪饞著稱的鴯鶓，很早便在澳洲出現，一直是人類的大敵（諷刺的是，鴯鶓也是澳洲的非官方國鳥，出現在國徽上）。鴯鶓是世上第二大的鳥類，站立高度約6呎，體重達100磅，體形略小於非洲鴕鳥。鴯鶓跟鴕鳥一樣不能飛行，但憑著雙腿奔跑，時速可達50公里。鴯鶓雙腿的力量在動物中堪稱數一數二，既可以摧毀鐵欄，亦能躍起之後借勢踐踏及擊退天敵澳洲野犬[1]。

這些不會飛的高瘦大鳥生活在遠離人煙的澳洲中西部。不過，當食物短缺的時候，鴯鶓就會跋涉千里到農場等地區覓食。在1932年便發生了這樣的事，觸發一場“戰爭”。

第一次世界大戰後，數以千計的軍人退役回到澳洲，促使政府設立“士兵安置計劃”，遷徙5,000多名退伍軍人至農場種麥放羊。不幸地，這些新殖民點侵佔了鴯鶓的棲息地，迫使鴯鶓改以穀物維生。每到收成時分，鴯鶓便會以牠們巨大的蹼腳和扁扁的黑喙蹂躪農夫的心血。

同一時期，經濟大蕭條導致農產品價格暴跌，農業陷入困境。農民以種種方法制止這些掠奪者成群肆虐。他們下毒、誘捕、甚至射擊，但效果不彰，唯有向軍隊求助。

於是，澳洲政府對自己的國鳥宣戰。士兵配備了在第一次世界大戰期間廣泛使用的劉易斯機槍(每分鐘可以發射500發子彈)和10,000發彈藥，企圖將鴯鶓主力殲滅。領兵的馬里帝茲少校對這次行動信心滿滿，帶了一名電影攝影技師，打算記下近在眼前的勝利。

十一月二日，馬里帝茲及其部下在Campion紮營，遇到50隻鴯鶓。當地的殖民者成功把群鳥誘至射程內，但鴯鶓迅速四散逃走，機槍根本無法瞄準。鴯鶓採用遊擊戰術，撤退快如閃電，正面掃射這些大鳥明顯是徒勞。再加上鴯鶓的羽毛堅韌，受驚之後盲衝亂撞，子彈實在起不了多大作用，結果平均需要10多發子彈才能殺死一隻鴯鶓。

鴯鶓屬於不會飛行的平胸類鳥，其他遠親包括鴕鳥和新西蘭的鷸鴕。平胸鳥的胸骨沒有可讓飛行肌肉附著的「龍骨特」，所以無法飛行。長期以來，科學家認為這些鳥類的祖先也不會飛行，但新發現的DNA證據表明，牠們有可能是由不同的飛行祖先演變而來，這就解釋了為什麼會有不同的平胸鳥分佈在南半球的不同地區。

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fact, it took, on average, more than 10 bullets for each kill.

"If we had a military division with the bullet-carrying capacity of these birds it would face any army in the world... They can face machine guns with the invulnerability of tanks. They are like Zulus whom even dum-dum bullets could not stop." – Major Meredith, commander of the Royal Australian Artillery, on the outstanding mobility and sustainability of emus [2].

The day after, the group established an ambush near a local dam, reported to be the water source for over 1000 emus. With renewed patience, the soldiers waited until the birds were in point-blank range. At 100 yards, they fired at their lumbering bodies – easy targets for soldiers, no? A major victory was all but certain.

Except that the "major victory" was in the emus' favour.

Despite thousands of rounds fired, fewer than a dozen emus were killed. Emus scattered as quickly as the human forces began firing, out of gunsight before anyone had a chance to reload. Apparently, the herd had developed their own understanding of military science, much to the dismay of the army. For each mob of birds, there was "always an enormous black-plumed bird... who keeps watch while his mates carry out their work of destruction", as one of the army observers bitterly recounted [3].

Realising the birds were smarter and quicker than they had originally anticipated, Meredith decided to mount a machine gun onto a truck, in order to keep up with the fleeing emus. Yet, not a single shot was fired, because the bumpy countryside made aiming impossible...and because a bumbling emu got tangled in the steering wheel.

As the negative press reached the parliament, representatives rolled collective eyes and deemed the "war" a lost cause. The Minister of Defence withdrew the military personnel on Nov 8, putting the Emu fiasco to an end. Such is the story of Australia declaring and subsequently losing a war against its wildlife. While one may find the spectacular failure of the army somewhat comical, one must give credit to the emus' survivability. After all, they are only as tough as their home – the harsh plains of the Australian outback. It is their survival instincts that won them the war, not just their heavy treads or incredible mobility. As a species native to Australia, the emu will remain common throughout her countryside.

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皇家澳洲炮兵團馬里帝茲少校對鴯鶓出色的機動性和堅持持續力，有這樣的評價：「假使我們有一個師團能有這些鴯鶓的載彈（中彈受傷後堅持戰鬥）能力，這個師在世上便無往而不勝了。....牠們面對機槍掃射時有如坦克般刀槍不入，就跟祖魯土著一樣，連開花彈也阻擋不了。」[2]

第二天，部隊得知超過1,000隻鴯鶓將於一個水壩附近聚集，於是設下了埋伏。汲取之前的教訓，他們今次更加有耐性，等到鳥群靠近機槍時才開火。對訓練有素的士兵來說，在100碼的範圍瞄準笨重的鴯鶓開槍，理當是易如反掌，可以穩握勝券。

