SCIENCE FOCUS 科言

Issue 005, 2015

The History of Nitrogen
氮的歷史

Will We Ever Run Out of Music?
音樂的限量

Interviews with Stanford University's Prof. Thomas A. Rando and UCSF's Prof. Donna M. Ferriero
斯坦福大學托馬斯·蘭度教授及 UCSF 唐娜·費列羅教授 專訪

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

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Acknowledgements 特別致謝

Message from the Editor-in-Chief 主編話語

Dear Readers,

I hope you are all enjoying the beginning of your well-deserved summer break, equipped with a copy of Science Focus' latest magazine of course! We have plenty of reading material in stock for your perusal in this issue – whether you are interested in finding information on Canadian university applications or would like to investigate where nitrogen is from – we've got you covered.

I would also like to take this opportunity to invite readers to send in their ideas and articles to Science Focus. Beginning in August, we will publish well-written articles that are sent in by secondary school students and our own HKUST students in the newly featured web blog section found on the Science Focus website. Express your interests and build your CV at the same time. It's never too early to start!

Enjoy your Science Focus!

Yours Sincerely,

Prof. Yung Hou Wong
Editor-in-Chief

親愛的讀者：

暑假開始了，經過一學年的努力，希望你們正在享受應得的假期，可別忘了新一期 的「科言」！我們為你準備了豐富的閱讀材料。無論你是有興趣知道留學加拿大 的資訊，還是氮氣的來源，都可以在本期找到答案。

我也想趁此機會邀請你們分享意見和投稿「科言」。從八月開始，「科言」網站的 最新博客平台將會發表由中學同學提供的優秀文章，以及科大同學的 作品。你們 可以藉此抒發興趣，同時讓個人簡歷更豐富。不要遲疑，趕緊發來吧！

祝你閱讀愉快！

主編 王殷厚教授
敬上

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Homepage: **http://sciencefocus.ust.hk**
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WHAT'S HAPPENING IN HONG KONG?

香港科技活動

By Wai Lam Raphaella So 蘇韋霖

Summer is just around the corner! Don't worry if you have not made travel plans yet, because there are just as many exciting events here in Hong Kong!

Gei Wai Harvesting

Gei wai harvesting is a shrimp culturing technique brought to Hong Kong in the 1940's. On July 19, you can explore this important coastal heritage for yourself by participating in World Wide Fund's tour! This tour includes a gei wai harvesting experience, an introduction to gei wai culture, a visit to the Gei Wai Museum, and more! Tickets go for $350 for the general public, and $290 for WWF Hong Kong members, the elderly (aged 65 or above), and full-time students (aged 18 or below). For more information and booking details, please visit *http://online.wwf.org.hk/booking/en/info.html?type=PT&st=Public#4*.

Junior Science Institute

The Junior Science Institute is a year-round programme offered to Form 4 to Form 6 students by the University of Hong Kong. Students will be able to learn about different science disciplines through hands-on workshops, laboratory classes, and other interactive activities. The following table shows the three programme periods and their respective application dates. The application period for the first semester of the upcoming school year is in September. The workshops are offered free of charge, but there is a commitment fee of $200 that will be refunded upon successful completion. For more details, please visit *http://www.scifac.hku.hk/community/scienriprog/about*. You can also visit their Facebook page for programme updates: *https://www.facebook.com/jsi.hku*.

Semester	Application Period
First Semester	September 2015
Second Semester	December 2015 – January 2016
Summer Semester	May 2016

Hong Kong Museum of Medical Sciences

Interested in learning more about the medical history of Hong Kong? Make a visit to the Old Pathological Institute. This 1906 building was originally designed to be a bacteriology laboratory, and has been declared as a historical monument in Hong Kong. Since 1996, it has been home to the Hong Kong Museum of Medical Sciences. Students can gain an appreciation of Hong Kong's rich heritage in traditional Chinese medicine as well as the history of western scientific medicine through visiting the museum. For more information on current exhibitions, please visit *http://info.hkmms.org.hk/en/home/*.

暑假快到了！如果同學們還未有安排旅行，不用擔心，香港一樣有很多有趣的活動等著大家參加！

基圍濕地時光之旅

香港早在40年代已引入基圍養蝦的方法。從7月19日起，你可以透過參加世界自然基金會舉辦的導賞團，認識這重要的沿岸傳統！行程包括參與收蝦過程、認識基圍文化、參觀基圍博物館等。公眾人士的團費為$350，會員、65歲或以上的長者和18歲或以下的全日制學生可享優惠價$290。欲了解更多詳情及預約，請瀏覽：*http://online.wwf.org.hk/booking/tc/info.html?type=PT&st=Public#4*

少年科學研習學院(JSI)

JSI是香港大學為中四至中六的學生而設的科學體驗計劃。學生可以透過工作坊、實驗課、和其他互動活動學習不同範疇的科學知識。有關新學年的報名時間可見於下表，九月份開始接受報名。一切活動免費，但申請人需交$200定金，完成後退還。若想了解更多詳情，請瀏覽：*http://www.scifac.hku.hk/community/scienriprog/about*。

同學亦可透過JSI的臉書專頁得知最新消息：*https://www.facebook.com/jsi.hku*。

學期	報名時間
第一學期	2015年9月
第二學期	2015年12月至2016年1月
暑期課程	2016年5月

香港醫學博物館

如果你對香港醫學歷史有興趣，就應該到以往的「病理檢驗所」看看。這棟大樓於1906年啓用，原是作為細菌學實驗室，現在是法定古蹟，自1996年起成為香港醫學博物館的館址。同學在此可以欣賞到香港豐富的醫學傳承，包括傳統中醫及西方醫學。展覽詳情可參考香港科學博物館網站：*http://info.hkmms.org.hk/zh/home-zh/*。

申請大學指南：加拿大

By Marco Wong 黃俊銘

As of 2014, Canada is ranked seventh in the world in most popular destinations for international students, making up 8% of Canada's post-secondary school student population. The University of Toronto, McGill University and University of British Columbia were among the top 50 universities in the world, as of QS University ranking 2014.

University System

Undergraduate degrees in Canada typically require 3 to 4 years to complete. A majority of the universities run on a bi-semester schedule, from September to April with summer courses offered from May to August. Others run on a full tri-semester system, where semesters begin in September, January and May.

Application Requirements for International Students

Admission requirements vary between institutions. Admissions are primarily determined by a review of previous academic records. Canadian institutions accept HKDSE/GCE A Level or IB Diploma Programme for prospective students from Hong Kong. Depending on the prospective programme and institution, applicants must also demonstrate their proficiency in either English or French. Applicants who do not have an English background are required to take the Test of English as Foreign Language (TOEFL), the International English Language Testing System (IELTS), or the French equivalent tests. Table 1 shows the general requirements for admission.

Requirements differ between institutions. Applicants should confirm the test scores required from their institutions of choice.

在2014，加拿大被選為第七位最受國際學生歡迎的升學地點，國際學生佔當地大專生人數8%。同年，多倫多大學、麥吉爾大學和英屬哥倫比亞大學均躋身在QS世界大學排名榜前50名。

大學系統

本科學位課程一般須要3至4年完成。大部分院校採用雙學期系統，九月至四月為一學年，另於五月至八月提供暑期課程。其餘院校行三學期制，每年九月、一月和五月開始新學期。

國際學生申請要求

每所大學有不同的招生要求。錄取條件主要是基於之前的學術成績。加拿大院校接受香港學生以中學文憑(DSE)、GCE、A Level或IB文憑為成績參考。視乎課程及院校，申請者還須要提供英語或法語水平證明。沒有英語或法語背景的同學須要報考TOEFL、IELTS或相等的法語考試。表1列明這方面的入學要求。

Test 考試	Minimum acceptable scores 最低申請分數
TOEFL	600 (paper-based 筆試), or 或 80 (computer-based 電腦卷)
TFI (for French required university, especially in Quebec 對法語有要求的大學，特別是位於魁北克省內)	785 or above for 或以上
IELTS	6.5 for most, 7 for some 多數院校要求6.5，部分要求7

Table I 表1

Institution 院校	Application Deadline 申請限期	Estimated tuition for Bachelor of Science (per academic year in HKD) 理學學位課程學費預計 (每學年港幣)
University of Toronto 多倫多大學	Between start of January to March depending on programme 一月初至三月，視乎課程	$70,000 to 250,000
McGill University 麥吉爾大學	Between mid-January to mid-April depending on programme 一月中至四月中，視乎課程	$217,560
The University of British Columbia 英屬哥倫比亞大學	Opens late August and ends January 31st of the next year 八月下旬開始至1月3日截止	$205,614
University of Waterloo 滑鐵盧大學	Last day for general applications: March 31st, visit *https://uwaterloo.ca/find-out-more/admissions/applying-waterloo/deadlines* for a list of exceptions 一般截止日期：3月31號，瀏覽以上網站查看例外課程截止。	$130,875

Table 2 表2

Application Procedure

The application procedure for each Canadian institution differs and no centralised system exists. It means that the requirements as well as the procedure may vary depending on the institution of choice.

Deadlines and Tuition

Universities encourage students to apply as early as possible, typically nine to twelve months prior to commencement.

Tuition for international school students are generally 2 to 4 times higher compared to that of local Canadian students. Fees vary by the popularity and ranking of the programmes, ranging from around CAD 8,000 (HK$50,000) to CAD 36,000 (HK$220,000) per year, or an average of CAD 15,000 (HK$92,000) per year.

In addition, accommodation and food can cost up to CAD 7,000 to CAD 13,000 (HK$43,000 to HK$80,000) per year, with books and insurance adding significantly to that cost. Table 2 shows the deadlines and tuition fees for several top ranked universities in Canada.

