SCIENCE FOCUS 科言

Issue 010, 2017

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天賦異稟短睡者

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THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

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Message from the Editor-in-Chief 主編話語

Dear Readers,

Welcome back to the tenth issue of *Science Focus*! Our beloved planet is in dire need of saving, as evidenced by the plethora of global issues in the media revolving around climate change, environmental awareness and new technology to ease the damage to the Earth. Much of this issue of *Science Focus* identifies current environmental and climate change research. As the next generation of scientists and policy makers, we hope to instill in our readers a sense of responsibility and invested interest in our planet's future.

We hope that you can take a break from all that studying by getting caught up with the latest science and technology news by reading our magazine. If you're interested in science and writing, please don't forget to keep sending your articles to our Science Focus Article Submission Competition, where we will select the best articles to be published in our magazine and to have a chance to win our juicy prizes!

Enjoy your *Science Focus*!

Yours faithfully,
Prof. Yung Hou Wong
Editor-in-Chief

親愛的讀者：

歡迎閱讀第十期「科言」！媒體有大量報導，圍繞著氣候變化、環保意識、新科技減低對地球的損害等等全球議題，正正顯示我們所深愛的地球極需守護。今期「科言」的主要內容是介紹當前與環境和氣候變化相關的研究。希望讀者們，也是下一代的科學家和決策者，能夠養成責任感，關心地球的未來。

我們希望你在忙碌學習中能夠抽空看看「科言」，瞭解最新的科技動向。若果你對科學和寫作同樣感到興趣，請不要忘記參加「科言徵文比賽」。被選中的優秀作品將會刊登在「科言」雜誌，並會有機會贏得豐富獎品！

請來享受閱讀「科言」！

主編 王殷厚教授
敬上

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WHAT'S HAPPENING IN HONG KONG?

Looking for something to do? Check out the following science activities and events happening in Hong Kong. 想好節目了嗎？不妨看看在香港舉辦的科學活動吧！

Astronomy March at the Hong Kong Space Museum

Take control of the cosmos at the Hong Kong Space Station in a month of astronomical observations!

香港太空館三月份活動

香港太空館的天文觀測課程及專題講座讓我們窺探宇宙的秘密。千萬不要錯過！

Event 活動	Date 日期	Time 時間
Astronomy Course: Astronomical Observation *天文課程：*天文觀測	March 21 2017年3月21日	7:00 pm – 9:00 pm
	March 25 2017年3月25日	2:30 pm – 4:30 pm
Special Lecture: Are You Ready for the Total Eclipse 2017 in the U.S.A.? *專題講座：*你為2017年美國日全食作好準備嗎？	March 26 2017年3月26日	3:00 pm – 5:00 pm

For more information, check out their official website: *https://www.lcsd.gov.hk/CE/Museum/Space/en_US/web/spm/whatsnew.html*

詳情請瀏覽：*https://www.lcsd.gov.hk/CE/Museum/Space/zh_TW/web/spm/whatsnew.html*

HK SciFest 2017

HK SciFest is back again at The Hong Kong Science Museum! Starting **February 18** to **April 23**, enjoy inspiring and interesting events from learning about the world of medicine to coding robots.

Check out their schedule here *http://hk.science.museum/en_US/web/scm/pp/ect_3.html* and visit their official website at *http://www.hk.science.museum/scifest2017/eintroduction.php!*

2017香港科學節

香港科學館又帶給你新一年的香港科學節。在**2月18日至4月23日**期間，有多項益智有趣的科學活動，帶你進入醫學、機械人編碼等不同領域，一起經歷科學的樂趣！活動日誌請見香港科學館網站：*http://hk.science.museum/zh_TW/web/scm/pp/ect_3.html*

或參閱香港科學節網站：*http://www.hk.science.museum/scifest2017/introduction.php*

Hong Kong Green Building Week – Green Ambassador Pitch

Get savvy about environmental issues. Students are invited to team up and come up with a plan to motivate people around them to combat climate change. You can watch your fellow peers, free of charge, on May 20, May 27 and June 7 at the Hong Kong Convention and Exhibition Centre.

Visit their website for more information: *https://www.hkgbc.org.hk/eng/gbw.aspx!*

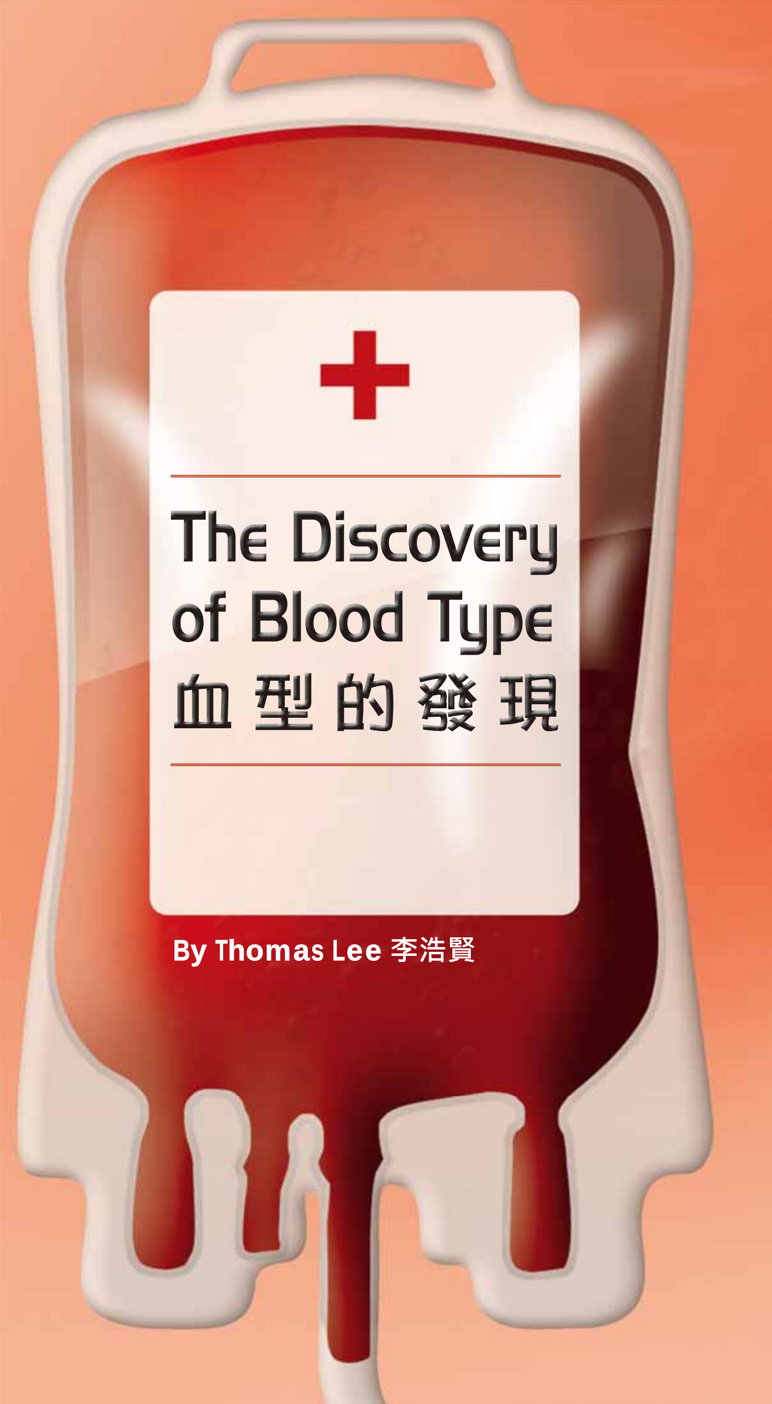
香港綠色建築週

想深入瞭解環境問題？香港綠色建築會議邀請各位同學組隊制定計劃，鼓勵週遭親友對抗氣候變化。你可以在6月7日到香港會議展覽中心，免費入場支持你的朋友。

詳情請瀏覽香港綠色建築週的官方網站：*https://www.hkgbc.org.hk/chi/gbw.aspx*

The Discovery of Blood Type 血型的發現

By Thomas Lee 李浩賢

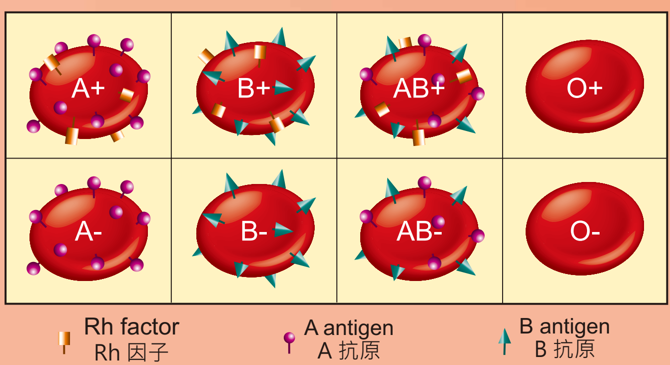


The Ancient Chinese had long believed that there was a special relationship evident in blood between paternity and offspring. While not in the least bit scientific, the mixing of blood was a paternal test used in many courts dynasties ago. It was not until centuries later, when scientists offered explanations to the relationship between blood type and paternity, that our understanding towards blood chemistry deepened.