不料，大獲全勝的竟然是牠們，而非他們。

雖然發射了數千發子彈，只有不足12隻鴯鶓被殺。槍聲響起時，鴯鶓馬上四散逃離機槍，士兵們根本沒有機會重裝彈藥。更令部隊沮喪的是，鴯鶓似乎已經發展出自己的軍事理論。其中一位觀察者憤憤不平地回憶：「每群都有一隻黑羽大鳥把風，讓牠的夥伴們到處破壞。」[3] 。

馬里帝茲終於明白這些鳥要比預期的更為機智和敏捷，決定把機槍架設在貨車上，希望能追上逃跑的鴯鶓。不過，士兵根本無法在崎嶇原野瞄準目標；再加上有一隻橫衝直撞的鴯鶓卡住了軚盤，結果一槍也未能發射。

當壞消息傳至議會時，眾議員全都翻起了白眼，認定這場“戰爭”已經是一敗塗地。國防部在十一月八日召回軍隊，正式結束了這齣鴯鶓鬧劇。這便是澳洲向其野生動物宣戰卻敗北的故事。不過，儘管澳洲軍隊的慘敗令人發噱，我們必須稱讚鴯鶓的求生能力。畢竟牠們來自澳洲內陸嚴峻的荒原，練就了堅韌本色。鴯鶓能贏得戰爭憑的是牠們的求生本能，不單止其有力的踏步或不可思議的機動性。鴯鶓作為本土動物，將會繼續在澳洲郊野繁衍昌盛。

The Great Emu War
鴯鶓大戰爭

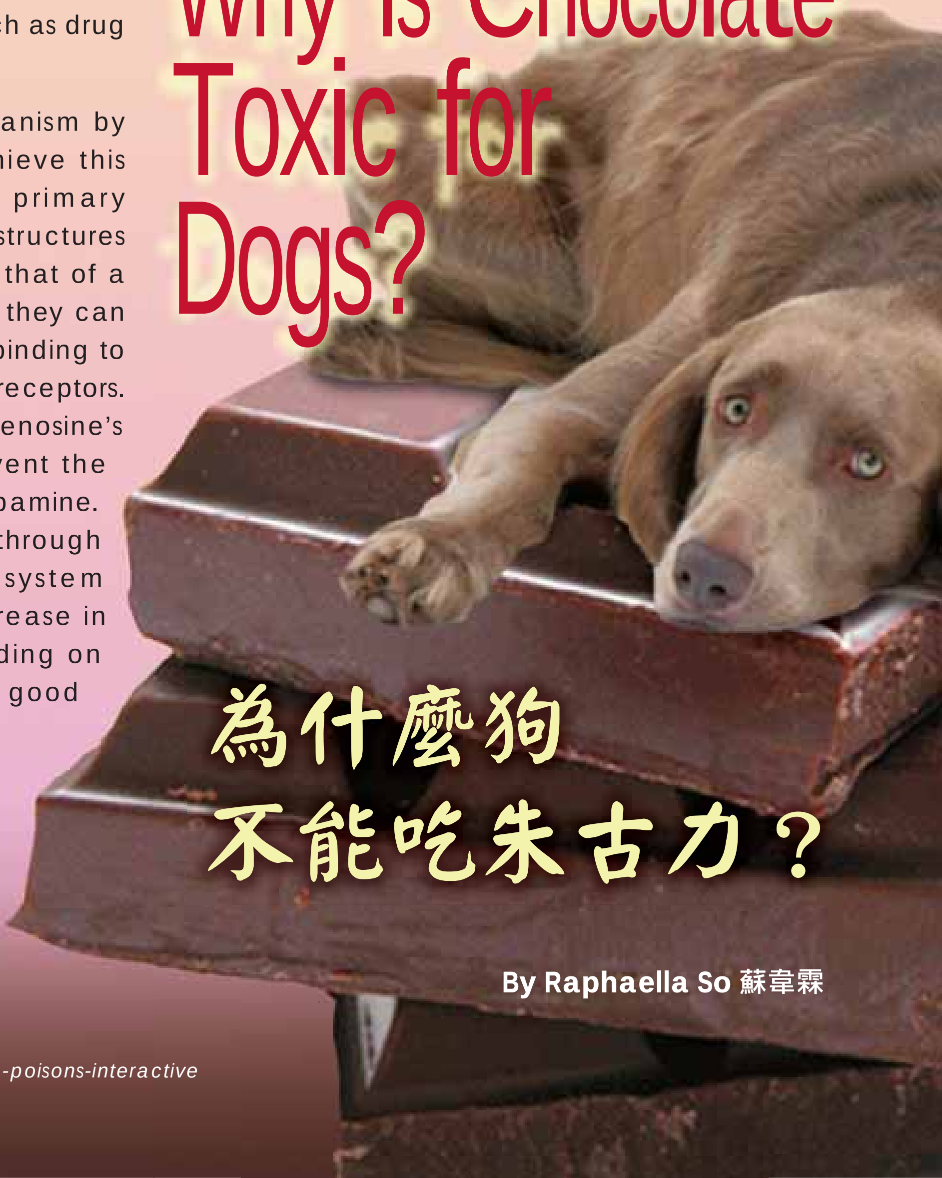
"There is nothing better than a friend, unless it is a friend with chocolate".

– Linda Grayson

Why is Chocolate Toxic for Dogs?

為什麼狗不能吃朱古力？

By Raphaella So 蘇韋霖



And yet, this delectable, universally loved treat is bad news for man's best friend. Dog owners are warned to be particularly careful with stashing away their chocolate, out of reach and out of sight from their furry companions. Accidental ingestion could cause an upset stomach at best, and be lethal at worst.