Immigration Requirements

Prospective students from Hong Kong must apply for a student visa to study in Canada. In addition, students admitted for programmes longer than 6 months require a study permit. Please visit the Visa Application Centre for the necessary information or the website of Citizenship and Immigration Canada: *www.cic.gc.ca/english/study/*

各院校有不同的要求，申請人應向有關院校確認考試成績要求。

申請程式

加拿大各院校的申請程序不一，沒有系統集中處理，錄取條件亦各有差異。申請者應申請多間院校或課程。

截止日期與學費

大學鼓勵學生儘早申請，通常在開學前九至十二個月就進行。

國際學生學費一般比加拿大公民高出2至4倍。學費與課程受歡迎程度和排名有關，大約在CAD 8,000 (HK$50,000) 到CAD 36,000 (HK$220,000) 之間，平均每年學費為CAD 15,000 (HK$92,000)。

此外，住宿及食物每年約花費CAD 7,000到CAD 13,000 (HK$43,000 到 HK$80,000)，書本及保險方面亦有一定開支。表2列明加拿大頂級學府的申請限期及學費。

入境規定

錄取的香港學生必須申請學生簽證才能在加拿大讀書。此外，修讀超過6個月課程的學生須要先取得學習許可。申請人可聯絡加拿大簽證申請中心或加拿大公民及移民網站以索取更多資料：*www.cic.gc.ca/english/study/*

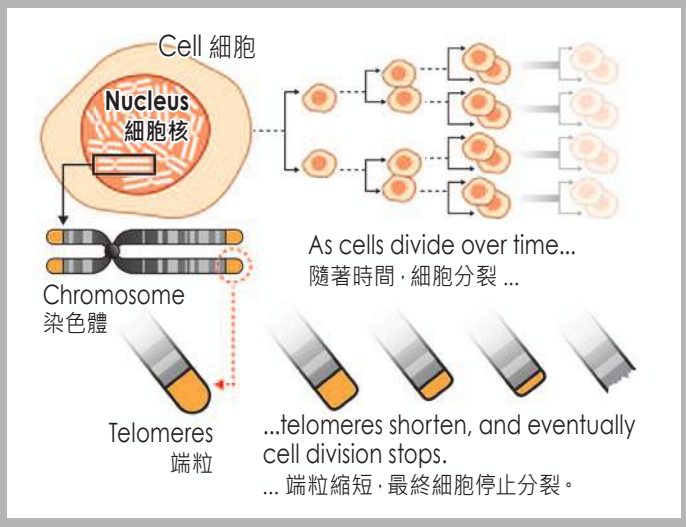
The Intricacies of AGING

複雜的衰老機理

By Wing In Chau 鄒穎妍

The fountain of youth is a quest that has transcended time and cultures. Applying modern technology to this mission has multiplied the types of products available on the market claiming to reverse aging. In the next few years, the global anti-aging industry is expected to grow into a US$346 billion market [1]. Most products at the consumer level target the symptoms or appearance of aging, but researchers may have made significant discoveries toward understanding the root of aging.

To tackle aging, it is important to understand what aging is. Biological functions rely on a cycle of cell division and cell death. This process, however, is finite and cells cannot divide forever. Every division involves cellular timekeepers, known as telomeres, located at the end of chromosomes. After numerous cell divisions, telomeres become shorter and eventually reach their minimum length, where cells will no longer be able to divide and lose its original function. These dysfunctional cells can contribute to the process of aging in a negative way. In 2014, scientists Timothy M. Tucey and Victoria Lundblad published a study of a cellular on-and-off "switch" that controls the mechanism of telomere shortening [2]. The mechanism involves an enzyme known as telomerase, which bears the ability to reconstruct telomeres. They discovered that telomerase could be switched on and off, which could prolong the telomere shortening process and achieve continuous tissue regeneration [2]. Harnessing this technology has the potential to regenerate vital organs in old age, and lead to the development of treatments for aging related diseases.



Current anti-aging 'remedies' can be divided into two main categories – *in-vivo* supplement and appearance restorers. The former is carried out by hormone replacement therapy, claiming to increase one's metabolic rate. However, no official investigations have thus far been able to support the claim that hormonal replacement therapy can extend one's lifespan or prevent age-related frailty [3]. On the contrary, certain studies have reported that this type of therapy may cause harmful side effects, such as increased risk of breast cancer, cardiovascular diseases, and stroke [4]. On the

other hand, appearance restorers mainly consist of cosmetic treatments or skin care products, dealing with the cosmetic aging and requiring repeated treatments to maintain temporary effects. According to Consumer Reports, the best performing cream only brought about a 10% reduction in the depths of wrinkles, suggesting that these types of products are extremely limited in their effectiveness [5].

Much work still needs to be done to make significant contributions to reverse aging. Prof. Thomas A. Rando pointed out that models used to investigate aging, such as laboratory mice, may not reflect the same results in complex animals (read his interview on Page 22). In fact, the more complex the biological organism, the less likely age reversal would work. Studies like this, however undoubtedly take a step in the right direction.

At the Biotechnology Research Institute of HKUST, which was established through a generous donation from The Hong Kong Jockey Club, researchers had successfully identified a telomerase activator TAT-2 from traditional Chinese medicines. The activator has been re-named as TA-65 and is now being used in a health maintenance programme by a US company.

由香港賽馬會捐助而成立的科技大學生物技術研究所，其研究人員從傳統中藥提取物中首次發現了端粒酶激活劑TAT-2。這活化劑目前被改名為TA-65，正由一間美國公司用於健康維保計劃。

不論古今中外，人們都在尋找青春之泉。隨著現代科技進步，市場上自稱能夠逆轉衰老的產品種類更是不斷倍增。預期未來數年，全球抗衰老產業將會成為一個規模達US$ 3,460億的市場[1]。大部分消費者產品都是針對衰老的徵狀或外觀變化，但科學家可能已有重大發現，了解衰老過程的原理。

在對抗衰老之前，必須先了解何謂老化。生物功能其實是繫於細胞分裂週期。然而，這個週期是有盡頭的，細胞不能永遠分裂。位於染色體末端的端粒(telomeres)，是一個細胞計時器，在每次細胞分裂後便會縮短。最終，當端粒到達其長度下限時，細胞不能再分裂，就會失去原有的功能，隨之而來的是衰退和老化。在2014年，科學家Timothy M. Tucey和Victoria Lundblad發表了一項研究，是關於控制端粒縮短機制的細胞「開關」[2]。該機制所涉及的端粒酶(telomerase)，擁有重建端粒的能力。他們發現端粒酶可以開啟和關閉，能夠延緩端粒的縮短過程，實現持續的組織再生[2]。利用這種技術，便有可能讓老年人的重要器官再生，與及發展針對老化相關疾病的新療法。

目前抗衰老「療法」可分為兩大類 — 分別為體內補充和外觀修復。前者是指聲稱可以加速代謝率的激素替代療法。然而，迄今沒有任何正式研究，證明激素替代療法可以延長壽命或預防老化所致的虛弱[3]。相反，某些研究指出，這類治療可能會引起有害的副作用，例如：增加罹患乳腺癌、心血管疾病和中風的風險[4]。另一方面，外觀修復法主要是指整形外科手術或護膚產品，處理外貌的老化，須要重複療程方能維持暫時性的效果。根據消費者報告(Consumer Reports)，最有效的面霜僅僅令皺紋深度減少10%，顯示這類產品的功效極為有限[5]。

要成功逆轉衰老，路途仍很遙遠。托馬斯．蘭度教授就指出，通過小鼠等模型所得出的老化研究結果，未必可以反映較為複雜的動物的反應（請參閱第22頁的專訪）。實際上，越是複雜的生物體，就越難逆轉老齡過程。不過，這類研究無疑是朝著正確方向邁出了一步。

References

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[4] U.S. Women's Health Initiative (2010). *Women's Health Initiative Clinical Trial and Observational Study.* Retrieved from *http://www.ncbi.nlm.nih.gov/projects/gap/cgi-bin/study.cgi?study_id=phs000200.v1.p1*

[5] Consumer Reports Tests Wrinkle Creams for the First Time (2007). *Consumer Reports*. Retrieved from *http://www.suncitydermatology.com/wp-content/themes/thesis_185/custom/consume-reports-creams.pdf*

THE HISTORY OF

Making up 78% of the atmosphere, nitrogen is the most abundant gas on Earth. It was first isolated in 1772 by a Scottish physician, Daniel Rutherford, and is an essential substance that allows the possibility of life. Yet, most of Earth's higher organisms are unable to directly utilise atmospheric nitrogen and instead, obtain it from food in the form of nitric compounds. In a process known as nitrogen fixation, diazatrophs (nitrogen fixing bacteria) are able to convert nitrogen gas into ammonia, nitrite and nitrate. The existence of these microbes casts doubt on the necessity of the enormous amount of nitrogen present in air. The fact that it occupies such a huge fraction of the gases present in the atmosphere calls its origin into question.

A previous school of thought suggested that nitrogen could have been deposited by comets, since ammonia (NH3) is an abundant compound in these interstellar rocks. One method to trace the origin of an element is to examine its isotopic signature or isotopic composition and whether it matches its hypothesised origin. For example, the most abundant nitrogen isotope is ^{14}N with 7 neutrons, at 99.6% in the atmosphere. However, ^{15}N also exists as a stable isotope, with 8 neutrons. The isotopic signature would be the ratio between the stable isotopes. In a research

Artist's Impression of a Baby Star Still Surrounded by a Protoplanetary Disc
image credits: ESO/L. Calçada

NITROGEN

氮的歷史

By Thomas Lee 李浩賢

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。

which bewildered scientists, it was found that the isotopic signature of terrestrial nitrogen and that of solar wind did not match, indicating that comets are unlikely to be the source of our planet's nitrogen [1].

The mystery was not dug up again until recently. Dennis Harries and his team at the Friedrich-Schiller University Jena, Germany, uncovered a clue within a natural time capsule. Their research studied two ancient meteorites, recovered in 1979 in Antarctica, and found that a type of nitride crystal called carlsbergite was encapsulated within. It was also found that the isotopic signature of one crystal in particular, had a close value to that of terrestrial nitrogen [2]. What this suggests is that the formation of nitrogen on Earth and that of the meteorite may share a common origin – the protoplanetary disc, or the rotating disc of dense gas around a newly formed star [3].