ABO blood groups were first identified in 1900 by Austrian physician Karl Landsteiner. With this identification, Landsteiner discovered that blood types are hereditary, and could be used as a way to test for paternity. Studies then revealed that a single ABO gene gives rise to four variants – A, B, AB, and O – through the co-dominant expression of alleles. In more modern science, molecular biology allowed scientists to identify that these genes encode enzymes in what is known as glycosyltransferase activity. This enzyme activity plays a role in modifying oligosaccharides on glycoproteins sitting on the surfaces of red blood cells. Glycoproteins are antigens, the identifier to our immune system, as well as the markers that differentiate one blood type from another.

Glycoproteins are guarded by various antibodies, which recognise the marker that signifies “self” and “non-self”. Foreign substances, such as viruses and bacteria, are exterminated. Likewise, foreign blood types are rejected by antibodies that attack certain red blood cell antigens. For instance, people with type A blood have A antigens on their red blood cells and make antibodies that attack B antigens. Thus, blood transfusion is highly regulated and could go catastrophically wrong by causing agglutination [1].

Aside from the four blood types, the Rh blood group system, including the Rh factor, is also important in blood transfusion. Named after the rhesus monkey, the Rh factor was discovered to be similar to the antigen of this primate. The Rh factor refers to the most important antigen within this group and an individual either has or does not have this antigen on their red blood cells. This is denoted by Rh positive and Rh negative, respectively [2].



The question of why humans have blood types to begin with has yet to be answered. Laure Segurel and her colleagues at the National Centre for Scientific Research in Paris surveyed ABO genes in primates. Their conclusions showed that the human ABO blood group likely stemmed from when gibbons and early hominids diverged in their evolutionary tracks [3].

In fact, by 2014 the International Society of Blood Transfusion had recognised 33 blood group systems, namely the MN, Diego, Kidd, and Kell. They are fortunately less common to us because

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。

	Group A A 組	Group B B 組	Group AB AB 組	Group O O 組
Red blood cell type 紅血球 細胞型態	A	B	AB	O
Antibodies in Plasma 抗體存在	Anti-B B 抗體	Anti-A A 抗體	None 無	Anti-A and Anti-B A 與 B 抗體
Antigens in Red Blood Cell 抗原存在	A antigen A 抗原	B antigen B 抗原	A and B antigens A 與 B 抗原	None 無

they trigger weaker and less frequent immune reactions. However, blood science is an ongoing study, and has been extended from identifying new blood groups in the human race to studying the correlations between blood type and risks to diseases and infections. Interestingly, these findings may conversely shine light on the reasons behind the existence of various blood types in human and closer primates in the first place.

古代中國人相信親子之間血脈相連，公堂上以滴血認親，這其實是毫不科學。多個世紀過去，科學家終於破解了血型和親緣的關係，加深我們對血液化學的認識。

奧地利醫生卡爾·蘭德施泰納於1900年首次發現ABO血型，之後更證明了血型的遺傳性，可以用於親子鑑定。以後的研究顯示ABO血型基因有多個等位基因，通過共顯性表達產生不同血型：A，B，AB和O。更後期的分子生物學研究發現這些等位基因編碼了不同的糖基轉移酶，將不同的糖基連接到紅血球膜上的糖蛋白。這些糖蛋白是抗原，是免疫系統的特徵，也是識別不同血型的標記。

在人體血液中，有不同的抗體辨別「自身」和「非自身」的糖蛋白標記，消滅病毒和細菌等異物。抗體也會攻擊外來血液中的紅血球抗原；例如：A型血人的紅血球帶有A抗原，製造的抗體就會攻擊B抗原。所以輸血過程必須受嚴格監控，一旦出錯就會導致紅血球凝集 [1]。

除了這四種血型之外，另一個與輸血有重要關係的血型系統是以Rh因子為主。Rh因子與恒河猴紅血球的抗原相似，所以得名。Rh血型系統是根據紅血球表面是否帶有Rh因子，而把血型分為Rh陽性和陰性 [2]。

對於人類血型的起源暫時所知不多。巴黎國家科學研究中心的勞荷·賽格瑞爾和她的團隊研究靈長類ABO基因，得出的結論是人類的ABO血型，可以遠溯至長臂猿和人類分開進化之前 [3]。

直至2014年，國際輸血學會已確認了33個血型系統，其中包括：MN，Diego，Kidd和Kell。這些血型系統引起的免疫反應不多也相對微弱，所以鮮為人知。關於血液的研究並沒有停止，並且已從考證人類新血型，拓展至探究血型與疾病感染風險之間的相關性。有趣的是，這些研究結果或可反過來提供線索，揭示人類和接近人類的靈長類動物中，為何會出現各種血型。

References 參考資料

[1] *https://www.ncbi.nlm.nih.gov/books/NBK2267/*

[2] *https://www.ncbi.nlm.nih.gov/books/NBK2269/*

[3] *http://m.pnas.org/content/110/16/6607.short?trendmd-shared=0*

Undoing Carbon Dioxide

逆轉二氧化碳排放

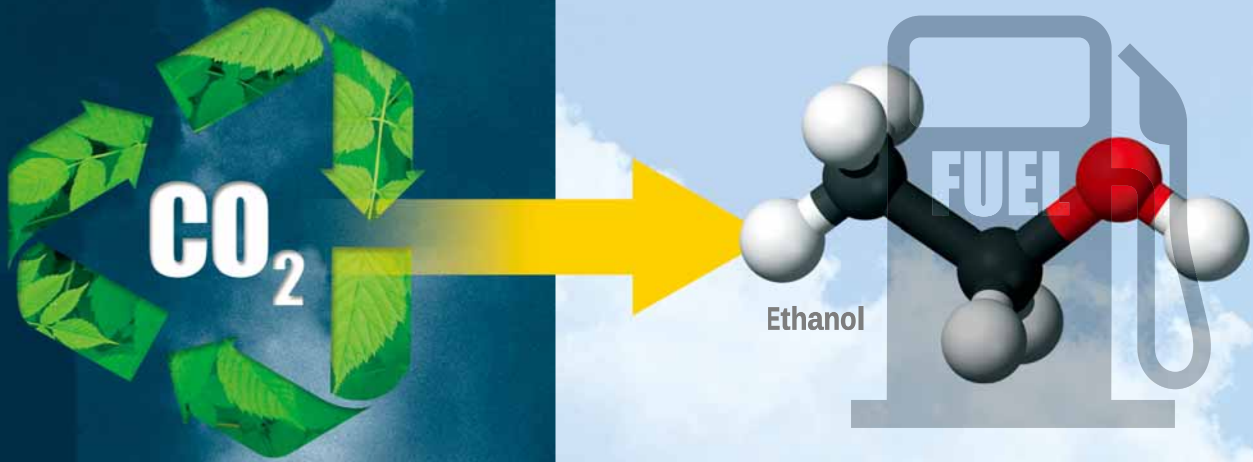
By Twinkle Poon 潘晴

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。

Global warming has been an ongoing problem for the environment due to the emission of carbon dioxide. Global temperatures rise, as do sea levels, causing unpredictable changes to ecosystems. Researchers have recently discovered a method that efficiently converts carbon dioxide into ethanol, effectively removing it from the atmosphere, and potentially turning it into useful fuel.