Chocolate's popularity is not only attributed to its luscious sugary taste, but also to its active compounds, namely, theobromine and caffeine from cacao [1]. These two compounds are known to promote the release of dopamine in human brains. Also known as the "feel-good" hormone, dopamine serves a critical role in the brain's pleasure-reward system as a neurotransmitter. It is also believed to be the culprit for addictive behaviours such as drug or gambling addictions.

The source of concern is the mechanism by which theobromine and caffeine achieve this stimulating effect. Theobromine is a primary metabolite of caffeine. Both chemical structures of theobromine and caffeine resemble that of a neurotransmitter called adenosine. Thus, they can potentially block adenosine's action by binding to and inhibiting the function of adenosine receptors. This blockade is a problem because adenosine's job is to promote drowsiness and prevent the brain from accumulating an excess of dopamine. When adenosine activity is diminished through competitive inhibition, the nervous system becomes hyperactive, causing an increase in heart rate and blood pressure. Depending on how you see it, this increase could be a good thing since it promotes alertness. However, too much of these chemicals can cause the jitters, as any overworked student who just downed three shots of espresso can testify.

Due to a difference in levels of tolerance, the effects of chocolate on dogs are much more pronounced. In humans, the lethal dose 50 (LD_{50}), which is toxicology jargon for "the dose at which 50% of the population will be killed by the chemical", is 1,000 mg/kg of theobromine [2]. Theoretically, the heavier the subject, the more of the drug they can tolerate. Not only are dogs much

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。

Further reading 延伸閱讀

http://ngm.nationalgeographic.com/2007/10/pets/dog-poisons-interactive

「沒有什麼比朋友更好，除非是帶著朱古力的朋友。」

- 琳達・格雷森

lighter and smaller in size compared to humans, but they also have a lower LD_{50} of 100 to 300 mg/kg for caffeine and theobromine [1, 2]. Mild signs of intoxication can already be detectable at around 20 mg/kg, with symptoms intensifying significantly at 40 mg/kg. The actual amount of chocolate deemed toxic to a dog is also affected by the type of chocolate (more cacao content equates to more theobromine and caffeine) and the dog breed [3].

Severe consequences of chocolate intoxication occur within six to twelve hours after ingestion. Symptoms include abnormal heart rate, loss of control over movement, increased thirst and urination, vomiting, diarrhoea, tremors and seizures, with abnormal heart rate or respiratory failure to most likely contribute to the cause of the death.

Yet dogs are not the only pets susceptible to chocolate intoxication. The LD_{50} in cats is around 200 mg/kg [2]. However, cats tend to be less indiscriminate in their eating habits and do not typically seek out sweet foods.

然而，對於人類最好的朋友—狗而言，這種可口，人人喜愛的美食是壞消息。小狗的主人可要小心收藏朱古力，放在牠碰不著、看不到的地方。小狗誤食朱古力可以引起胃部不適，甚至失去性命。

朱古力的吸引力不只是因為有甘美含糖的味道，也因為它的主料可可含有可可鹼和咖啡因等活性化合物[1]。這兩種化學物質可以促進多巴胺在人腦的釋放。多巴胺是一種“讓人感覺良好”的激素，也是一種神經遞質，在大腦的快感獎勵機制中起著關鍵作用，被視為是吸毒或賭博等成癮行為的罪魁禍首。

朱古力的毒性跟可可鹼和咖啡因的作用機制有關。可可鹼是咖啡因的主要代謝物，兩者的化學結構都與神經遞質腺苷非常類似。因此，它們可以和腺苷的受體結合，抑制其功能，阻止腺苷的作用。通常，腺苷能夠防止大腦積聚過多的多巴胺，讓人產生睡意。當腺苷的活性因競爭性抑制而減少，神經系統就會變得異常活躍，導致心跳加速和血壓增加。平常我們會覺得這是一件好事，因為可以提高警醒度。可是，太多這類化學物質卻會使人體過度緊張。任何過度疲累的學生，連喝3杯特濃咖啡後都可以作證。

由於狗隻的耐受性比人類低，朱古力對狗的影響更為明顯。對於人類來說，可可鹼的半數致死劑量（LD_{50}）是每公斤1000毫克[2]。LD_{50}是毒理學用語，意思是這個劑量的化學物質可以殺死一半受試動物。從理論上說，越重的人就可以承受越多的可可鹼。狗不僅比人類輕而小，咖啡因和可可鹼LD_{50}也只有每公斤100至300毫克[1, 2]。在每公斤20毫克的情況下，狗隻會表現出不同程度的輕微中毒症狀；在劑量達到每公斤40毫克時，更會呈現嚴重的中毒症狀。到底需要進食多少朱古力才會中毒，就要視乎朱古力類型和狗隻品種。一般來說，含有較多可可的產品就有更多的可可鹼和咖啡因 [3]。

狗誤食了朱古力後，會在6到12小時內呈現中毒跡象，包括：心率不正常、動作失控、經常口渴和尿頻、嘔吐、腹瀉、發抖、抽搐，其中心率異常或呼吸衰竭更大有可能會導致死亡。

其他寵物也會因朱古力中毒。貓的LD_{50}大約為每公斤200毫克[2]。可是貓主人不必如此擔心，因為貓比較挑食，也不刻意尋找甜食。

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SINGIN' IN THE BRAIN

腦中迴旋曲

By Thomas Lee 李浩賢

A catchy tune frequently leaves a lasting impression, sometimes appearing to run on perpetual auto-loop. Much to our frustration, it is almost as if the more effort contributed to eradicating the stubborn melody from our consciousness, the more determined it is to remain entrenched. Pesky music producers and advertisers are known to deliberately create repetitions in hit songs and catchy jingles to cling to the minds of consumers. The aim is clear: to burrow firmly into the brains of listeners. Believe it or not, this phenomenon has a name befitting its description – earworm – with its etymology stemming from the German word "Ohrwurm", or known more scientifically as an "involuntary musical image". Researchers were determined to dissect the 'parasite' in the Earworm Project in an effort to illuminate the mechanisms of the subconscious mind.