The nitrogen in carlsbergite is mysterious in itself. Nitrogen is rarely found in crystals, and is more typically found as a gas. The team posits that the formation of carlsbergite involved thin gas surrounding "freely floating dust grains covered by ice with the presence of ammonia" [3] that was interrupted by a large body, which created a gigantic shock wave. The energy from this occurrence raised the temperature

氮氣佔大氣層78%，是地球最豐富的氣體。1772年，蘇格蘭醫師丹尼爾·盧瑟福首次分離氮氣。氮是生存不可缺少的物質，然而地球的高等生物，多數不能直接利用大氣中的氮，而是從食物中的硝酸化合物攝取氮元素。固氮菌可以透過固氮作用將氮氣轉化成氨氮、亞硝酸鹽和硝酸鹽。這些微生物的存在，讓人思考空氣中是否必然要有大量的氮氣。氮在大氣中佔有如此分量，這一事實亦引發了對其起源的探討。

曾經有學說認為氮可能是彗星留下來的，因為這些星際天體含有大量的氨（NH_3）。研究員分析同位素的訊號或同位素組合，再與假設的源頭對比，就可以追溯元素的來歷。例如，在大氣中，有7粒中子的^{14}N是最豐富的氮同位素，含量達到99.6%；然而，具有8粒中子的^{15}N，也是一個穩定的氮同位素。同位素訊號就是這兩個穩定同位素的比率。研究結果讓科學家感到困惑，他們發現地球及太陽風的氮同位素訊號並不相同，說明彗星不太可能是我們這個星球氮元素的來源[1]。

近年，再有科學家嘗試破解謎團。德國耶拿市弗裡德里希·席勒大學的丹尼斯·哈裡斯和他的團隊從天然的時間囊發現線索。他們分析在1979年從南極洲發掘的兩顆古老隕石，發現隕石包含一種氮化物晶體，稱為氮鉻礦。哈裡斯的研究指出其中一顆晶體中

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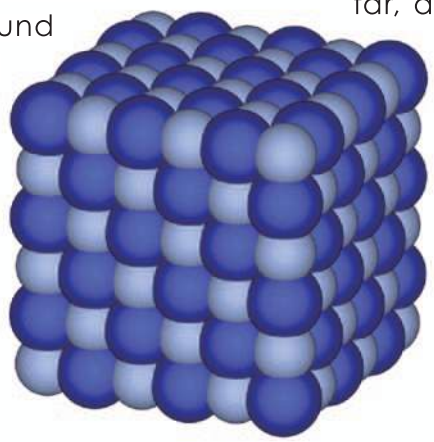
of the gas, and melted the ice shells to form carlsbergite.

A similar process may have occurred for the formation of the Earth. 4.6 billion years ago, an astronomically large nebula (a cloud of dust and ice), may have collapsed due to turbulence, which heated up the centre, increased the spin and condensed the dust and gas into the protoplanetary disc [2]. Harries and his team propose that the primordial ice (prehistoric ice) may have been dragged to the inner portions of the Solar System in the protoplanetary phase, during which ammonia was evaporated and bombarded by small bodies, forming carlsbergite-containing bodies. As our planet is located in the inner Solar System, it is possible that the primordial ice may have accumulated on Earth during its formation [4]. NASA's Dawn spacecraft recently entered the orbit around the dwarf planet Ceres, which is located within the asteroid belt. The team is expecting to collect samples on asteroids for further matching of nitrogen's isotopic signature to provide more support to these theories, among other projects.

While the origin of nitrogen remains a mystery, we can attempt to answer the question of why there is so much nitrogen in the atmosphere compared to other gases. One theory is that when the Earth formed billions of years ago, gases readily mixed with other chemicals to form rocks or oceans. Nitrogen, however, is a relatively inert gas, which ended up settling in the Earth's atmosphere. Additionally, nitrogen is a diatomic molecule and is unable to escape into space unlike lighter molecules such as hydrogen.

Why is all of this important? Discovering the origins of nitrogen provides information on the age-old question of how life began or whether biomolecules can be synthesised. So far, attempts to create biomolecules based on the assumptions of the Earth's early days have proven to be difficult and not particularly reliable. But with the help of rapidly advancing technology, we are able to unravel life's mysteries little by little.



Chromium(III)-nitride

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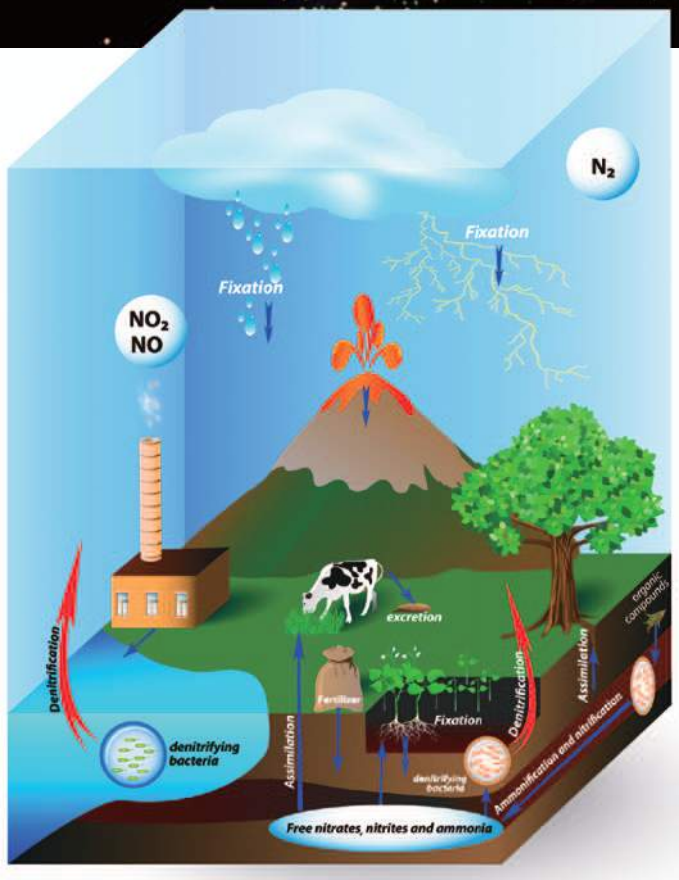
的氮同位素訊號，很接近地球氮的同位素訊號[2]。這暗示地球和隕石中的氮可能有同一源頭：就是原行星盤，即圍繞在年輕星體外的濃密盤狀氣體[3]。

氮鉻礦中的氮元素也讓人費解。氮一般是以氣體形態存在，極少在晶體中出現。研究組推斷氮鉻礦的形成，是由於在稀薄氣體中有“被含氨冰包裹的浮塵”[3]，遇到巨大天體，引起龐大的衝擊波，所產生的能量提高了氣體的溫度，導致冰殼熔化，形成了氮鉻礦。

類似的過程可能發生在地球形成的時候。大約在四十六億年前，偌大的星雲(一團微塵與冰體)可能已經崩潰，處於亂流狀態，中心溫度升高，旋轉加速，微塵和氣體凝聚成原行星盤[2]。哈裡斯團隊推論，在原行星的階段，原始冰體(史前冰)被拖帶至太陽系的內部，在這過程中，氨蒸發掉並與小天體撞擊，形成含有氮鉻鑭的天體。由於地球位於內太陽系，原始冰體可能因此囤積在形成中的地球[4]。美國國家航空航天局的黎明號太空船進入了穀神星軌道，穀神星位於小行星帶。研究團隊期盼能收集小行星上的樣本，以作更多的氮同位素訊號配對研究，從而為這些理論提供更多的支持。

氮的來源仍是一個謎，不過我們可以嘗試回答，為什麼相對其他氣體，在大氣中會有這麼多的氮。有理論指出，在數十億年前，地球形成初期，氣體很容易與其他化學物混合形成岩石和海洋。氮卻是一種



惰性氣體，最終停留在地球的大氣層。另外，氮氣是雙原子分子，無法像那些較輕的分子例如氫逃逸到太空。

為什麼這些研究值得重視呢？探索地球的氮來源，可以為古老的問題提供資料，有助了解生命起源、探討生物分子是否可以人工合成。迄今為止，模擬假設性早期地球環境而進行的生物分子合成試驗，遇到很多困難，結果亦不大可信！不過隨著科技的急速發展，我們正在一點點解開生命的奧秘。

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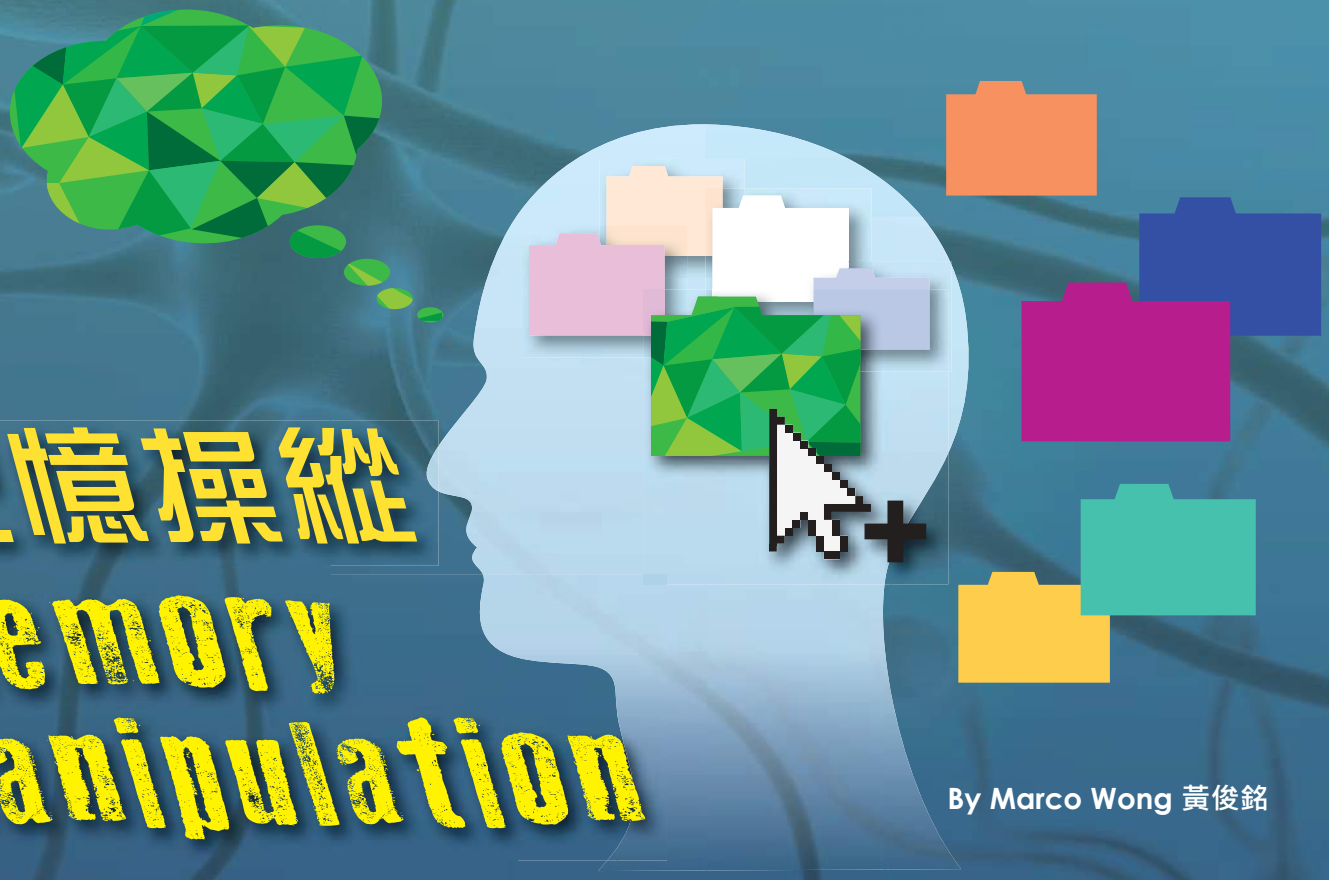

記憶操縱
Memory Manipulation

By Marco Wong 黃俊銘

Corporate espionage , memory implantation and information extraction straight from a person's mind may sound like the familiar synopsis to *Inception*, but scientists are making progress toward bringing this treacherous fantasy to real life.