Researchers from The Oak Ridge National Laboratory's Department of Energy accidentally stumbled upon an electrochemical process that harnesses nanotechnology and catalysts to turn carbon dioxide into ethanol, which can be used as a fuel.



Their original goal was to grow a graphene based catalyst and to assist in the conversion of carbon dioxide into methanol, which also happens to be the first step in producing fuel. However, they realised that the catalyst was doing surprisingly well, so well in fact that they noted the catalyst was doing the entire reaction on its own, skipping anticipated steps [1]. The technique involves using a copper catalyst designed with copper nanoparticles on the surface of silicon, and applying electricity to carbon dioxide in water. Only 1.2 volts are needed to complete the conversion to ethanol at 63% efficiency. The reaction also works in room temperature and can be easily switched on and off without energy penalty, which indicates that the energy conversion can be used as energy storage when generating intermittent renewable energy from wind or solar.

The scientists stated that the reaction is typically difficult to achieve with one single catalyst [2].

The key to this reaction seems to lie with the manipulation and design of the catalyst. While copper itself is not an impressive catalyst, by arranging the copper nanoparticles similar to a lightning rod formation, the surface area is maximised (and therefore creates more reactive sites for the reaction to take place). Each spike is around 50 nanometers in length and the tips of these spikes provide the most concentrated areas for the reaction. The energy breaks the dissolved carbon dioxide and reforms it as ethanol. The researchers stated that this process is synonymous to the reverse reaction of ethanol being split into carbon dioxide and other molecules in the presence of oxygen [3].

Advantages of the reaction are twofold. First, the catalyst in question – copper – is inexpensive and easy to manufacture, particularly in comparison to more commonly seen catalysts such as titanium dioxide. Due to its availability and low cost, researchers suggest that their technique to produce ethanol could be fine-tuned to be commercially viable. Second, ethanol can be used as an additive to gasoline that powers vehicles, used in power generators, or as a fuel in ethanol fuel cells.

Their technique still needs to be honed if it were to become viable on the commercial level. Production rate and efficiency need to be increased and there is still much to study in the catalyst's behaviour. Excess atmospheric carbon dioxide has posed a perplexing problem for scientists for decades, but this technique offers a low-cost, efficient solution to reversing the release of carbon dioxide.

ORNL researchers developed a catalyst made of copper nanoparticles (seen as spheres) embedded in carbon nanospikes that can convert carbon dioxide into ethanol. (Photo credits: ORNL)

二氧化碳排放導致全球氣溫上升，持續對環境造成損害。全球暖化使海平面上升，給生態系統帶來不可預測的變化。研究人員最近發現一種將二氧化碳高效轉化為乙醇的方法，可以有效移除大氣中的二氧化碳，並有可能將其轉化為有用的燃料。

美國橡樹嶺國家實驗室能源部的研究人員偶然發現了一種電化學過程，運用納米技術和催化劑將二氧化碳轉化為可以充當燃料的乙醇。

他們最初的目標是要製造一種石墨烯催化劑，應用在生產燃料過程的第一個步驟，輔助二氧化碳轉化為甲醇，結果卻是出奇地好。他們意識到這種催化劑其實是略過預設的步驟，自行完成整個反應 [1]。 該項技術所用的銅催化劑是以銅納米顆粒鋪設在矽表面而成。僅需以1.2V電壓將電流通過溶解於水中的二氧化碳，就可以將63%的二氧化碳轉化為乙醇。這化學反應可以在室溫進行，啟動或結束都容易，不會損耗能量。這意味著從風力或太陽產生的間歇性再生能量，可以通過這種能量轉換方式儲存。

科學家指出通常是難於以單一的催化劑來完成整個反應 [2]。

該反應的關鍵似乎在於催化劑的操作和設計。雖然銅本身不算是出色的催化劑，但將銅納米顆粒排列成類似避雷針的結構後，表面積得到最大化 (並因此而產生更多反應位點) 。每支針長約50 nm，針尖提供極度集中的條件讓反應進行。注入的能量將溶解在水中的二氧化碳打碎並重組成為乙醇。研究人員指出，這過程正是把乙醇在氧氣中被分解成二氧化碳和其他分子的逆反應 [3]。

這反應具有兩方面優勢。首先，所討論的催化劑—銅，價格低廉而且易於生產，尤其是相對更常見的催化劑如二氧化鈦等而言。由於供應充足和成本低，這種生產乙醇的技術可以改良為商用。其次，乙醇可以作為車用汽油的添加劑，也可用於發動機或乙醇燃料電池。

不過，若要應用在商業層面上，這種技術仍需要多加改進，提高生產率和效率；此外，對這種催化劑的行為也要作更深入的研究。在過去數十年，科學家們為大氣中過剩的二氧化碳煞費苦心，這種技術為逆轉二氧化碳的釋放，提供了一種低成本、高效率的解決方案。

References 參考資料

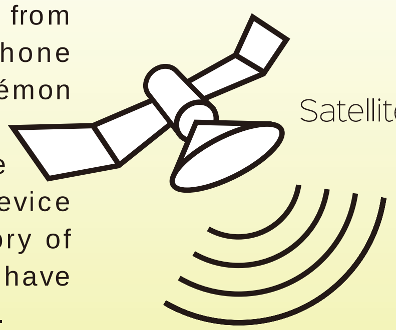
[1] McCrokle, M. Nano-spike Catalysts Convert Carbon Dioxide Directly into Ethanol. *Oak Ridge National Laboratory* (2016). Retrieved from *https://www.ornl.gov/news/nano-spike-catalysts-convert-carbon-dioxide-directly-ethanol*

[2] Jeffrey, C. Reversing the Combustion Process to Convert CO_2 into Ethanol. *New Atlas* (2016). Retrieved from *http://newatlas.com/co2-ethanol-nanoparticle-conversion-ornl/45920/*

[3] Scharping, N. Nanospikes Convert Carbon Dioxide Back Into Ethanol. *Discover Magazine* (2016). Retrieved from *http://blogs.discovermagazine.com/d-brief/2016/10/19/nanospikes-convert-carbon-dioxide-back-into-ethanol/#.WHiXltJ9670*

The GPS and Its Connection to Relativity 全球定位系統

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。



Global positioning systems (GPS) have taken the world by storm since its development in the 1970s. Its applications have extended from purely navigational assistance to smart phone gaming, spawning popular apps such as Pokémon Go and its predecessor Ingress. In addition to the complex technology of satellite signalling, the GPS is often quoted as a device that is directly affected by Einstein's theory of Special and General Relativity, but scientists have managed to circumvent this problem entirely.

A GPS can be divided into three segments, namely, specialised satellites, the control centre, and the user device or receiver. Around 30 satellites containing atomic clocks orbit the earth. At any given time, the GPS receiver must be able to receive radio emissions from at least four satellites to determine the location. The receiver essentially calculates the distance between each of the satellites based on the time required for the transmissions to be received. In a process called trilateration that somewhat resembles a Venn diagram, the satellites create information in the form of spheres. The intersections where these spheres overlap pinpoint the location of the GPS receiver. More satellites signals received equate to more accurate of a location.

Since the location is determined by measuring the time it takes for a signal to be received, recording time accurately is crucial. In a nutshell, Einstein's theory of Special Relativity states that a clock moving relative to an observer will be slower than a clock that is stationary. The theory of General Relativity then states that gravity also has an effect on the way time ticks; the stronger the gravitational field, the slower the clock ticks. Satellites are in orbit around the earth at 14,000 km/hour at approximately 20,000 km above ground. By the theory of General Relativity, the clocks carried by the satellites would essentially be running at a faster time to one on Earth (the effect of general relativity due to less gravity in orbit is greater than the effect of specific relativity induced by higher movement speed), creating an error of about 38 microseconds per day. When this effect accumulates over time, the positioning detected by the GPS would be so off that it would be next to useless.