At London's Goldsmith's College, Dr. Victoria Williamson investigated this phenomenon by collecting thousands of earworm stories and experiences. She reports that earworms occur more frequently for individuals who play music on a regular basis or are more exposed to music. From a database of more than 2500 experiences, it was found that earworm tunes differed across the board, with only several songs named more than once, deeming it "a very individual phenomenon". However, a small number of songs were cited more often, especially when they were promoted in the mass media, suggesting somewhat intuitively that repetition and exposure to certain tunes are more likely to embed songs more deeply into the subconscious [1].

Western Washington University's music psychologist, Dr. Ira Hyman noted that earworms are likely to appear during low cognitive activities, not unlike mind wandering or daydreaming. Surprisingly, however, schoolwork was reported as an activity that triggered the return of intrusive songs, likely owing to songs having association with a particular class. Thus, earworms seem to appear more frequently at both ends of the cognitive load spectrum [2].

For those that are more easily irritated by these interfering repetitive tunes, psychologists propose a potentially successful method in reducing the "stickiness" of earworms. Based on a theory known as the Zeigarnik effect, they claim that individuals tend to experience intrusive thoughts about things they have started but have yet to finish. Thus, consciously playing out a song to completion may be able to curb the intrusive repetition brought about by earworms. Other psychologists suggest thinking about a different song could help to displace the original earworm.

While most people's earworms are generally innocuous, for some, a persisting earworm could be an indication of a more serious condition. One woman was convinced that she could 'hear' her earworms and that they were not limited to her consciousness. The condition was so severe that the playback of familiar songs kept her up at night. An MRI revealed a lesion in the white matter of her brain in an area known as the auditory association cortex, which governs hearing and memory of the brain, causing auditory hallucinations [3].

Some experts believe that this phenomenon of earworms is rooted in the way music arose in human societies [4]. Different rhymes and melody arrangements allow certain songs to be more memorable than others, and particularly easier to remember than just words themselves. With language invented only some 5000 years ago, anthropologists suggest that prior to this, information may have been communicated through tunes. Melodies which stuck around for longer in the subconscious would naturally possess an advantage. Further studies on earworms could elucidate the evolution of memory and perception.

容易上口的韻律多會留下深刻的印象，甚至有時在腦海中循環播放，不休不止，越是要擺脫，越是固執地存留在我們的意識中，令人沮喪。可惡的音樂製作人和廣告商更會刻意在流行曲和宣傳作品植入重複的旋律，目的明顯是要聽眾牢牢記住。這種現象有一個貼切的稱呼叫「耳蟲」，源自德語「Ohrwurm」；另一個比較學術的名稱是「非自主音樂意象」。研究人員通過解剖耳蟲，嘗試了解人腦的潛意識。

倫敦大學金史密斯學院的維多利亞·威廉姆森博士研究耳蟲現象，收集了數以千計的案例。她指出經常奏樂或接觸音樂的人，較常有耳蟲效應。團隊分析載有2,500多個案例的數據庫，發現耳蟲曲調因人而異，只有少數的樂曲出現多於一次，說明這是「非常個人的現象」。不過，確有一些歌曲被點名次數較多，尤其是當曲調在媒體熱播時；由此可見，某些調子經重複播放及接觸後，更有可能植入到更深層的潛意識[1]。

另一方面，西華盛頓大學的音樂心理學家，艾拉·海曼博士指出，耳蟲較有可能在大腦認知活動放緩時(例如：白日夢)出現；但是，亦有報告指出功課也可以觸動腦內不停播放歌曲，這可能是因為樂曲與該課堂有關。似乎，在大腦認知活動極高或極低時，耳蟲都會更頻繁地出現[2]。

心理學家提出驅趕耳蟲的方法，或可幫助那些對此效應感到厭煩的人。蔡加尼克效應指出，我們會特別在意那些已開始但未完成的事情。因此刻意讓腦中樂曲完整播出，或許可以遏止耳蟲重複侵擾。其他心理學家提議想像另一首歌曲，可以幫助取代原來的耳蟲。

耳蟲通常都是無害的，不過有些人長期經歷這效應，可能是有較嚴重的問題。有一位女士堅信自己能「聽」到樂曲，而且不單只是在意識層面上，情況嚴重以致她徹夜難眠。磁振造影檢查發現她大腦白質有損傷跡象，位置就在支配聽覺記憶的聽覺聯合皮層，所以產生幻聽 [3]。

有專家認為耳蟲這現象與人類社會音樂的起源有關[4]。不同的音韻旋律編排可以讓某些歌曲更深入記憶，也比純文字更令人難忘。語言的歷史大約只有5,000多年，人類學家認為在此之前資訊可能是通過歌曲傳達，可以停留在潛意識較長時間的樂曲自然會更有優勢。進一步的研究可能會揭示記憶和認知的進化歷程。