Implantation of memories is not, by any means, a new idea. In the 1990s, one famous formal study on memory implantation involved a participant's family members to narrate true events that occurred in the participant's childhood, but to insert a false event that did not take place. The false event in each case was about getting lost in a shopping mall. The participants were then asked to recall each event in more detail and to rate how well they remembered the events. It was found that 5 out of 24 participants incorrectly recalled the false memory as an event that actually occurred [1]. While not overly exciting, it does show that memories are malleable even with very little coercion.

Memories can be classified into two categories – explicit and implicit memories. Explicit memories or 'declarative memories' are formed and temporarily stored in the hippocampus. These are memories that can be recalled, such as facts, knowledge and information about particular experiences. Implicit memories, on the other hand, are procedural, referring to skills that are learned. The ability to swim or to ride a bike are examples of ingrained implicit memories. Memory manipulation is potentially possible for explicit memories, and has become a prime target for research in neuroscience. This is because, unlike the coercion technique mentioned in the "Lost in the Mall" experiment, memories can be tweaked through knowledge of the hippocampus' mechanism.

Most of the large, pyramidal neurons in the hippocampus have been demonstrated to possess a causal role during navigation. These neurons are known as place cells and they fire when an animal enters a specific area of its total environment. This helps the animal to acquire information about when it moves into a certain place [2]. There is also a second type of cell in the hippocampus; these are small cells known as granule cells. Granule cells are more active during the day while pyramidal cells come awake during sleep [3]. The previously mentioned place cells are thought to "replay" wake-experiences during sleep for memory consolidation.

French researchers applied this mechanism to 'manipulate' memories in mice. They allowed mice to explore an open field environment and recorded the spike patterns created from place cells during this exploration. During sleep, these

memories would be 'replayed', mimicking the patterns observed during wakeful exploration. Whenever these patterns were observed, either during awake or sleep time, the scientists 'rewarded' the mice by stimulating the medial forebrain bundle (MFB) to cause release of dopamine (the feel-good hormone). To the mice, this was the same as being rewarded with food. The reward signal merged with the memory to connect one specific part of the total open field with a sense of happiness. It was found that when the mice awoke, they spent 5 times more time at the location connected with the place cells* which were linked with being rewarded, thus effectively creating a new memory in the mice – that a particular location was met with reward [2].

Memory manipulation has far-reaching implications. For one, it can potentially be applied in therapy where traumatic memories can be altered to become less so. The research in this area, particularly in coercion and suggestion, also provides ample warning in relying on witness testimonies in legal settings. For now, however, we can be thankful that memory manipulation at this level has only been attempted on animals.

* The importance of the discovery of place cells by John O'Keefe in 1971 was recognized this past year by the award of the Nobel Prize in Physiology or Medicine. The prize was shared with Edvard and Mary-Brit Moser for their discovery of a second type of memory cell known as a 'grid cell'

約翰•奧基夫在1971年發現了"位置細胞"(placecells),去年獲頒諾貝爾生理學或醫學獎,成就的重要性得到認可。該獎項是與愛德華•莫澤和邁-布裡特•莫澤共享,他們發現了另一種記憶細胞"網格細胞" (grid cell)

商業間諜、植入記憶、從思想直接套取資訊,這種種就像大家所熟悉的電影「潛行兇間」(Inception)的劇情,但科學家正逐步將這危險的幻想帶進現實。

無論從任何角度而言,植入記憶都絕不是新想法。20世紀90年代,有一個著名的研究,親屬對參與者講述童年的真實事蹟,但加插了實際沒有發生的虛假事件。這些捏造的事件都是關於在商場迷路。之後參與者要回憶每件事情的細節,評估他們的記憶。結果發現,24名參與者中有5名錯誤記起沒有發生的事[1]。結果雖然不太令人興奮,但確實表明了即使是少量的操控也能鑄造記憶。

記憶可以分為兩類:外顯記憶(explicit memory)和內隱記憶(implicitmemory)。外顯記憶又稱陳述記憶,在海馬體形成及暫時存儲。這類記憶隨時可以被徵用,例子包括:事實、知識、與特定經驗有關的資訊等。相對地,內隱記憶屬於程序性,指的是已經學習了的技能,例如游泳或騎自行車。陳述記憶有可能受操縱,也是神經科學家的主要研究範疇。方法不是像「商場迷路」實驗中所用的技巧,而是要通過認識海馬體的機理而調整記憶。

已有證據顯示多數在海馬體中的大型錐體細胞,在導航過程中具有關鍵作用。這些被稱為位置細胞(place cell)*的神經元,在動物進入總環境中的特定區域時,便會發出脈衝,讓動物取得訊息[2]。海馬體內還有一類小型細胞,稱為顆粒細胞。顆粒細胞白天較活躍,而錐體細胞則在睡眠期間甦醒[3]。前面提及的位置細胞會在睡眠中"重播"清醒時候的經歷以鞏固記憶。

法國研究人員應用這個機制「操縱」老鼠的記憶。他們先讓老鼠探索開放的環境,記錄位置細胞產生的活動規律。這些記憶會在睡眠期間重播,模擬探索時的神經活動規律。當科學家觀察到這些規律時,不管是在清醒或睡眠時,都會透過電擊刺激老鼠的內側前腦束(MFB)釋放多巴胺(感覺良好的激素)以作「獎勵」。老鼠的感受就如同得到食物一樣。獎勵信號與記憶合併,就將特定的位置與幸福感連接起來。結果發現,老鼠醒來後,在那特定的位置停留的時間增加了5倍。這種方法成功創造了新的記憶,令老鼠以為在那位置獲得過獎勵[2]。

記憶操控具有深遠的影響。例如可用於治療創傷記憶,改變記憶以減輕病症。這方面的研究,特別是與脅迫和提示有關的,可以讓依靠證人證詞的執法機構多加警覺。不過就目前而言,我們可以慶幸只會以動物作這類記憶操縱實驗。

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GENETICALLY MODIFIED MOSQUITOES

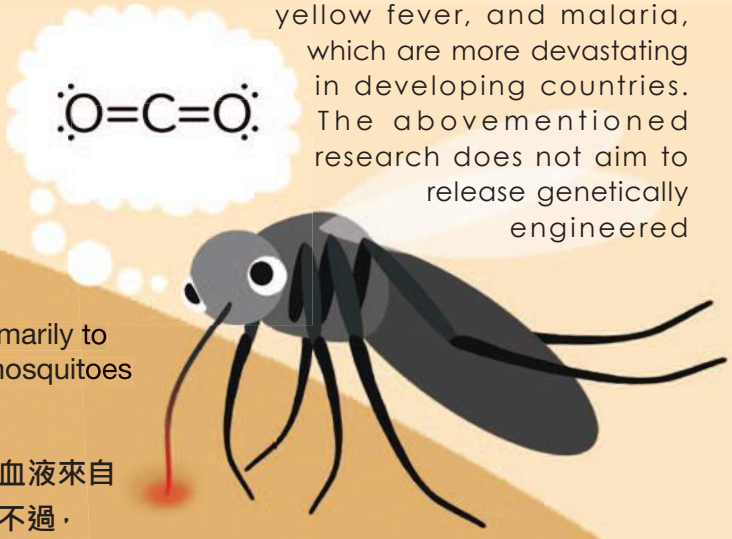
By Jacqueline Aw 歐婷梅

As residents of Hong Kong, we are all too familiar with the infuriating little pests that feed on our blood through their tube-like mouths. Not only do they suck our blood, but they also leave behind unwanted signatures in the form of itchy rashes on the exposed skin of victims. Itchy welts are not even the end of it. Mosquitoes are carriers of a number of devastating diseases such as dengue fever, yellow fever, and malaria. While some of us are busy swatting away these nasty creatures in the summer heat, others remain unfazed and unaffected. Could it be that these pests are selective of their victims?

With the large number of compounds to examine, researchers have yet to pinpoint exactly what factors mosquitoes use to determine their ideal feeding target. There are, however, several factors that may attract mosquitoes, including carbon dioxide output, body temperature, and body odour related chemical compounds [1]. We are more likely targets when participating in physical activity, which increases our CO_2 output and body temperature. In addition, expectant mothers exhale 21% more CO_2 than the average person and have a higher body temperature around the navel, and is reported to be more attractive targets for mosquitoes [2]. Another study suggests that among humans who secrete blood type substances on their skin (approximately 76% of the population), mosquitoes seem to have a significant preference for individuals with blood type O than for people with blood type A, possibly due to the release of chemical odourant markers [3,4].

Several chemosensory receptor families are related to the ability of mosquitoes to sense odours. Orco is an obligate co-receptor for one such family. A recent study at The Rockefeller University used genetically engineered *Aedes aegypti* mosquitoes that lack the orco gene to study the effects of these proteins on mosquitoes' odour-sensing abilities. Mosquitoes naturally feed on nectar to satisfy their metabolic needs. However, the ones with mutated orco genes lost their odour-sensing abilities and were unable to distinguish between honey and glycerol (glycerol has a similar viscosity to honey but is odourless). In addition, certain species of mosquitoes (*Aedes aegypti* and *Anopheles gambiae*), which have a natural tendency toward selecting human blood over other warm-blooded vertebrae lost their evolutionary preference even in the presence of CO_2. Modified mosquitoes were not attracted to human scent when no CO_2 was present [5].