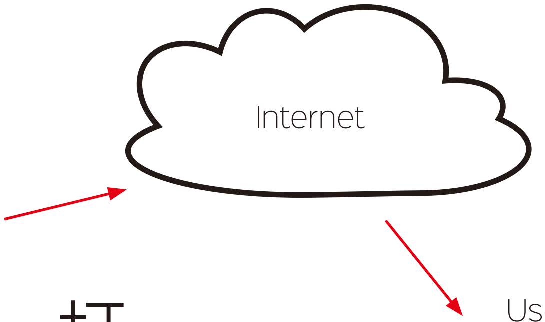
Yet, this is not the case. A commercial GPS is able to pinpoint a location to an accuracy of about 3 to 5 metres. Satellite clocks are already adjusted for general and special relativity to match the correct time on Earth, making up for the discrepancy between the user location and the satellites'. Additionally, the GPS receiver is also capable of performing calculations that are

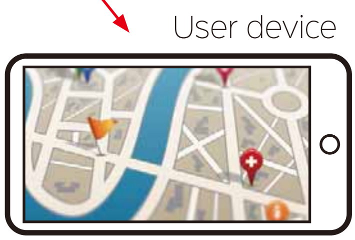
與相對論

By Jason Long Him Cheung 張朗謙

required due to Special Relativity. Without these adjustments, the GPS would no longer work to any meaningful degree of accuracy after around 2 minutes as the time lag becomes cumulative.

A smartphone uses a technology known as "Assisted GPS", which receives signals from both satellites and from servers such as mobile network cellular sites. Compared with a GPS, most smartphones are actually able to pinpoint location faster since it siphons help from connectivity, but where it shines in efficiency, it lacks in accuracy. It would be wise to not entirely trust a smartphone's GPS lest you walk into a river (yes, it has happened before). Common sense goes a long way!





打從70年代起，全球定位系統（GPS）開始發展，影響席捲全球，應用範圍從基本的導航輔助，延伸至手機遊戲，造就了風靡一時的手機應用程式如Pokémon Go及其前身Ingress。除了是複雜的衛星信號技術的成果，GPS也是會直接受愛因斯坦的狹義及廣義相對論影響的裝置，不過科學家已有對策。

GPS可以分為三個部分，即專用衛星、控制中心、以及用戶裝置或接收器。有大約30顆裝載原子鐘的衛星在環繞地球運行。無論何時，GPS接收器都要接收來自至少四個衛星的無線電波以確定位置。接收器利用電波傳送所需的時間來計算與每個衛星之間的距離，使用的三邊測量法與維恩圖有點像：衛星訊號呈球狀，從球面的交會點可以找出GPS接收器的位置。收到愈多衛星的訊號，就可以得到更精確的定位資料。

由於是以測量訊號的傳輸時間來定位，能夠準確地記錄時間是至關重要的。愛因斯坦的狹義相對論的精義是：在觀察者眼裡，移動中的時鐘要比靜止的時鐘走得慢。廣義相對論則指出重力亦會對時間產生影響：重力場越強，時間越慢。衛星在地表以上約20,000公里的軌道，以每小時14,000公里的速度運行。根據廣義相對論，衛星攜帶的時鐘要比地球上的時鐘快（軌道上的重力較小，所產生的廣義相對論效應，蓋過因高速移動而出現的狹義相對論效應），產生每天約38微秒的誤差。隨著時間累積，GPS的定位就會大大偏離正確位置，資訊近乎無用。

不過，現實卻並非如此。商用GPS定位的精確度可以高達約3至5米。衛星上的時鐘其實已根據廣義和狹義相對論作出調整，與地球上的時間同步，彌補了用戶位置和衛星在時間上的差異。此外，GPS接收器亦能按照狹義相對論而進行必要的計算。若果沒有這些調整，GPS在短短2分鐘後，就會因累積的時間落差而不能作出有意義的準確定位。

智能電話使用的技術稱為協助全球定位系統，從衛星及伺服器（如流動網絡的基站）接收信號。相對於一般的GPS，大多數智能手機得力於網絡傳送，能夠更快速地定位，只是效率雖然優勝，定位精度卻嫌不足。所以明智的做法是用點常識，不要完全信賴智能手機的GPS，免得掉進河中（這是真有其事的）。

Further Reading 延伸閱讀

http://www.astronomy.ohio-state.edu/~pogge/Ast162/Unit5/gps.html

Sleep is for the Weak – Natural Short Sleepers

天賦異稟短睡者

By David Iu 姚誠鵠

All mammals have to sleep. The necessity of sleep puts even the most powerful men and women on their backs. During this sacred time, tissues replenish and organs recalibrate. Humans spend roughly a third of their lifetime in serene slumber – except a small group of "natural short sleepers" who make up just 1 – 3% of the world's population. These super beings are simultaneously night owls and early birds, potentially working well into the night and waking up early in the morning, feeling entirely refreshed without the assistance of power naps or caffeine.

> ***I come to life about 11 at night, if I went to bed earlier, I'd feel like half my life was missing.***
>
> *- Linda Cohen, a short sleeper*

The study of short sleepers is a largely uncharted area in sleep medicine and what is responsible for their ability to function on little sleep is widely disputed. One theory suggests that some short sleepers may have a mild form of a psychiatric disorder known as hypomania, characterised by pervasive euphoria and hyperactivity. In a study from The University of Pittsburgh Medical Centre, natural short sleepers scored significantly higher than experimental controls in test scales for hypomania [1].

There are also possible genetic factors that influence short sleeping patterns. A variation in the gene ***hDEC2*** was discovered in natural short sleepers in 2009, by a research team led by Dr. Fu Ying-hui at The University of California, San Francisco who intended to study a circadian rhythm disorder called Familial Advanced Sleep Phase syndrome (FASP). It is a rare condition in which patients become lethargic in the evening and wake up unusually early. To their surprise, they found that the subjects naturally woke up early (around 4 am), but went to bed past midnight, contrary to what would be expected with sufferers of FASP. Genetic screening revealed that the subjects shared a single gene variation, which, once introduced to lab mice, elicited a short sleep phenotype as well [2].

Despite these discoveries, progress in identifying the genetic causes and molecular mechanisms of short sleepers remain marred by difficulties in finding true short sleepers. The data is difficult to obtain since short sleeping hours is hardly a disorder that is cause for a trip to the clinic.

Before you jump to the conclusion that you may be a short sleeper, here is something you should know. Whilst many claim to be short sleepers who regularly maintain fewer than 7 hours of sleep per night, most are chronically sleep-deprived. In fact, for every 100 people who think they do not need more than five or six hours of sleep every night, only about 5 can actually function with that little sleep, while the rest belong to a third of the

population who just do not get enough sleep for health and productivity. Dr. Christopher Jones, a neurologist at The University of Utah, oversaw the recruitment of short sleepers in the 2009 study. According to Dr. Jones, short sleepers are not only blessed with different circadian rhythms, they also feature faster metabolisms and are often more emotionally upbeat.

As splendid as gaining more hours in a day may sound, the National Institute of Health recommends sleeping at least 7 hours a day. Anything less is associated with suboptimal health and performance, particularly in memory. With the hustle and bustle of a cosmopolitan Hong Kong, the average person sleeps just 6.5 hours a day. Dr. Fu stressed that those of us who do not belong to the sleepless elite should aim to get the amount of sleep we truly need.