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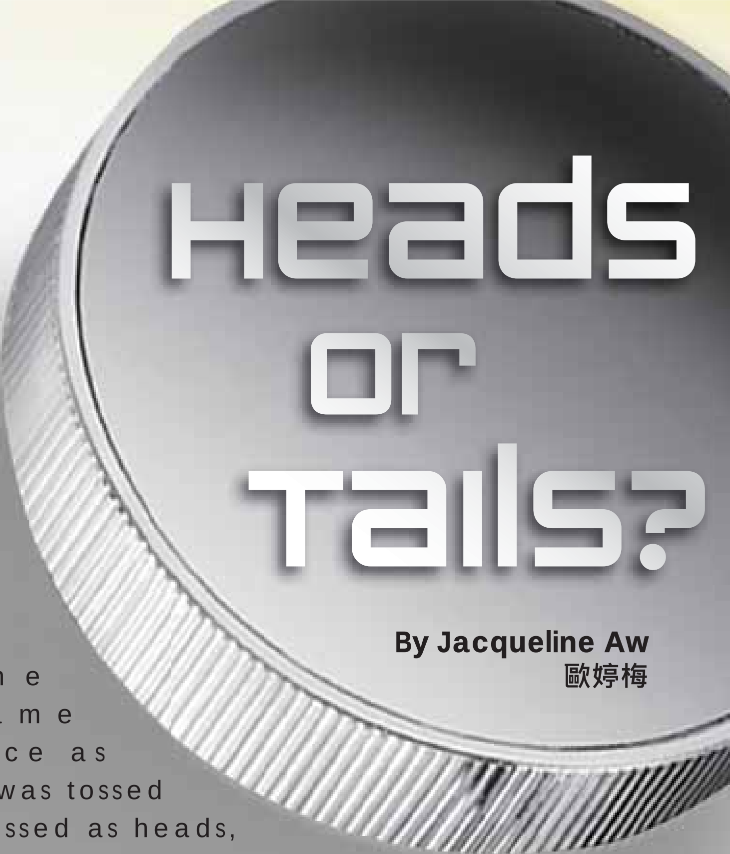

Heads or Tails?

By Jacqueline Aw
歐婷梅

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

根據數學科文憑試課程綱要，本文或可作為有用的補充讀物。

The first accounts of coin-flipping date all the way back to the Romans, where the chance outcome of either heads or tails was believed to be a manifestation of divine will. While nowhere near as serious, coin-flipping today is still considered as an unbiased way to reach a decision or settle a dispute. In certain sports, it is commonly used to decide which side each team plays on, or to select the winner in the case of a tie. But just how random is the coin flip? A former professional magician turned statistician, Persi Diaconis, was interested in exploring this question.

Diaconis and his colleagues carried out simple experiments which involved flipping a coin with a ribbon attached. By unwinding the ribbon from the flipped coin, the number of times the coin had rotated was determined. To eliminate undesirable variations in the coin toss, the initial conditions of the coin toss must be consistent. Thus, a coin-tossing machine was used, where the coin was placed on a spring which was released by a ratchet. Additionally, a high-speed slow motion camera was employed to capture 100 frames of 2D images for each coin toss. The 2D images enabled them to measure the orientation of the coin mid-flip with angled precision [1].

They found that when the initial conditions were the same, the coin flip would produce the same result, implying that the unpredictability of the coin toss is most likely caused by human inconsistencies. Additionally, when the coin is tossed by hand, there is a slight bias of a 51% chance that the coin lands on the same face as it was tossed (tossed as heads, results in heads). When a coin is spun on a surface, it is biased to land with its heavier side down [2]. With these biases in place, some magicians and gamblers are able to perform "controlled coin flips" - the coin is hit exactly in the centre so that its angular momentum vector lies perpendicular to the coin, causing it to go up without turning. As a result, the coin consistently lands on the face that it started with pre-toss. They may also use a coin with slightly shaved edges to manipulate the coin to always land on a certain face when spun [1].

In fact, even 'random' number generators in our computers are not entirely random. Steve Ward, a Computer Science and Engineering professor at MIT, states that by following rules and relying on algorithms, computers are specifically programmed to be deterministic, which means that they give the same answer to the same question every time [3]. The computer generators are known as pseudorandom number generators (PRNGs), which are algorithms that take in a seed number to generate a sequence of numbers that approximate random numbers. Therefore, the 'random' sequence can actually be reproduced if the seed value is known. Truly stochastic occurrences are physical phenomena such as radioactive decay or cosmic background radiation, which can be measured over short timescales.

However, several caveats were not taken into account in Diaconis et al.'s experiments. Human-generated coin flips are subject to variations including the height and speed of the toss, and the manner in which it is tossed and received. They concluded these limitations infer that the classical assumption that a coin flip has the statistical probability of ½ for landing on either side still holds true. Hence, in order to enhance fairness in a coin toss, one should be blind to the initial condition of the coin, by tossing it right out of the pocket or shaking the coin between cupped hands before tossing, for example. Moreover, the non-flipper should call the coin toss while the coin is in the air, so it is pointless if the flipper tries to flip in his favour.