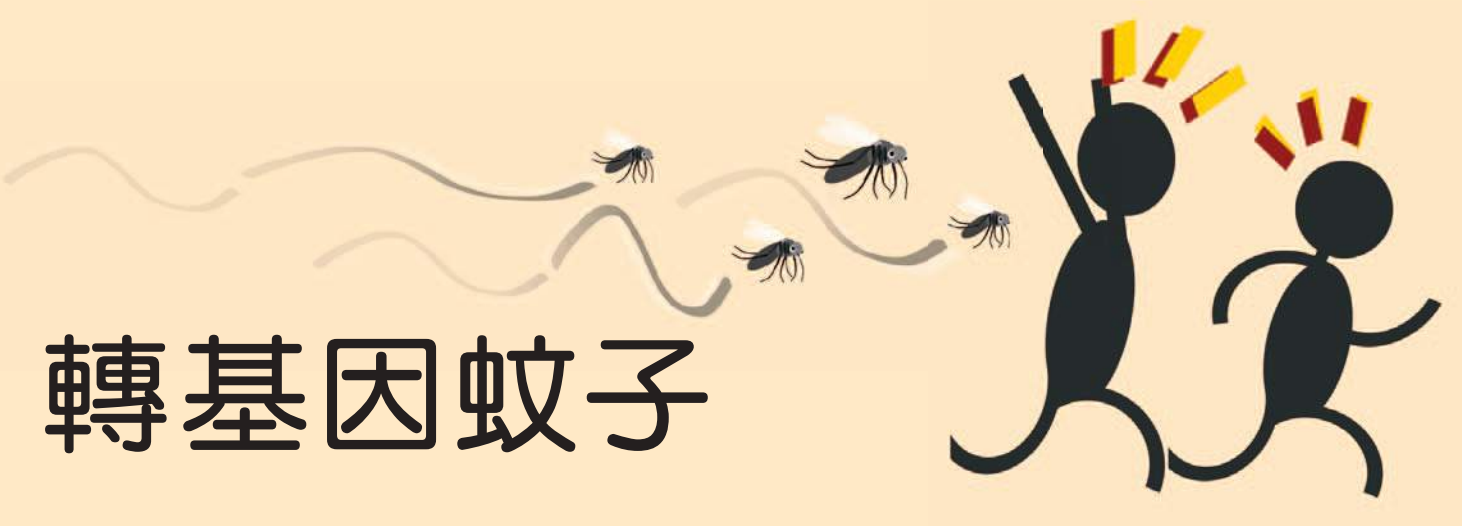
Research into mosquito preferences are essential for curbing diseases such as dengue, yellow fever, and malaria, which are more devastating in developing countries. The abovementioned research does not aim to release genetically engineered



Did you know:

While there are more than 3500 species of mosquitoes which feast on blood from a range of hosts, including mammals, birds, reptiles, amphibians, and fish, only female mosquitoes bite, primarily to acquire protein for egg production. Male and female mosquitoes feed on nectar or other forms of plant sugars for food.

你知道嗎：雖然有超過3,500種類的蚊蟲，吸取的血液來自不同的動物，包括：哺乳類、鳥類、爬行動物和魚類等；不過，只有雌蚊才會吸血，以取得產卵所須的蛋白質。雄蚊和雌蚊都是以花蜜或其他植物糖為食物。



轉基因蚊子

mosquitoes with no sense of smell. Instead, it is to apply their findings to help formulate next-generation insect repellents that target the orco gene. Another possibility is to reduce the population of mosquitoes that are attracted to humans, such as *A. aegypti*, by genetically modifying male mosquitoes to produce non-viable offspring. The ultimate goal is not to kill off mosquitoes once and for all, but to divert their appetites from humans to other seemingly more delicious options on the menu.

身處香港我們對昆蟲界的吸血鬼絕不陌生。在你候車時，稍不留神便被它們用管狀的嘴巴，狠狠的叮一口，皮膚紅腫發癢不止。蚊蟲還可以傳播各種疾病，比如登革熱、黃熱病和瘧疾等。當我們忙於在炎炎夏日驅趕這些討厭鬼時，卻會發現身旁的人不受它們滋擾，難道受害者都是經過精心挑選的嗎？

由於須要分析的化合物很多，研究人員尚未能查出蚊蟲是怎樣選定理想目標。然而，吸引蚊蟲可能有幾個因素，包括：二氧化碳排放量、體溫和與身體氣味相關的化合物[1]。進行體力活動的時候，我們的二氧化碳排放量和體溫都會提高，更有可能成為蚊蟲的目標。此外，孕婦呼出的二氧化碳成份比一般成人要高出21%，而且腹部周圍的體溫較高，她們便成為蚊子的首要獵物[2]。另一項研究表明，在皮膚分泌血型物質的人羣中（約佔人口76%），O血型的人比A血型的人更有機會吸引蚊子，這可能是與釋放的化學氣味標記有關[3,4]。

蚊子的感測氣味的能力和幾個化學感受受體家族有關，其中一個家族的專性共受體是orco。最近，紐約洛克菲勒大學的研究員改變埃及伊蚊的基因，觀察失去orco蛋白對它們的氣味感知能力有何影響。蚊子天性是以花蜜為食，滿足代謝需要。但是，研究發現orco基因突變的蚊子失去對氣味的感測能力，無法分辨蜂蜜和甘油的區別（甘油的粘度與蜂蜜類似，但甘油是無味的）。此外，某些種類的蚊子（埃及伊蚊和岡比亞按蚊）向來偏愛人血多於其他溫血脊椎動物，基因改變後，即使在二氧化碳中亦沒有這進化偏好。經基因改變的蚊子在沒有二氧化碳時，也不會被人的氣味所吸引[5]。

要制止登革熱、黃熱病和瘧疾等疾病，研究蚊蟲偏好是至關重要的。這些疾病在發展中國家尤具有破壞性。上述研究的目標不在於要釋放沒有嗅覺的基因改造蚊子，而是要將成果用於配製針對orco基因的新一代驅蟲劑。另外一個方向是對雄蚊進行遺傳修飾，產生不能存活的後代，從而減少偏好滋擾人類的蚊子，如埃及伊蚊。最終的目標不是要徹底滅掉蚊子，而是要將它們的胃口轉移到其他對象。

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THE BIG BANG THEORY UNDER SCRUTINY

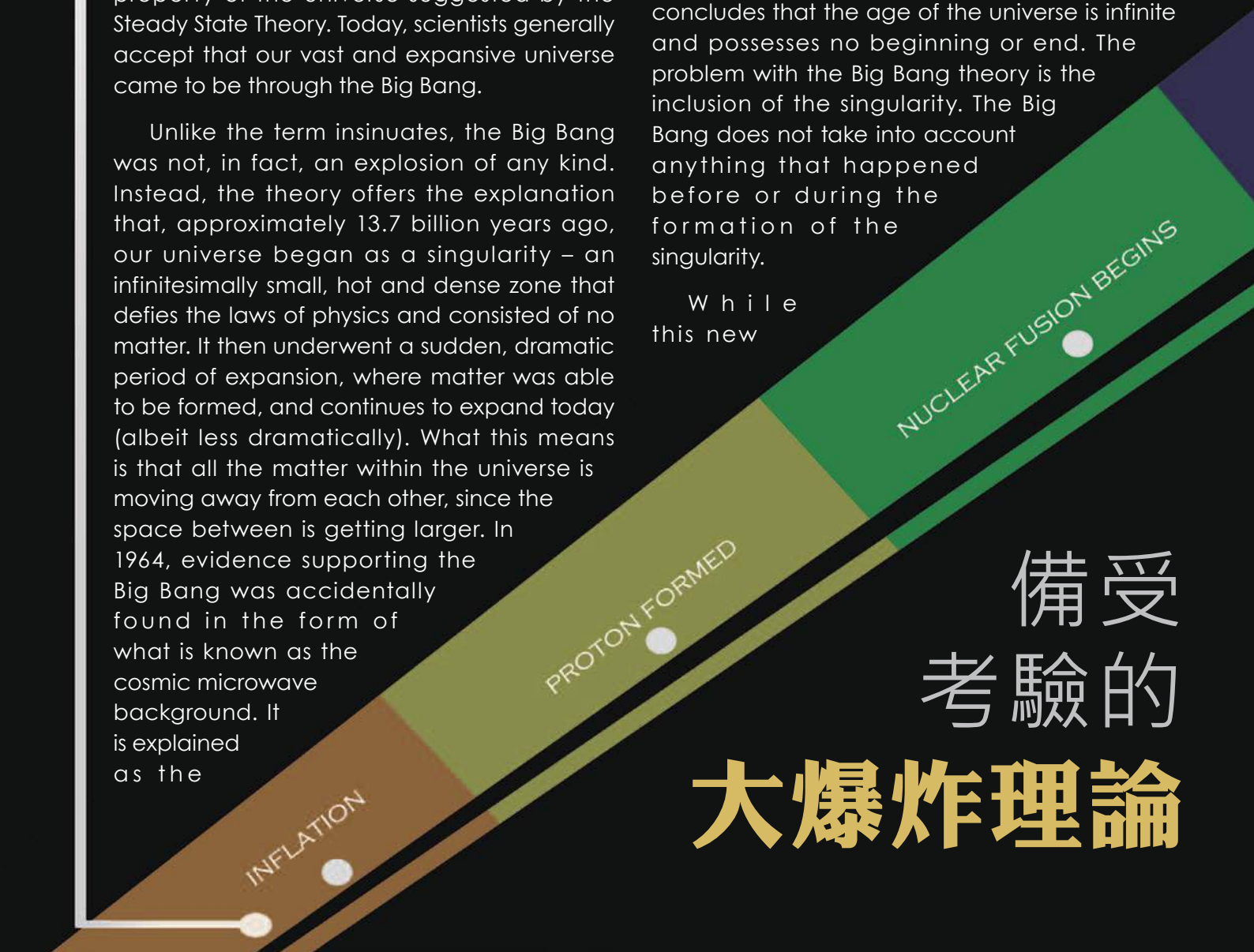
By Wing In Chau
鄒穎妍

In the 1940s, three scientists namely, Hermann Bondi, Thomas Gold, and Fred Hoyle put forward the now obsolete, Steady State Theory. The theory stated that the universe is continuously expanding through the creation of new matter at the same rate as old matter becomes unobservable, suggesting that the universe is space- and time- homogeneous. In other words, the universe does not change at any place or time with neither a beginning nor an end. However, with the advancement of radio astronomy in the 1950s, evidence piled up against the Steady State Theory. In particular, it was found that extragalactic radio sources (signals from outside of our galaxy) scatter differently from closer galaxies, contradicting the space-homogeneous property of the universe suggested by the Steady State Theory. Today, scientists generally accept that our vast and expansive universe came to be through the Big Bang.