所有哺乳類動物都要睡覺。即使是世上最具威權者，也會因睡眠而倒下。在這神聖的時刻，身體組織得到補給，器官重新調較。人類一生中大概有三分之一的時間都在安睡中度過，但也有例外。有一小撮「短睡者」，約佔全球人口的百分之一到百分之三，可以集「夜貓子」和「早起鳥」於一身，即使工作至夜深，大清早醒來依然是精神奕奕，無需以補眠或咖啡因提神。

我每晚十一點左右會變得活力充沛。若然早睡，就像失去了一半人生。

短睡者 蓮達·高恩

有關短睡者的研究仍是睡眠醫學中一片未知的領域。他們睡得少卻依然保持效率，當中原因眾說紛紜。其中一套理論指出，有些短睡者可能患有一種輕微的精神疾病，稱為「輕中度躁狂病」，經常感到興奮躁動。賓夕法尼亞大學醫療中心的一項研究顯示，天生的短睡者在輕中度躁狂病測試中，得分遠比實驗對照組高 [1]。

不過，短睡模式也可能是受遺傳因素影響。2009年，加州大學三藩市分校傅嫈惠博士的團隊在研究「家族性睡眠時相提前綜合症」(FASP) 的過程中，在短睡者中發現了***hDEC2***基因變異。FASP是一種罕有狀況，患者的生理時鐘與一般人不同，在傍晚時分已感到非常睏，起床時間也就相應地提早許多。傅博士團隊驚訝地發現有些研究對象，雖然早早醒來（約淩晨四時），卻與FASP患者不同，深夜之後才開始休息。研究人員以基因篩檢方法，發現他們擁有相同的基因變異。將這變異引入實驗老鼠體內，也會誘發短睡表型 [2]。

儘管有這些發現，對於短睡現象的遺傳因素和分子機制，仍是所知不多，因為要找到真正的短睡者並不容易。一般人不會視睡眠時間短為病態而主動求診，所以搜集數據有相當難度。

在你斷定自己是短睡者之前，可要知道一些事實。許多人聲稱自己是短睡者，經常保持每晚睡眠時間少於七小時，其實他們多半是長期睡眠不足。實際上，美國一項調查顯示，每一百位認為自己只需要五到六小時睡眠的人當中，只有五個人真的只需要少量睡眠，剩下的人跟三分之一的美國人一樣，都沒有得到充足的睡眠來保持個人的健康和生產力。在2009年的研究中負責招募短睡者的猶他大學神經科學家克裡斯托佛·瓊斯博士表示，短睡者除了有不同的生理時鐘，還有更快的新陳代謝，而且普遍較為情緒樂觀。

每天少睡一點，可以節省數小時，看似是挺不錯的；但美國國立衛生研究院建議每天最少要睡七小時。不足這時數可能會影響健康及表現，特別是記憶。然而，在香港這繁忙的大都會裡，每晚平均睡眠時間就只有6.5小時。傅博士一再強調，一般人應按照自身真正的需要而安排睡眠量。

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應許之地

The concept of space nations has been a staple of science fiction for a long time coming, but an international group of scientists and entrepreneurs have begun serious proposition of the establishment of *Asgardia*. Named after the city of the skies ruled by Odin in Norse mythology, the *Asgardia* project has already recruited citizens to be part of its future. Its announcement has sparked much discussion and unanswered questions.

Asgardia is a prototype of a free and unrestricted society, a placeholder for knowledge, intelligence and science at its core while recognising the value of each human life. This ambition was announced at a press conference in Paris in October 2016. Its core aim is to launch a robotic satellite as early as the end of 2017 or 2018, followed by the establishment of a permanent space station that will act as a nation in outer space. The preliminary idea proposes a society governed by 12 ministries. The first eleven ministries are fixed, while the 12th ministry would be decided by popular vote through *Asgardia*'s Facebook community. Becoming a citizen of *Asgardia* is as simple as filling a form on their official webpage [1].

Its utopian concept, while perhaps slightly far-fetched, is at least grounded in noble motivation. The launching of a robotic satellite would potentially act as a shield for Earth, protecting it from cosmic rays, space debris and asteroids, according to a press release. Perhaps more worryingly, Earth's natural resources will likely be depleted in the near future and building a space nation would be a nifty solution. Finally, a curiosity for the unknown and to step into the unexplored are deeply entrenched in human nature. Just as humans were driven to discover new Earthly continents centuries past, space exploration is a natural step in progression [2].

While there has been much debate about *Asgardia*'s feasibility as a recognised and legal nation, its scientific achievability is just as ambitious. Scientists have proposed that *Asgardia*'s role in defending Earth against asteroids, for instance, would involve firing powerful lasers to alter the trajectory of the asteroid away from Earth. To minimise rays of charged particles from the sun that damage satellites, scientists propose giant magnetic fields that deflect these harmful particles. Not only would these projects require large sums of investments to get started, they are also scientifically challenging.

For now, the proposers of *Asgardia* have remained relatively vague. Its initiation has undoubtedly sparked discussion on space regulations, which are currently lacking. Unlike the International Space Station, which is a joint venture between nations, *Asgardia* aims to be one entity. For now, the initiators hope that the project would be crowdfunded. Signing up to

THE PROMISED LAND

By Thomas Lee 李浩然

become a citizen is apparently open to anyone (although it has been stated that precedence will be given to those who develop or invest in space technology). For the less ambitious and the commitment-phobes, the cheapest rides around space currently costs around USD$60 million on a Falcon 9 rocket.

長期以來太空國只是科幻小說的基本素材，由科學家和企業家組成的國際團隊卻認真籌建「阿斯伽迪亞」。阿斯伽迪亞是以北歐神話中奧丁統治的天空城命名，經已開始招募國民參與未來。這項計劃自公佈之後，惹來許多議論和問題。

阿斯伽迪亞的構思是要建立自由且不受制約的社會原型，以知識、智慧和科學為核心，承認每個人生命的價值。項目於2016年10月在巴黎的新聞發佈會上公佈，首要目標是要在2017年底或2018年發射一枚機器人衛星，然後建立永久太空站，發展成外太空國家。初步構想的社會是由12部管治：當中11部的職能已定了下來，餘下1部由阿斯伽迪亞的臉書專頁社群投票決定。只要填寫官方網頁上的表格，就可以成為阿斯伽迪亞公民 [1]。

這烏托邦概念雖然有點遙不可及，卻是出於崇高的動機。據新聞稿所述，發射的衛星可能會為地球提供屏障，保護地球不受宇宙射線、太空碎片和小行星傷害。或許更讓人擔憂的是：地球資源很有可能在不久將來耗盡，建設太空國會是很好的對策。人類對未知總是充滿了好奇，嚮往到未知之地。人類受此驅使在多個世紀以前發現了地球上的新大陸，現在要勘探太空也是自然不過 [2]。

阿斯伽迪亞能否得到確認，成為有法律地位的國家，目前還有許多爭議；至於在科學方面，能否達成宏大願景也很難說。有科學家提出阿斯伽迪亞要保護地球免受小行星撞擊，可以使用強大激光改變小行星軌跡。此外，太陽的帶電粒子流會破壞衛星，科學家建議利用巨大磁場偏轉有害粒子運行方向。這種種方案都需要大量投資才能啟動，而且要克服許多科技上的挑戰。

阿斯伽迪亞的籌建者迄今仍未作出具體說明，不過計劃無疑引起了對太空條約的關注。有別於多國合作的國際太空站，阿斯伽迪亞將會是自成一體。發起人目前希望透過眾籌方式集資。似乎任何人都可以登記成為公民（不過將會優先考慮那些參與開發和投資太空技術的人）。至於較為務實謹慎的人，目前往太空最便宜的方法是乘坐「獵鷹9號」火箭，費用大約為6000萬美元。

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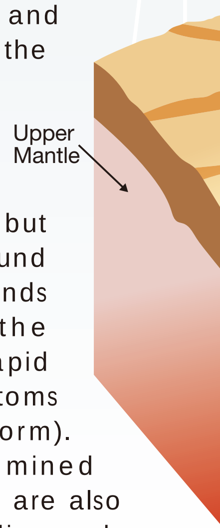
Synthetic Diam

An age-old status symbol of luxury and wealth, the crystal of carbon better known as diamond is a must-have jewel to adorn a ring finger. Its entrancing sparkle (measured as brilliance or lustre), characteristic properties such as its hardness, and longstanding role in western marriages have ensured that a diamond does not come cheaply. Yet, its high value is not derived from its rarity – rather, diamonds are counter-intuitively the most common gem, surpassing the more affordable rubies, sapphires and emeralds in abundance.

Diamonds were brought to unparalleled demand in the 1930s when De Beers Diamond Company (holding 90% of the world's entire diamond supply) launched the world's most successful advertising campaign, convincing the public that "diamonds are forever". Simultaneously, De Beers permanently slashed worldwide production, artificially raising the price of diamonds. In an effort to combat the stranglehold of De Beers and other cartels on the diamond supply, scientists have been attempting to perfect the synthesis of lab-made diamonds from raw carbon. The quality of these synthetic diamonds is rapidly reaching that of natural diamonds, turning a scientific endeavour into a high-stakes gambit.