擲幣結果非隨機？

擲硬幣的記載最早可以追溯到羅馬時代，當時相信結果可以彰顯神的旨意。今日不再那麼認真看待擲幣，但以這方法裁決或調停爭議，仍然被視為是最公正的。有不少運動以擲幣來決定隊伍的角色，或在和局的情況下選出勝方。可是，擲幣結果是否真正隨機呢？統計學家和前職業魔術師佩爾西·戴康尼斯對此非常感興趣。

戴康尼斯和他的同僚就此進行了一些簡單的實驗，例如在硬幣附上絲帶，擲出之後再鬆開纏著硬幣的絲帶，由此得出硬幣旋轉的圈數。為了確保每次擲幣的起始條件一致，沒有差異，研究人員設計了一部擲幣機，由棘輪帶動的彈簧擲出硬幣。另外，他們還動用了高速攝影機，為每一次擲幣拍攝了100幀二維圖像。通過分析這些圖像，他們可以準確計算硬幣在空中翻轉的方向和角度 [1]。

他們發現，在相同情況之下擲幣，結果其實不會變。這意味著擲幣的不可預測性很有可能是出自人為的不一致。此外，經人手擲出硬幣，結果會稍為偏向擲出的一面，概率達51%。也就是說，硬幣擲出時是頭像向上，結果頭像向上的機會也會稍高。如果在平面上旋轉硬幣，較重的一面朝下的機會較高 [2]。有些魔術師和賭徒便是利用這些偏差來控制擲幣結果。只要對準硬幣正中心用力，讓角動量向量垂直於硬幣，拋出的硬幣就不會旋轉，以同一面降落。他們也可以利用邊緣稍被磨製的硬幣來達到同樣的效果 [1]。

實際上，即使「隨機亂數產生器」也並非完全隨機。麻省理工學院計算機科學及工程教授史蒂夫·禾特指出，電腦遵循特定的規則和演算法，按確定性程式運作，對相同的問題只能提供同樣的答案 [3]。這些被稱為「偽隨機數生成器」(PRNGs) 的演算法，接收稱為種子的原始數字，然後產生一連串看似隨機的數字。只要知道原始數字，就可以複製出這串「隨機」數字。相對於此，自然界中反倒有不少真正隨機的現象，例如可在短時間內測量的放射性衰變和宇宙背景輻射。

不過，戴康尼斯團隊的實驗並未能考慮所有因素。人手拋擲硬幣可以有多方面的變化，包括：高度、投擲速度和拋接方式。因此他們認為傳統的假設依然成立：擲幣得正反面的統計概率各有一半。如果希望有公平公正的結果，擲幣一方就不要在事前知道硬幣的正反面，直接從口袋裡拋出；或者拋出之前，先以雙手覆蓋並加以搖晃。另一方也可以在硬幣拋出後才作出選擇，擲硬幣者就無從按自身利益操縱結果。

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Fingerprints: Your Biological QR Code

Winning article of the ***Science Focus*** Article Submission Competition.
「科言」徵文比賽得獎文章。

Each person is unique, evidenced by the very tips of our fingers. Scientifically known as epidermal or papillary ridges, fingerprints are distinct to every individual. Even identical twins have different fingerprints! Thus, fingerprint identification is one of the most fundamental methods of forensic science, and is recognised as such - - references to it can be ubiquitously found in television shows and films. But let's not take the science behind this valuable technique for granted. How does fingerprinting actually work?

Forensic scientists classify fingerprints into three categories based on the surface upon which it was left: plastic, patent and latent. Plastic prints are those of which are left on soft surfaces such as wax and wet paint, and are often three-dimensional. Patent prints are clearly visible prints left on non-porous surfaces, due to the transfer of blood, dirt, ink or paint from the fingertips to the surface. Latent prints are the most subtle of prints, formed due to the deposit of oily residue known as sebum, which reside on the fingertips. Barely visible to the naked eye, they can be found on both porous and non-porous surfaces.

The former two can be easily documented by photography, but latent prints are more difficult to obtain. The use of specialised tools is necessary to increase the print's visibility. Dusting for prints with special fingerprint powder is universally recognised, but there are two other lesser known methods by which latent fingerprints are captured.

In the United States, the Reflected Ultraviolet Imaging System (RUVIS) is one such tool commonly used by law enforcement agencies. RUVIS operation occurs in two stages: first, a portable shortwave ultraviolet (UV) light is shone onto the non-porous surface, which will either reflect

每個人都是獨一無二的，證據就你的指尖上。指紋的學術名稱是乳突線紋，因人而異，即使是同卵雙胞胎的指紋也是不同的！因此，指紋識別是法證科學必用的方法之一，在電視劇與電影中也會經常出現相關情節。但是，指紋是如何收集鑑定的呢？且讓我們看看指尖背後的科學。

法證學家將指紋分為三種：成型紋、明顯紋和潛伏紋。成型紋是留在軟性材料表面，例如蠟和未乾油漆上的指紋，往往保留著三維特徵。明顯紋是清晰印在無孔表面的指紋，通常是由沾上血液、污物、油墨或油漆的指尖留下。潛伏紋是最隱晦的指紋，由殘存的指尖皮脂所形成，可以在多孔或無孔的表面找到，很難用肉眼看見。

成型與明顯指紋很容易被拍照留存，搜集潛伏指紋卻沒那麼容易，必須使用專門的工具增加指紋的可見度。除了眾所周知的特製指紋粉，其實還有兩個方法可以套取潛伏指紋。

美國執法機構通常使用反射式紫外線影像系統（RUVIS）。RUVIS內置特殊設計的鏡片，可讓紫外線穿透並阻隔其它波長的光線，增強指紋影像的清晰度。在具體操作時，先以便攜式短波紫外線燈照射無孔表面，光線會被反射或吸收，法證專家再以手提RUVIS裝置捕捉指紋影像。

化學顯影劑茚三酮也可用於收集指紋。除了皮脂，指紋分泌物一

or absorb UV light. Then, forensic scientists use the handheld RUVIS device that has a specially designed lens installed within that both bypasses UV light and blocks light of any other wavelength, enhancing the imaging of the print.