Unlike the term insinuates, the Big Bang was not, in fact, an explosion of any kind. Instead, the theory offers the explanation that, approximately 13.7 billion years ago, our universe began as a singularity – an infinitesimally small, hot and dense zone that defies the laws of physics and consisted of no matter. It then underwent a sudden, dramatic period of expansion, where matter was able to be formed, and continues to expand today (albeit less dramatically). What this means is that all the matter within the universe is moving away from each other, since the space between is getting larger. In 1964, evidence supporting the Big Bang was accidentally found in the form of what is known as the cosmic microwave background. It is explained as the leftover radiation during the early stages of the universe where expansion was happening faster than the speed of light, during which atoms were formed after the universe cooled and were unable to absorb the thermal radiation.

While widely accepted, it should be noted that the Big Bang theory is a model for the evolution of the universe and not the only plausible theory. In a recent paper published last year, two physicists, Ahmed Farag Ali and Sauya Das, constructed a new model by revising the quantum equations and trajectories [1]. In this new hypothesis, the universe is said to be filled with a quantum fluid possibly consisting of hypothetical particles called gravitons. The model eliminates the potential existence of part of the Big Bang theory – that is, the singularity. It concludes that the age of the universe is infinite and possesses no beginning or end. The problem with the Big Bang theory is the inclusion of the singularity. The Big Bang does not take into account anything that happened before or during the formation of the singularity.

While this new



備受考驗的大爆炸理論

hypothesis provides a twist on the well-known Big Bang theory and seeks to identify some of the missing pieces, it may turn out to be missing some pieces of its own. For now, the Big Bang theory is still the most popular explanation of the state of our universe because of the insurmountable physical evidence such as the cosmic microwave background or galactic redshifts.

Find out more info on evidence for the Big Bang theory on our website at *http://sciencefocus.ust.hk*.

在20世紀40年代，赫爾曼．邦迪(Hermann Bondi)、托馬斯．戈爾德(Thomas Gold)和霍．伊爾(Fred Hoyle)，這三位科學家提出現已過時的穩恆態理論(Steady State Theory)。該理論指出，宇宙在不斷地創造新的物質，並以同樣的速度擴大，使舊物質變得不可見。因此，他們認為宇宙擁有空間(space-)和時間(time-)的均勻性(homogeneity)。換句話說，宇宙在時空上並沒有起點、變化和終結。然而，隨著20世紀50年代電波天文學(radio astronomy)的發展，越來越多的證據反映穩恆態理論並不可行。河外射電源(extragalactic radio sources)就是其中最關鍵的證據，因為它推翻了穩恆態理論所提出的宇宙空間均勻性，在較近的星系有不同散射。如今，科學家們普遍接受浩瀚宇宙源於大爆炸。

宇宙大爆炸，有違其名，並非指任何一種爆炸。相反，該理論是指在大約137億年前，我們的宇宙乃是一個奇點(singularity) — 不含物質，違反所有物理定律的無限細小、高溫和密集的區域。然後，它開始了一次突然和劇烈的擴張過程，使物質得以形成。時至今日，這個擴張過程仍未停止。這意味著宇宙中所有的物質隨著空間的擴張而逐漸遠離彼此。在1964年，意外發現了宇宙微波背景輻射(cosmic microwave background)，成為支持宇宙大爆炸論的有力證據。它被詮釋為早期宇宙以比光速更快擴張時，所遺留下來並無法被物質所吸收的剩餘輻射。

雖然爆炸理論被廣泛接受，但應注意的是該理論只是其中一個對宇宙演化過程的推斷，而非唯一可行的理論。兩位物理學家，艾哈邁德．法拉格．阿裡(Ahmed Farag Ali)和修恩．達斯(Sauya Das)，便於去年發表一篇文章，通過修改量子方程和軌道建設出一個新模型[1]。這項新假說指宇宙是由量子流體(quantum fluid)所構成的，含有大量假想引力子(gravitons)，否定了宇宙大爆炸中奇點的存在。該模型亦推論宇宙有永久的生命，宇宙從未有開始，更不會有終結。這個新模型彌補了大爆炸理論對奇點存在前及形成過程所欠缺的描述，為宇宙演化理論帶來新觀點。

雖然這個新假說為宇宙大爆炸理論帶來新的挑戰，解決了大爆炸理論不足之處，但它亦可能有所缺漏。到目前為止，因為有宇宙微波背景、銀河紅移等重要證據，大爆炸理論仍然是最流行對宇宙狀態的的解釋。

想閱讀更多關於宇宙大爆炸理論的詳細資訊，可瀏覽我們的網站 http://sciencefocus.ust.hk。

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Why do KOALAS Hug Trees?

By Wai Lam Raphaella So 蘇韋霖

Koalas are adorable and that alone makes them a worthy topic to write about. These animals spend approximately 20 hours each day sleeping or gripping trees and have evolved specialised features for climbing and tree-hugging. However, it is unlikely that koalas hug trees just to be adorable. So, why do they spend so much time hugging trees? More specifically, what are the evolutionary advantages of tree-hugging?

Australian summers are brutally hot. Some terrestrial animals maintain a stable body temperature by migrating to cooler subterranean areas, or by losing heat to the ground through conduction. Other animals such as dogs and kangaroos lick themselves and rely on evaporative heat loss. When water molecules evaporate off of the animal's skin, latent heat of vaporisation is absorbed by the water, i.e., the heat is absorbed from the surroundings when liquid is converted to gas, leaving the surface temperature cooler than it was before. Humans also use this mechanism of thermoregulation through sweat evaporation.

Koalas, on the other hand, are arboreal animals, meaning that they are adapted to living on trees. They are physically tied to their habitats and cannot easily migrate to cooler areas during Australia's extreme summers. These summers are also incredibly dry and water sources are scarce. Wild koalas rarely drink, instead they obtain most of their water intake through the eucalyptus leaves they eat. The scarcity of water therefore limits the koala's ability to thermoregulate through evaporation.

Tree bases and tree trunks are significantly cooler compared to the air, presumably because the xylem (transport tissue) stores large amounts of ground water. The surface of the trunk provides a conductive heat sink for koalas in the summer. A recent report showed that under hot conditions, koalas were more likely to adopt a tree-hugging posture, which exposed more of their body surface area to the cool surface. During the experimental period, koalas most frequently hugged a non-food tree species, *Acacia mearnsii*, which had the coolest temperatures.

Is this tree hugging method effective? On a 35°C day with a wind speed of 0.1 m/s, a completely shaded 11.3 kg male koala is required to lose 10.33 watts of heat in order to maintain a constant body temperature (a koala's body temperature ranges from 35°C to 37°C). The koala can lose up to 7.07 watts of heat by hugging the lower trunk of an *A. mearnsii* alone. In other words, it only needs to lose an additional 3.26 watts of heat through evaporation – 68% less than no hugging!

Evaporative heat loss is a costly thermoregulatory mechanism for it exhausts

為什麼樹熊要緊抱大樹？

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。

the scarce water storages of koalas. Tree trunks provide a conductive heat sink for koalas, and hence, the act of tree-hugging serves as an alternative means of thermoregulation, minimising the need for evaporation. Tree-hugging koalas are therefore more capable of conserving their scarce water resources. This thermoregulatory strategy greatly enhances the survival of koalas in hot and dry climates, providing an evolutionary advantage for the species.

樹熊緊抱大樹的形象一向深受喜愛。這些動物每天會花大約20小時睡覺或抓緊大樹，而且身體結構利於攀爬和抱樹。可是樹熊總不是為了討好人類才抱著樹幹吧？那為什麼樹熊要花那麼多時間抱樹？抱緊樹幹可以帶來什麼生存優勢嗎？

澳洲的夏天十分炎熱，不少陸地動物都要去較陰涼的地方，或接觸地面以傳導散熱。部份動物，例如是狗或袋鼠，則會舔弄其身軀，加速汗水蒸發，將身體熱能帶走，讓皮膚涼快。人類也是通過汗液蒸發來調節體溫。

可是，樹熊乃樹棲類動物，其活動範圍極其有限，不能隨意遷往較涼爽的地方避暑。此外，夏天極其乾旱，水源不足。野生樹熊甚少飲水，主要是靠進食油加利樹葉補充水分。水分稀少，不能用加速排汗的方法來降溫。為此，樹熊有一種另類的降溫方法 — 抱樹。

樹幹的木質部儲存了大量的地下水，所以樹底和樹幹的溫度要比空氣低得多，樹幹的表面就成為樹熊的傳導性散熱器。近期有報導，樹熊在高溫情況下，更多採用抱樹姿勢，將身體表面貼近涼爽的樹幹表面。實驗期間，樹熊最經常擁抱的樹種，是非食用的黑荊樹，擁有最低的樹幹表面溫度。

究竟樹熊的抱樹散熱法有多湊效？在一個溫度達攝氏35度和風速每秒0.1米的環境下，一隻棲息於陰影下的11.3公斤雄性樹熊，須要散去10.33瓦特的熱能才能保持恆溫(樹熊的體溫在攝氏35至37度間)。透過抱緊黑荊樹幹，樹熊就能散發接近7.07瓦特的熱能，大幅減少排汗降溫的須要。換句話說，它只須要蒸發散去額外3.26瓦特的熱量就可以了 — 比沒有抱樹少68%！

蒸發散熱是一種昂貴的體溫調節機制，主要是因為耗盡樹熊稀缺的身體水分。樹幹成為樹熊的傳導散熱器。因此，擁抱大樹的行為其實是出於溫度調節，減少蒸發散熱的需要，藉此增加樹熊在乾燥炎熱的環境中的生存能力。

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音樂的限量

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。

Music has been part of human culture since the dawn of symbolic human communication. Flutes made from the bones of birds and mammoth tusks from 42,000 years ago represent the earliest reliable archaeological evidence. To date, online music databases hold tracks in the millions – for example, the cross-referencing music database *Discogs* holds an impressive 151 million tracks on its site. However, there are a finite number of tones that can be distinguished by the human ear. Taking into consideration the rate at which tunes are being created, it is no wonder artists are getting sued for copying tunes. Is it possible that it is just a coincidence? Could we actually be running out of music?