Diamonds have been mined in India since at least 3000 years ago, but it was not until the 18th century that they were shown to be composed of carbon. Lavoisier used a lens to concentrate sunlight onto the surface of a diamond in a vessel filled with oxygen. The diamond combusted spectacularly and the vessel's air was precipitated in limewater, producing a milky solution. Through this experiment, Lavoisier was able to show that diamond reacts with oxygen to produce carbon dioxide. Lavoisier deduced that since diamonds and charcoal both produced CO_2, they must be made of the same substance: carbon [1]. Tennant later proved that since the combustion of diamond and graphite both produce the same volume of CO_2, they must be equivalent forms of carbon.

Natural diamond formation requires the conditions of high pressure (4.5 – 6 GPa) and high temperature (900 – 1300 °C). Within the Earth's mantle, there is sufficient pressure exerted by the weight of the rock above and sufficient thermal energy provided by the Earth's core. These areas of the Earth are hardly accessible, but deep and violent volcanic eruptions around 47 million years ago brought these diamonds to the surface. Diamonds form in the mantle within the volcanoes' ejecta. Rapid cooling of the ejecta lock the carbon atoms in place (otherwise, graphite would form). Most naturally formed diamonds are mined from rocks called Kimberlites. Diamonds are also sometimes formed from the impact of diamond-laden meteorites. The collision generates sufficient pressure and temperature for diamond formation to occur.



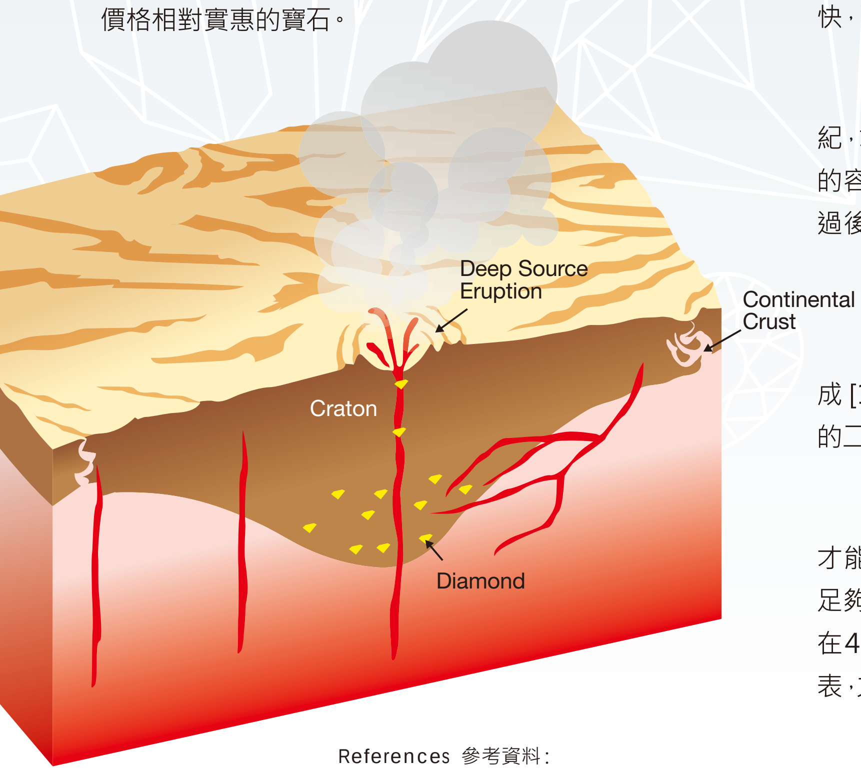
This article may be useful as supplementary reading for chemistry classes, based on the DSE syllabus.
根據化學科文憑試課程綱要，本文或可作為有用的補充讀物。

人造鑽石

NDS

By David Ren 任大偉

俗稱為鑽石的碳元素結晶，一直是奢華和財富的象徵，已成為無名指不可缺的飾物。它擁有讓人著迷的璀璨光芒（按光澤度而評鑑），和至高硬度等特徵，加上在西方婚俗中有悠久的地位，所以鑽石絕不便宜。不過，鑽石的價值雖然高，卻與稀缺無關；反之，鑽石是最常見的寶石，其量遠超過紅寶石、藍寶石和祖母綠等價格相對實惠的寶石。



在上世紀30年代，戴比爾斯鑽石公司（掌控全世界鑽石總供應量的90%）推出了世界上最成功的廣告活動，說服公眾「鑽石恒久遠」，將鑽石需求推高至前所未有。同時，戴比爾斯永久減產鑽石，人為地提高了鑽石價格。為了打擊戴比爾斯和其他壟斷者對鑽石供應的控制，科學家們一直嘗試完善以碳原料合成人造鑽石的工藝。合成鑽石的質量提高得很快，已經接近天然鑽石，令科研活動變成回報豐厚的舉措。

早於3000年前，在印度已有鑽石開採活動，但直至18世紀，才能證明鑽石是由碳組成。拉瓦西把鑽石置入充滿氧氣的容器中，利用透鏡把陽光聚焦在鑽石表面。鑽石壯麗燃燒過後，容器中的氣體可以和石灰水作用產生沉澱，讓石灰水變成乳白色。通過這實驗，拉瓦西成功證明了鑽石與氧發生化學反應，產生二氧化碳。拉瓦西更推論出鑽石和木炭同樣產生二氧化碳，一定是由相同的物質（碳）組成 [1]。譚能特後來證明，由於鑽石和石墨的燃燒產生等體積的二氧化碳氣體，它們必定是同素異形體。

天然鑽石需要高壓（4.5-6 GPa）和高溫（900-1300 ℃）才能形成。在地球深不可達的地幔層，上方岩石的重量帶來足夠的壓力，地核提供足夠的熱能。在這裡生成的鑽石，大約在4700萬年前的劇烈火山爆發中，隨著火山噴出物來到地表，之後迅速冷卻鎖定碳原子（不然就會化為石墨）。絕大多

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Beyond creating jewels, diamonds have wide applications due to extraordinarily high hardness and chemical stability. For example, industrial diamonds are able to cut through most substances. Diamond windows are extremely impact and abrasion resistant, so they are suitable for spacecraft or laboratory equipment. These applications have prompted scientists to synthesise diamonds in the laboratory by recreating the conditions of natural diamond formation.

A popular method for diamond synthesis is “chemical vapour deposition” (CVD). A sliver of diamond is first placed into a high temperature, low-pressure chamber. Then, a methane-hydrogen gas mixture in a 1:99 ratio (methane contains carbon; hydrogen strips off non-diamond carbon) is pumped in. The gases are ionised into plasma via a laser. Over time, free carbon radicals adhere to the diamond seed to grow larger [2]. CVD allows notably fine control over the impurity level and gem size of the final diamond. It is the impurity level that dictates the final color of the diamond as boron impurities yields blue diamonds, nitrogen makes yellow diamonds, and radiation makes green diamonds [3].

Experts find it increasingly difficult to distinguish a natural diamond from an artificial one; their structures are chemically identical. Since artificial diamonds form differently to natural diamonds, the processes leave distinct growth patterns such as growth striations and discontinuous growth blocks [4].

For instance, IIb type diamonds are inherently blue and emit blue light for a moment (phosphorescence). The reflectance and phosphorescence spectrum differ between natural and artificial diamonds. To leverage this phenomenon, one may shine UV light upon a IIb diamond and observe the subsequent orange-red phosphorescence at a wavelength of 660 nm (sometimes the orange-red is overpowered by blue-green phosphorescence). Other diamonds simply fluoresce under UV light. Upon testing several blue boron-doped synthetic diamonds, it was discovered that they lacked the characteristic 660 nm phosphorescence [5]. Note that this method only works when comparing blue synthetics to type IIb diamonds, one of the rarest types.

Spotting a synthetic diamond remains an inexact science [2]. As synthesis methods improve, it will become even more difficult to identify a synthetic diamond.