Alternatively, chemical developers such as, ninhydrin, can be used to make the print more visible for analysis. Typically, sebum is not the only residue left behind by fingertips. Sweat, which contains amino acids and inorganic salts, is commonly present in the print mixture. The latent print left on a porous surface can be treated with ninhydrin to react with the amino acids and inorganic salts, which turns purple in colour. This reaction can be catalysed with the use of a simple household iron!

In Hong Kong, fingerprints are securely stored in a government database in order to assist with forensic identification. Computer programmes are specifically designed to cross-reference print samples for a match. However, print identification is not without its limits, and there have been numerous cases of mistaken matches due to incomplete print samples. Developers constantly strive to find a balance between precision, which carries the risk of not yielding a result, and generalisation, resulting in too many results.

Such databases might be on their way out, however, as a forensic science company known as ArroGen Group has purportedly developed a revolutionary fingerprinting process called Finger Molecular Identification (FMI) that analyses the chemical composition of prints and allows for the determination of the biological characteristics of the print's owner — revealing the gender, age and whether the perpetrator is a smoker.

Watch out for where you leave your prints!

指紋：與生俱來的二維碼

By Christopher Cheng 程鵬
Chinese International School, 漢基國際學校

般還帶有汗水，其中含有氨基酸和無機鹽，可與茚三酮起化學反應。留在多孔表面的潛伏指紋經茚三酮處理後，就會變成紫色。這化學反應可以家用熨斗來催化！

香港政府設有安全的指紋數據庫來配合法證鑑定。雖然有專門設計的電腦程式交叉比對指紋樣本，但識別指紋還是有很多限制，亦有因指紋樣本不完整而造成錯配。專家努力追求平衡：既不會過於精準以致一無所獲，也不會因太籠統而出現太多的結果。

不過，可能不再需要這樣的數據庫了。據報道，ArroGen Group法證公司已經開發出一種稱為手指分子鑒定 (FMI) 的指紋識別方法，這種革命性技術可以分析指紋的化學成分，並能確定指紋主人的生物學特性，例如性別、年齡及是否吸煙等。

注意你在哪裡留下了指紋！

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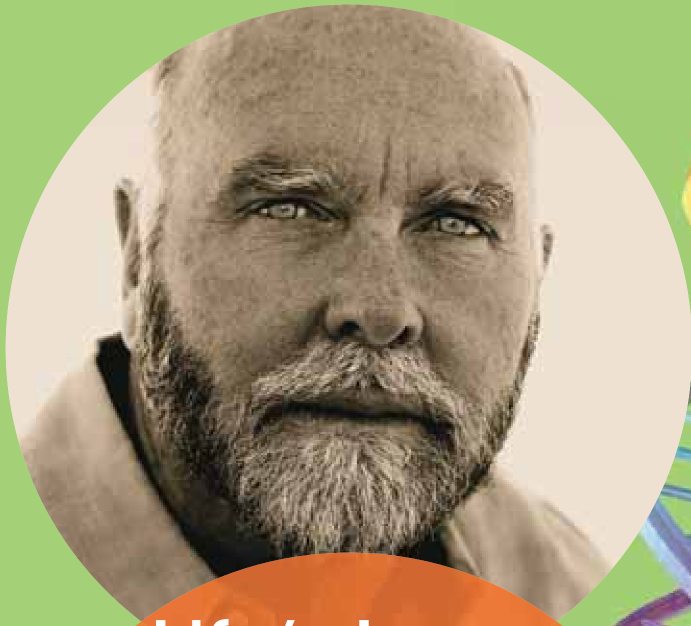
Launched
Human Genome Project
in 2008



Life's Lego Blocks with DR. J. CRAIG VENTER 生物積木──克萊格·凡特博士

By Andy Cheung 張文康

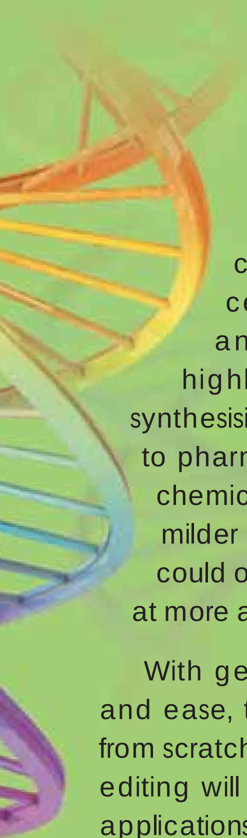
Observing biological organisms under a microscope reveals a realm of organisation obscured to the naked eye. Regardless of the size of the organism, its genetic makeup at the fundamental level is composed of four nucleotide bases of DNA – adenine, guanine, thymine and cytosine – the biological blueprint to all things living. How small can life actually be? Dr. J. Craig Venter, biochemist, geneticist, entrepreneur and most notably pioneer to the Human Genome Project, and his team attempt to answer this question.

Geneticists typically measure the complexity of organisms by estimating the number of genes in a genome and how the genes are arranged, instead of their physical size. Referring to the collective noun for all the genetic material of an organism, the genome contains genes that code for instructions to a particular step of life function. Living organisms appear, behave and operate differently owing to genes. To put things in perspective, a fruit fly consists of about 13,600 genes and a human is estimated to possess between 20,000 and 25,000 genes.

In an innovative procedure known as gene designing, Dr. Venter and his research team deal with synthesising a genome with only a minimal set of genes required for the most basic of life forms. By using synthetic biological techniques, they sorted and removed redundant or non-essential genes, beginning from *Mycoplasma mycoides* (a type of bacteria) which consists of 525 genes. As a result, they successfully created JCV-syn3.0, composed of only 473 genes. In doing so, they were able to identify the essential genes that can sustain life. The tricky part is that gene functions are complex and subtle. Tiny modifications could drastically change cell functions and deem a cell unviable. In addition, the monumental task of sorting out redundant genes for the same essential function is compounded by the fact that some genes must cooperate with others to be effective.