In the interest of this question, *Plus Magazine* examined the possible number of melodies available, taking the following assumptions:

自人類懂得以符號作溝通工具，音樂就成為人類文化的一部分。以鳥骨和猛獁牙製於42,000年前的笛子，為此提供了最早而可靠的考古學證據[1]。時至今日，網絡音樂數據庫保存過億首曲目，單在*Discogs*音樂數據庫已存有1.51億曲目。可是，人類聽覺只能分辨有限的音調。現在樂曲創作頻繁，無怪乎藝人常惹上抄襲之嫌。難道這些都是巧合嗎？我們是否到了音樂的盡頭？

為了探討這個問題，由英國牛津大學出版的網上數學雜誌「Plus」[2]，按下列原則評估了可用旋律的數量：

1.

A melody will only be considered as a single combination of sequential notes. Chords, counter-melodies or bass lines will be disregarded.

撇除和絃、副旋律和低音聲部，單一連串的音符才會視為旋律。

2.

Melodies are within one octave (from C to C').

旋律包含在一個 (從C到C') 八度音階內。

3.

Within the octave, any of the 13 chromatic notes can be used.

旋律可由八度音階內的13個音符組成，包括：C, C#, D, D#, E, F, F#, G, G#, A, A#, B, C'；旋律並不限於大調或小調。

4.

We are interested in relative melodies so D to D or E to E are not included because it is already included in C to C.

旋律數量只計算相對音高。因此，像G# - F和E – A組合並不包括在內，因為這些都是絕對音高。同度音程，如 C – C、D – D或G – G組合，都不計在內。

Going up in pitch 音高向上			Going down in pitch 音高向下		
First note 旋律中第一個音符	Second note 旋律中第二個音符	Pitch difference (semitones) 半音程	First note 旋律中第一個音符	Second note 旋律中第二個音符	Pitch difference (semitones) 半音程
C	C	0	C'	C'	0
C	C#	1	C'	B	-1
C	D	2	C'	A#	-2
C	D#	3	C'	A	-3
C	E	4	C'	G#	-4
C	F	5	C'	G	-5
C	F#	6	C'	F#	-6
C	G	7	C'	F	-7
C	G#	8	C'	E	-8
C	A	9	C'	D#	-9
C	A#	10	C'	D	-10
C	B	11	C'	C#	-11
C	C'	12	C'	C	-12

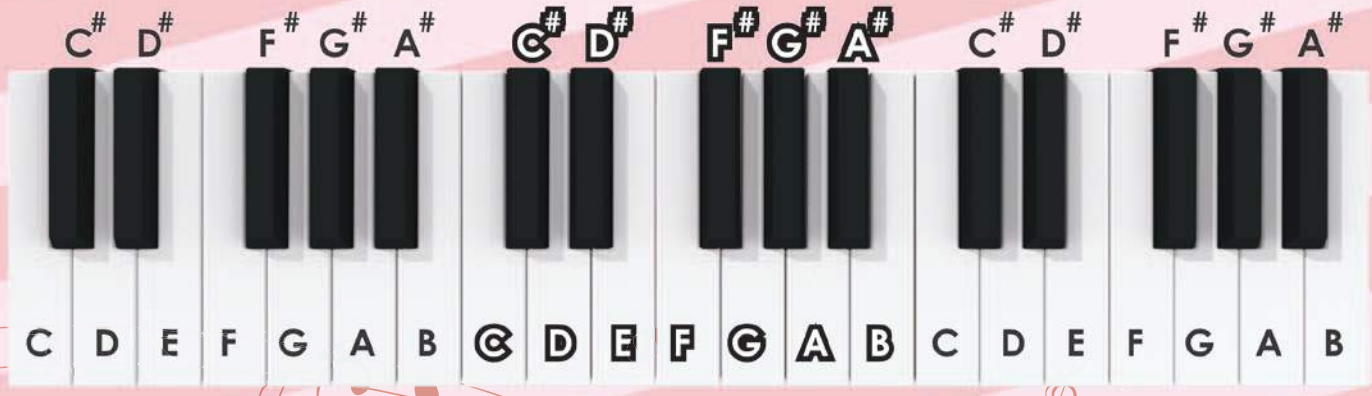
From the assumptions and the table above, we obtain 25 notes of two-note tunes (eliminating C' to C' because it is the same as C to C).

Listing out all the combinations is a tedious and time-consuming task. Therefore, we employ the use of permutations or an 'ordered arrangement'. If we only had 2 notes, C & D to choose from and are limited to a two-note melody, then we would obtain 4 combinations: CC, CD, DD and DC. If we had 2 notes to choose from and are limited to a three-note melody, we would obtain 8 combinations: CCC, CCD, CDC, CDD, DCC, DCD, DDC and DDD. The formulae for these two scenarios would be 2^2 possibilities and 2^3 possibilities (number of starting notes$^{\text{number of notes in the melody}}$). In our more complicated scenario, the first note can be any of the 13 notes; the second note is similar and so on. If n is the number of notes in our melody, then the possible combinations of notes is given by 13 x 13 x 13 x .. x 13 = 13^n. To find the duplicates, we apply the same thought process. For a duplicate sequence that does not contain a C, there are 12 choices for the starting note, 12 choices for the second note etc. We obtain 12 x 12 x .. x 12 = 12^n. Thus, the combinations we can obtain from a melody with n notes without duplicates is $13^n - 12^n$.

We can easily generalise the above discussion to find the number of melodies in any scale. Let "s" be the number of possible chromatic notes we can use. We obtain $s^n - (s-1)^n = s^n [\ 1-(1-1/s)^n\ ]$.

A song consisting of six notes has approximately 1.84×10^6 combinations and a song consisting of ten notes provides a whooping 7.5×10^{10} possibilities! We've eliminated rhythms, but to account for that, a rough approximation brings us to 8.25^{19} possibilities, or 2.6 trillion years' worth of material. Not to mention that this is without harmonisation, tempo and all the other variations possible in music.

Although popular songs tend to gravitate toward certain patterns of melodies, it is mostly due to what we find to be pleasing to listen to. In conclusion, it is safe to say that we will not be running out of music any time soon.



排除C'–C'(同度音程)後,雙音符旋律共有二十五組。

列出所有組合是繁瑣和耗時的任務;因此,我們採用排列組合來尋找答案。如果我們只有兩個可選擇的音符:C和D,而旋律也只有兩個音,我們會得到4種可能的旋律:CC、CD、DC、和DD。如果我們有兩個可選擇的音符和三音旋律,我們會得到8個不同的旋律:CCC、CCD、CDC、CDD、DCC、DCD、DDC和DDD。這兩種情況可以用$2^2=4$和$2^3=8$來表達(始音數^{旋律數})。在更複雜的例子,我們的始音有13個,第二個音也是有13個,如此類推。如果將旋律數設為n,那我們可以得到的旋律組合有$13 \times 13 \times 13 \times \ldots \times 13 = 13^n$個。若要排除重複旋律,我們可以通過同樣的思維過程。重複旋律不含有C音,所以我們擁有12個可選擇的始音,第二個音符也有12個等等。我們可以得到$12 \times 12 \times \ldots \times 12 = 12^n$個旋律。所以,我們可以得到$13^n$-$12^n$無重複的旋律。

我們可以輕而易舉地從上述得出任何旋律組合數。設s為可用的音符數,就會得到$s^n - (s-1)^n = s^n[1-(1-1/s)^n]$。

根據這些計算,6個音符能組織約1.84×10^6旋律,而10個音符便能給人7.5×10^{10}旋律!若旋律混合全音或八分音等不同節奏表達,粗略估計,在2.6兆年都不愁沒有素材。我們甚至還未提及和聲配置法,配器法,拍子等多元變化。

然而即使旋律組合多不勝數,過往的歌曲多傾向特定旋律。這可能是人類喜歡熟悉的節拍和旋律,又或是受現有的旋律影響,而局限了我們的創作。總而言之,我們大可放心,音樂在短期內都不會用盡。

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This article is based on ***How many melodies are there? By Oli Freke*** – Retrieved from *https://plus.maths.org/content/how-many-melodies-are-there* for further reading

The Possibility of Age Reversal – Prof. Thomas A. Rando

逆轉年齡的可行性 —— 托馬斯·蘭度教授

By Cherry Chow 周卓瑩

Director of Glenn Laboratories for the Biology of Aging and Deputy Director of the Stanford Centre on Longevity at Stanford University, Prof. Thomas Rando obtained his MD and PhD in cell biology from Harvard University and completed his residency in Neurology at The University of California San Francisco.

Prof. Rando's team studies a whole host of topics related primarily to muscle biology, in particular muscle stem cell biology, the intersection between muscle stem cell biology and aging, muscular dystrophy as well as tissue engineering. The topic of aging cropped up a decade ago during the study of stem cells. They questioned, "Why is it that when people or mice get older and older, their stem cells don't work as well as they do when they're young?"

Stem cells function in two main ways. Stem cells in muscle tissue activate in response to injury and divide until the tissue is repaired. Their other function is a normal, stem cell-mediated mechanism, where stem cells in the skin or in the gut continuously make new cells to replace old ones. These processes seem to deteriorate as a person ages – for example, wounds in young children heal much quicker than they do in older adults. "It's really a declining function over the whole life course", Prof. Rando explained.

Their studies in this area involves whether the deterioration is reversible. "If it's genomic – meaning if it is related to damage or mutations in DNA, then it unlikely to be reversible". But if it's anything else, then it is probably reversible to some extent". The approach to studying age reversibility in the perspective of stem cells is analogous to genetic switching. During cell development, differentiation of the cells takes place to determine the function of the cell and portions of the DNA to become inactive. The idea of age reversibility is analogous to turning one kind of cell to a different kind of cell, for example a liver cell to a brain cell, by controlling the genes expressed and masked. "In theory, if that is partly what aging is, you could take an old cell and make it a young cell". Prof. Rando's group has already made aged stem cells function like a younger cell by intervention. "At this point, we can't conclusively say that we've reversed aging as opposed to enhancing the function of these old cells. But we have ideas on how to study that". However, he explains that no molecular definition for aging currently exists, and is a fundamental difficulty that needs to be addressed.

Another challenge is limited time. Science is a slow process and studies on aging is particularly difficult since experiments cannot commence until a batch of test subjects (such as mice) age. Clinical trials in humans would naturally be even more challenging in length and complexity, not to mention the ethical issues that would accompany such experiments. Studies on aging are, nevertheless, ongoing and significant progress is currently being made in understanding the fundamentals of age reversal.