At the moment, the demand for synthetic diamonds is dwarfed by that for natural diamonds. However, as prices decrease due to further improvements to the technology, consumers may change their minds. Perhaps natural diamonds truly have an inherent value that does not exist in synthetics.

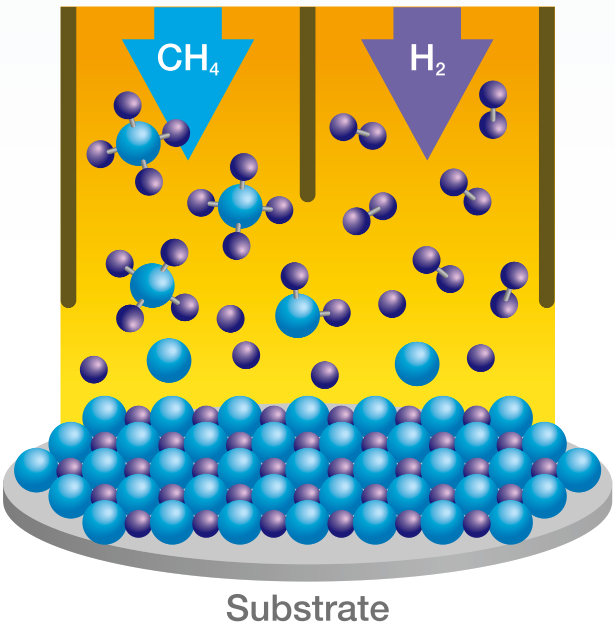
Regardless, the greatest demand for diamonds lies in the semiconductor industry. As transistors become thinner, silicon struggles to whisk away unwanted heat. With adequate doping, however, diamonds can prove to be the saviour of the semiconductor industry. Their naturally high thermal conductivity is conducive to withstanding higher temperatures without breaking down. In extension, diamond-based semiconductors cool faster, are more environmentally friendly, and switch voltage more readily than a silicon semiconductor. The primary obstacle to widespread adoption of diamonds in the semiconductor industry is their cost. With the advent of synthetic diamonds (specifically boron diamonds because only boron diamonds are semiconductors), a new age of semiconductors may emerge [6].

SYNTHETIC DIAMONDS 人造鑽石

數的鑽石都是從這些「金伯利岩」中開採得來。偶然在隕石撞擊地球時，也會產生足夠的壓力和溫度形成鑽石。

鑽石有非常高的硬度和化學穩定性，除了可作首飾，還有許多用途。例如，工業用鑽石可用於切割大多數物料。鑽石窗具有極強的抗衝擊和耐磨性，適用於航天器或實驗室設備。因此，科學家希望能模倣天然條件，在實驗室中合成鑽石。

合成鑽石通常是用「化學氣相沉積」或CVD生產。先將一小塊作為種子的鑽石放入高溫低壓室中，然後泵入比例為1:99的甲烷—氫氣混合物（甲烷提供碳元素，氫氣移除多餘的碳原子），再用鐳射將氣體變成等離子體。其中的遊離碳自由基附著在種子上，讓鑽石逐漸變大[2]。CVD可以精準控制生成鑽石的雜質和大小。鑽石成品的顏色取決於雜質：含硼的是藍鑽、含氮的是黃鑽，接觸到幅射的就成為綠鑽[3]。



專家們也認為，越來越難分辨天然和人造鑽石。它們的化學結構完全相同，不過形成過程不同，留下了不同的生長紋、不連續的生長結構等特徵[4]。

舉個例子，IIb型鑽石本身是藍色的，也會發出短暫的藍色磷光。天然和人造鑽石有著不同的反射率和磷光光譜，可以利用這來分辨兩者。IIb鑽石經紫外線照射後，會放出660 nm波長的橙紅色磷光（有時橙紅色會被藍綠色的磷光蓋過）。其他鑽石在紫外光下只會發出螢光。測試過幾顆摻雜硼的合成藍鑽後，發現它們都不能放出那種特殊的660 nm磷光[5]。不過這方法只適用於比對合成藍鑽和IIb鑽石（最罕見的鑽石種類之一）。

鑑別人造鑽石仍說不上是一門精確的科學[2]。隨著合成方法的改進，要識別合成鑽石將會變得更加困難。

目前，對合成鑽石的需求跟天然鑽石相比是微不足道。不過，當技術進一步改善以致價格下降後，消費者可能會改變主意；除非天然鑽石確實具有在合成鑽石中找不到的內在價值。

無論如何，對鑽石需求最殷的還是半導體工業。電晶體變得越來越薄，矽材料已難於應付所產生的廢熱。摻入足夠雜質的鑽石可以讓半導體工業解開這困局。鑽石有很高的熱導率，可以承受高溫而不會損毀。相對於矽半導體，鑽石半導體更快冷卻，更環保，也更易切換電壓。目前尚未能在半導體工業中廣泛採用鑽石，主要的障礙是成本。隨著合成鑽石的出現（特別是硼鑽，因為只有這類鑽石能作半導體），可能會出現半導體的新時代[6]。

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Patience is a Virtue

By Rinaldi Gotama 李嘉德

What comes to your mind when you hear the word ***dominance***? You may think of a group of confident athletes and cheerleaders, or that one person in your class who frequently answers questions in class. The phenomenon of social dominance is not only seen in humans, but also exists in the animal kingdom – especially in our closest living relatives, the chimpanzee.

Chimpanzees are one of two extant great apes living in the forest of Central Africa (the other being gorillas). They travel in small groups of up to ten individuals to forage or hunt. The memberships of these small groups are often dynamic, where chimps regularly split with current groups and merge with new groups. Sometimes, these small groups join together in a large gathering when food is abundant or to increase chances of mating.

But similar to human groups, a lack of a clear shot-caller or leader could potentially signify chaos. Social hierarchy exists in chimpanzee communities, dictating the quality of life, such as who gets to eat the most fruits or to mate with the highest-ranking females [1].

Within this community, studies have shown that male chimpanzees are dominant to all females, with one male reigning at the top. This dominant male is called the *alpha* – and he is usually the fittest and the most aggressive in a group. Other than brute force, the ranking system also appears to follow the age of the chimps; ranking increases with age and peaks at around 20 years old, before seeing a decline as the chimp ages [1].

The social system of chimpanzees is studied by scrutinising their behaviour during their interaction with one another. To determine the social ranking of each chimp, scientists observed their communication through a signal called the "pant-grunt" – performed by one chimp to another in a display of submission. The researchers then noted who submits to whom, and eventually plotted a hierarchy in the community of chimps [2].

Though, living in this seemingly orderly community is not as harmonious as it appears. Male chimps fight each other constantly for the highly coveted *alpha* status to gain access to more food and better chances to sire an offspring. Even though females also exhibit similar hierarchical status within the community, their rankings were less prominent as they have fewer interactions between them in comparison to male chimps [2]. Studies show that rather than fighting, female chimps prefer to "wait in queue" until one dies or leaves the group [3].

Such seemingly "passive aggressive" behaviour could be beneficial to the females. Compared to males, female chimpanzees seem to have adopted a long-term strategy for survival. If a male wants to sire an offspring, he can mate with multiple females in a short period of time. For a female however, she can only raise one young chimpanzee at a time – thus her reproductive success depends heavily on how long she can survive [3]. For female chimps, good things come to those that wait. As they avoid challenging each other in a series of potentially-tumultuous fights, they also avoid dangerous situations and threats to their survival.