"We had to be careful to keep at least one gene for each essential function".

Yet, even with JCV-syn3.0, there are 149 genes for which Dr. Venter and his team have yet to precisely define a function for.



The research on synthetic genes could divulge insight on the principles of cell design. Cells that perform delicate and specifically designated tasks are highly coveted for pharmaceuticals and synthesising complex chemicals. In comparison to pharmaceuticals synthesised in the traditional chemical route, biological synthesis operates at a milder condition and is often more selective. This could open an avenue to a wider variety of drugs at more affordable prices.

With gene editing gaining increasing traction and ease, the question of whether building genes from scratch is worth it begs to be asked. While gene-editing will most likely remain as the technique for applications involving genetic alterations (for example in drug synthesis), gene synthesis opens doors to understanding the genome at a more fundamental level.

As one of the primary forces behind the Human Genome Project, Dr. Venter and his firm Celera Genomics pioneered a strategy for sequencing the human genome in just three years, revealing a wealth of information and illuminating gene sequences associated with numerous diseases such as breast cancer.

顯微鏡揭露了單憑肉眼無法看到的生物體系。然而從根本而言，凡是有生命的生物，不論大小，基因都是由DNA的四種核苷酸鹼基–腺嘌呤、鳥嘌呤、胸腺嘧啶和胞嘧啶–組成，構成生物的藍圖。生物體到底能有多小？克萊格·凡特博士和他的團隊試圖回答這個問題。他是一位生物化學家、遺傳學家、企業家，也是最受矚目的人類基因組計劃開拓者。

遺傳學家衡量生物體的複雜性時，一般是考慮基因組中基因的數量和排列，而不是生物體的大小。基因組是指生物體的全部遺傳物質，其中包括藏有生物機能運作指令編碼的基因。生物體在外觀、行為和機能上的不同，都可以歸因於基因的差別。果蠅約有13,600個基因，人類基因的數目則介乎20,000至25,000之間。

凡特博士的團隊利用創新工序「基因設計」，合成載有生命所需最少基因量的基因組。他們從擁有525個基因的絲狀支原體細菌入手，以合成生物技術分類及排除多餘或非必要的基因，成功創造了只有473個基因的JCV-syn3.0，並且辨識了維持生命所必需的基因。最讓人費心的是基因的功能複雜而微妙，即使是微小的修改也有可能會大大改變細胞的功能，以致細胞不能存活。此外，要分辨那些是功能重複的冗餘基因可不容易，再加上有些基因需要相互合作才能發揮作用，更添難度。

「我們要小心為每項基本功能保留至少一個基因。」

即使小如JCV-syn3.0，也有149個基因的功能未被確定。

14TH The World's 50 Most Influential Figures 2010

有關合成基因的研究或可有助揭示細胞設計的原理。目前亟盼得到的是能夠執行精細特定任務的細胞，可用於製藥和合成複雜的化學物質。相對於傳統的化學方法，操作生物合成所需的條件較溫和，而且藥物的選擇性較強。這方面的研究可望開拓製藥新途徑，提供種類繁多而且價格合理的藥物。

基因編輯技術漸趨普及和簡易，我們不禁要問：是否還值得從頭構建基因？若純然是為了改變基因以配合藥物合成等目的，基因編輯技術很有可能是最適合；不過，基因合成卻可以讓我們對基因組有更根本的理解。

凡特博士和他創辦的塞雷拉基因組公司是人類基因組計劃中的主力，以新策略在短短三年完成人類基因組的定序，取得豐富資訊，還指出許多可能與疾病(如：乳腺癌)相關的基因序列。

Test Yourself 測一測

1. What is it called when a solid changes directly into a gas?
   當固體直接變成氣體，這個過程叫：
   - a. Sublimation 昇華
   - b. Evaporation 蒸發
   - c. Condensation 凝結
   - d. Dissolution 溶解

2. If there is a 1.5V battery and a bulb on a simple series circuit, and the battery is changed to a 3V, what happens to the bulb?
   一枚1.5 V電池和一盞燈泡以串聯的方式連接。若電池的電壓增加到3 V，燈泡將會：
   - a. It gets dimmer 變暗
   - b. It gets brighter 變亮
   - c. It remains unchanged 持續不變
   - d. It gets overheated 過熱

3. In addition to sunlight, what else is required for photosynthesis to take place?
   除了陽光，還需要甚麼才可以進行光合作用？
   - a. Sugar and water 糖和水
   - b. Water and oxygen 水和氧氣
   - c. Carbon dioxide and water 二氧化碳和水
   - d. Oxygen and carbon dioxide 氧氣和二氧化碳

4. Which component of the cell is responsible for making proteins?
   以下哪一種細胞器負責製造蛋白質？
   - a. Lysosomes 溶酶體
   - b. Ribosomes 核糖體
   - c. Mitochondria 線粒體
   - d. Golgi apparatus 高爾基體

5. Nuclear power is generated using which of the following elements?
   下列哪種元素可用來生產核電？
   - a. Uranium 鈾
   - b. Hydrogen 氫
   - c. Carbon 碳
   - d. Germanium 鍺

6. Alkali metals have how many valence electrons?
   鹼金屬有多少個價電子?
   - a. 4
   - b. 3
   - c. 2
   - d. 1

Answers 答案 : a, b, c, b, a, d

For detailed answers and explanations, please visit our website.
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