托馬斯·蘭度教授是史丹福大學格連老化生物學實驗室(Glenn Laboratories for the Biology of Aging)的主任及史丹福壽命研究中心(Stanford Center on Longevity)的副主任。蘭度教授於哈佛大學取得醫學博士學位及細胞生物學博士學位,並在加州大學三藩市分校完成他的神經部住院醫師訓練。

蘭度教授實驗室研究團隊圍繞肌肉生物學展開一系列課題,包括:肌肉幹細胞生物學、肌肉幹細胞與老化的交义研究、肌肉萎縮症和組織工程學。老化研究的課題始於10年前,當時他們正在研究幹細胞,提出一個疑問:「為什麼當人類或是老鼠老了,幹細胞的功能便不及年輕時?」

幹細胞主要有兩種功能。肌肉組織受損,便會啟動組織內的幹細胞進行分裂,直至組織被修復好。另一種功能則是在正常情況下,通過幹細胞介導的機制,讓皮膚或腸道等組織的細胞不斷更新。這些能力似乎會隨著年歲轉差,譬如說,幼兒的傷口癒合速度比起年長的成年人快得多。蘭度教授解釋:「這實在是在生命歷程中不斷下降的功能。」

他們在這範疇的研究涉及細胞功能下降能否被逆轉。「如果這現象是與基因組有關,即是與基因損傷或突變有關,那就不太可能逆轉;但如果是別的情況,那在一定程度上,還是可以逆轉的。」從幹細胞生物學的角度考慮,年齡可逆性就等於基因開關的研究。在細胞發育的過程中,細胞會進行分化以決定其功能,部分基因就會變得沒有活性。年齡可逆性就好像把某種細胞轉化成另一種細胞(譬如將腦細胞變成肝細胞),都是透過控制基因的表達或遮蓋。「理論上,如果這真的是老化過程的一部分你就可以將衰老細胞變成年輕細胞。」蘭度教授的研究團隊已經成功讓衰老細胞的功能變得與年輕細胞相若。「現在,我們還未能確定已經可以逆轉細胞老化過程,只能說是強化了這些衰老細胞的功能。不過,我們已有頭緒如何進行這方面的研究。」然而蘭度教授表示,目前「老化」在分子層面還未有確切定義,形成了根本困難,必須得到解決。

另一個挑戰就是時間的限制。科學是非常緩慢的過程,尤其是關於老化的研究,因為必須要等待實驗對象(例如老鼠)年老後才能開始實驗。在人體進行的臨床實驗,無論在時間及複雜性上,都極具挑戰性,更遑論這類實驗所引起的道德爭議。雖然如此,關於老化的研究依然得以進行,並且取得重要進展,對老化的可逆轉性有了更深入的了解。

Role Model in Science – Prof. Donna M. Ferriero

科學家典範—唐娜·費列羅教授

By Cherry Chow 周卓瑩

Prof. Donna Ferriero is Professor of Neurobiology and Pediatrics at University of California, San Francisco, Physician-in-Chief at UCSF Benioff Children's Hospital and Principal Investigator of UCSF's Neonatal Brain Disorders Centre.

唐娜·費列羅教授為加州大學三藩市分校(UCSF)神經內科及兒科學系教授、UCSF 貝尼奧夫兒童醫院的主任醫生,以及 UCSF 的新生兒腦障礙中心的首席研究員。

Prof. Ferriero knew very early on in her formative years, that she was cut out to be more than what many women chose for careers back then. Her prolific journey began in science, something that she had loved since high school. Equipped with a bachelor's degree in zoology and a master's in immunology from Rutgers University, she then obtained a degree in medicine and pursued her postdoctoral studies at the University of California, San Francisco. Not only did she manage to overcome obstacles that accompanied choosing a career in a male dominated industry, but went on to achieve much more. Prof. Ferriero now balances her time between being Chief Physician at UCSF Benioff Children's Hospital and a researcher at the UCSF Neonatal Brain Disorders Centre.

Over the past 20 years, Prof. Ferriero has focused her research efforts primarily on the pathobiology of hypoxic-ischemic injury in the developing nervous system (in newborns). This type of injury is mainly an effect of insufficient blood flow to the brain to maintain its normal functions and lowered oxygen concentration in arterial blood due to stroke in the brain. Many cases result in motor or cognitive disabilities, and birth asphyxia related injuries as a whole, accounting for 23% of all neonatal deaths worldwide [1,2]. While experts are uncertain on the causes of hypoxic-ischemic injuries in newborns, Prof. Ferriero provides several theories. Overly-reactive protective mechanisms during birth, trauma, infection, or genetics are likely culprits. Uterine rupture and placenta abruption in pregnancy can also separate blood supply from the mother to the fetus.

Much of her current research seeks to find innovative treatment for hypoxic-ischemic related injuries in newborns, in the form of signaling and repair by growth factors. These growth factors

are proteins made by the body that promote healing and growth, not only in the brain, but also in the liver, kidney and heart. One such growth factor is called erythropoietin (EPO), and is already a commonly prescribed drug for anemia patients or cancer patients undergoing chemotherapy, to promote red blood cell count. Her research investigated the effect of EPO on oxygen deprived cells from the hippocampus (a common injured area from newborns afflicted with stroke) and returned promising results.

Her successful career is perhaps even more pronounced at a time when there were very few women role models for anything. "It never happens anymore but when I was a resident I went to my first academic meeting in neurology. Neurology is a very male dominated specialty and still is. I was standing there, I was standing close to this big hall and the coat check room was right over there. Some guy came up to me and handed me his coat because he thought I was the coat check girl!" While gender discrimination is not as marked as it was before, she believes that there is still an unconscious bias. "It will take your generation to fix that but I think we'll get there. We need more women in science and medicine!"

The balance between being a physician and a researcher is one that Prof. Ferriero tries to maintain by spending 25% to 50% of her time attending and performing research in her remaining time. Her passion for both is evident – "I really enjoy the science but it's almost selfish in a way because it is intellectually stimulating, I hope it will benefit mankind, but I get much more immediate gratification from interacting with a baby in the family or a child". It is that passion which she advises prospective science students to look for in their own careers because "it's not a job, it's just fun, it's your life".

費列羅教授很早就知道，她比許多女性有更高的事業抱負。科學，一門她自高中就愛上的學問，開展了她的豐富旅程。在羅格斯大學取得動物學學士學位和免疫學碩士學位後，費列羅教授在UCSF完成了她的醫學學位和博士後研究。她不僅在男性主導的行業中克服重重障礙，並繼續取得更多成就。費列羅教授現同時擔任UCSF貝尼奧夫兒童醫院主任醫生，以及UCSF的新生兒腦部疾病中心研究員。

在過去的20年，費列羅教授的研究聚焦在發育中神經系統（即初生嬰兒）缺氧缺血性損傷的病理學。這種損傷是指流向腦部的血液不足以維持其正常功能，及動脈血液含氧度低於正常水平，主要由腦中風所導致。許多個案都會因此出現活動上或認知上的障礙，而出生過程中的窒息情況，佔全世界初生嬰兒夭折原因的23%[1,2]。對於初生嬰兒缺氧缺血性損傷的成因，專家們仍未有定論。費列羅教授就此提出了一些理論：嬰兒自身保護機制的過度反應、外傷、感染或者遺傳，都可能是罪魁禍首。懷孕期間的子宮破裂及胎盤剝離，亦會阻斷母體往胎兒的血液供應。

目前，費列羅教授大部分的研究是關於生長因子的信號傳遞與修復，旨在尋找新方法，醫治受缺氧缺血性損傷影響的初生嬰兒。這些生長因子是一種由身體製造的蛋白質，能夠促進癒合和生長，不僅針對大腦，而且對肝臟、腎臟和心臟的細胞也有效用。促紅細胞生成素（EPO）是其中一種生長因子，通常會處方予貧血症患者或正接受化療的癌症病人，用以增加紅細胞數量。她的研究檢視了EPO對海馬體缺氧細胞（初生嬰兒因腦中風而受損的常見部位）的影響，並取得可喜的成果。

當年各行業都少有女性榜樣，令費列羅教授的事業成就更顯出眾。「當我還是一名住院醫師的時候，首次參加神經內科學術會議。神經內科曾經是一個非常男性主導的專業，現在還是。當時我站在衣帽間接近大廳的位置，一位男士向我走過來，遞給我他的大衣，以為我是服務員！」在費列羅教授看來，時至今日，儘管性別歧視不常發生，潛意識偏見依然存在。「要等你們這一代來解決問題，但我想我們總會做到。我們須要有更多的女性投身科學和醫學的範疇！」

費列羅教授花大概25%至50%的時間診症，餘下的時間做研究，以保持兩方面的平衡。她對兩者的熱愛是顯而易見的 — 「我真的很喜歡科學，甚至近乎自私，因為科學帶來知性上的刺激。我希望科學能夠使人類受益，但我透過與孩子嬰兒的互動，可以得到更即時的滿足感。」她勉勵有志科研的學生，要在自己的職業中找到激情，因為「它不是一份工作，它是樂趣，它是你的人生。」

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Test Yourself! 測一測

1. A cube is at rest on a table. What happens to the pressure applied by the cube on the table if the dimensions (using the same material) of the cube are doubled?
一個立方體塊放置在桌上，當它的尺寸增大一倍時，由它施加的壓強會如何變化(材料不變)？
   a. Nothing 沒有改變
   b. Doubled (x2) 以前的兩倍
   c. Quadrupled (x4) 以前的四倍
   d. Octupled (x8) 以前的八倍

2. Which enzyme extends and maintains the length of chromosomes?
哪種酶素負責維持染色體的長度？
   a. Protease 蛋白酶
   b. Telomerase 端粒酶
   c. Polymerase 聚合酶
   d. Amylase 澱粉酶

3. What percent of an atom is empty space?
原子的結構有百分之多少是空間？
   a. 10%
   b. 27%
   c. 52%
   d. 99%

4. The best resonance structure is one that has
最穩定的共振結構包含：
   a. High bond length 鍵長較高
   b. Atom splitting 原子分裂
   c. More bonds, fewer charges 鍵數多、電荷少
   d. Charged particles 帶電粒子

5. The longest bone in the human body is the
人體最長的骨頭是：
   a. Femur 股骨
   b. Fibula 腓骨
   c. Humerus 肱骨
   d. Tibia 脛骨

6. True or False 是非題
A balloon filled with water will explode when a burning candle is placed underneath it for 10 seconds.
當一個燃燒的蠟燭放置在裝滿水的氣球底下，氣球就會爆炸。
   a. T 是
   b. F 非

Answers 答案: b, b, d, c, d, f

For detailed answers and explanations, please visit our website.
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