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等待，值得嗎？

聽到「優勢」一詞，你或會想到那些總是在運動場上耀武揚威的運動員和啦啦隊、或是那位老是搶著答問題的同學。其實，「社會優勢」現象不單是見於人類社群，也普遍存在於動物界，特別是在人類的近親黑猩猩族群中尤為明顯。

黑猩猩是現存在中非森林中的兩類大猿之一（另外一類是大猩猩）。牠們結伴覓食和打獵，每群不超過十隻。群落成員經常變換，拆夥之後又融入新群落。有時，不同的群落還會在食物豐足的日子、或是交配季節聚集起來。

跟人類社會一樣，若沒有發號司令的領導者，就有可能出亂子。黑猩猩的社群也有等級之分，主宰黑猩猩的生活質素，決定哪位成員可以享用最多的水果，或跟地位最高的雌性交配 [1]。

研究顯示，在這些群體中，雄性黑猩猩支配所有雌性（女生們對不起啦~），而且只有一隻雄猩猩會擔當領導者，屹立於社會階梯的頂層，被稱為阿爾法雄性，通常是族群裡最健壯和最好鬥的一隻；但除了蠻力以外，年紀似乎也會影響社會地位。黑猩猩的地位隨年齡而攀升，在二十歲左右達到巔峰，之後隨著年華老去而下降 [1]。

你可能會問，子非猩，安知猩之位？其實是通過細察牠們的互動行為，來探索黑猩猩的社會系統。為了判斷每隻黑猩猩的社會地位，研究人員分析牠們的溝通信號，特別是在表示服從時發出的一種獨特的伴著喘氣的咕嚕聲。研究人員們根據這些聲音記下每隻黑猩猩服從的對象，以此分析出族群裡的等級高低 [2]。

不過，在這看似循規蹈矩的社群裡生活，並非如想像般和諧。覬覦阿爾法地位的雄性黑猩猩經常互相打鬥，以爭取高位所帶來的饒飽和更多繁衍後代的機會。另外，儘管雌性黑猩猩在社群中也有類似的階級分野，卻不如雄性明顯，因為雌性之間的互動不及雄性頻繁 [2]。研究顯示，雌性黑猩猩不會以武力爭取，寧願安分守己，等待上位者過世或者離群 [3]。

雖然如此，雌性黑猩猩的「被動攻擊」式行為好處甚多。跟雄性相比，雌性黑猩猩似乎傾向採取長線策略求存。雄性可以在短時間內跟多名雌性交配，完成傳宗接代的目的。雌性卻只能在同一時間撫養一隻幼猩，因此生殖成功率在很大程度上要取決於能活多久。既然進化適應性與壽命掛鉤，就意味著打鬥的代價太高，不值得為了爭奪高位而冒險 [3]。

對於雌性黑猩猩來說，耐心等待自然會帶來好處。牠們不會互相挑戰，捲入連番的惡鬥，也就可以避開險境，降低了對生存的威脅。

THE BENEFITS OF ORGANIC FOOD

By January Lok Yi Cheung 張樂兒

According to the U.S. Department of Agriculture (USDA), produce grown without the use of artificial fertilisers, pesticides and dyes and not processed using industrial solvents can be categorised as organic. Animals that turn into meat cannot be fed growth hormones or regular use of antibiotics. Furthermore, both produce and meat cannot have undergone genetic modification. These stringent rules typically translate to higher prices in the organic alternatives, but organic products are generally viewed as the healthier option.

However, according to a recent comprehensive literature review conducted by scientists at Stanford University Medical Center, organic food may not necessarily contain higher nutritional value or offer fewer health risks than non-organic food. Taking account of 17 studies that documented subjects who had normal diets versus organic diets, and 223 studies which examined nutrient levels in organic food and conventional produce, they did not find substantial evidence that supported significant health benefits in organic foods. Aside from phosphorous, vitamin content was similar in both types of food as well.

The study did reveal that organic produce in particular had less risk of pesticide contamination and that while they still contained pesticides, the levels were all under safety limits [1]. However, Christie Wilcox, postdoctoral researcher and scientific communicator at Scientific American, explains that conventionally grown produce is also strictly monitored for pesticide residue [2], and "from a practical standpoint, the marginal benefits of reducing human exposure to pesticides in the diet ... appears to be insignificant" [3].

That being said, the advantages of organic farming for the environment and for ethical reasons are far-reaching, even if the health benefits seem to fall flat. In a paper published by *Nature*, scientists David Crowder and colleagues reported that organic farming not only alleviates ecological damage brought about by human activity, but also restored balance between predator and pathogen biological control agents, which extended to natural pest control [4]. For instance, organic weed management enhances suppression, instead of elimination by synthetic herbicides used in conventional farming.

There is also evidence to show that organic farming may be more energy efficient than conventional methods. In a three decade study conducted by the Rodale Institute, they grew conventional and organic corn under controlled conditions and recorded the energy usage in both. The results were astounding. One hectare of corn grown conventionally required 71% more energy than that of the organic corn. They attributed this large discrepancy in energy requirement to the use of nitrogen-based fertilisers. Conventionally grown corn used synthetic nitrogen fertilisers, which requires a large amount of oil to manufacture [5]. While the organic crop also required nitrogen, they were able to use sources from compost, nitrogen-fixing crops (legumes) and natural fertilisers that contained the element. It seems, that organic farming may reduce our carbon footprint significantly.

Organic foods are indisputably more expensive than conventionally grown crops and the average consumer must make a decision as to whether it is worth the extra investment. The premiums attached to organic foods come from a typically lower yield – more time to produce and smaller farms. While there appears to be mounting evidence

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。

有機食品的好處

for insignificant health and nutritional benefits from the consumption of organic produce, the advantages of organic farming for the environment are extensive. Besides, organic food generally does taste better than their conventional counterparts.

根據美國農業部（USDA）訂定的標準，種植過程中不使用人造肥料、農藥和染料，加工程式也不涉及工業溶劑的產品，可以歸類為有機。提供肉類的動物，飼養不能使用生長激素或抗生素。產品和肉類都不能經過基因改造。這些嚴格的規限通常反映在有機食品較高的價格，但普遍認為有機產品較為健康。

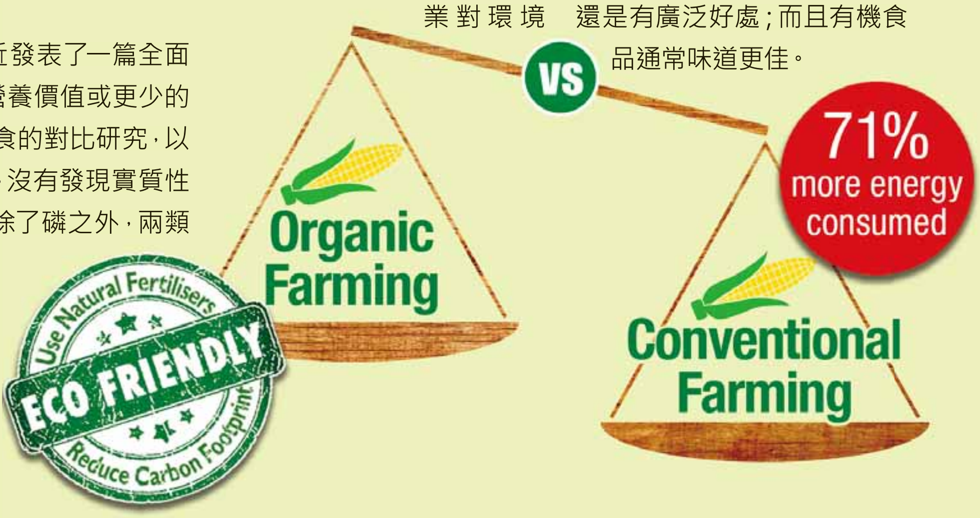
然而，史丹佛大學醫學中心科學家最近發表了一篇全面的文獻綜述，指出有機食品未必有更高的營養價值或更少的健康風險。他們參考了17項正常與有機膳食的對比研究，以及223項有機和常規產品營養含量的分析，沒有發現實質性的證據支持有機食品有顯著的健康益處。除了磷之外，兩類食品的維生素含量相若。

這研究卻揭示了有機產品受農藥污染的風險較低，所含的農藥量在安全值範圍內 [1]。《科學美國人》負責科學傳訊的克利斯蒂·威爾科克斯博士解說：常規種植的產品在使用農藥方面已受到嚴格監管 [2]，「從實際角度考慮，人體減少從膳食中攝取農藥，所得到的邊際效益... 似乎是微不足道」[3]。

話雖如此，即使有機農業的健康效益似乎平平，但就環境和道德層面而言，卻有深遠的意義。在《自然》發表的一篇論文中，大衛·克勞德等科學家報告有機農業不僅減輕人類活動所造成的生態破壞，更還原了捕食者和病原體生物防治劑的平衡，達到自然病蟲害防治 [4]。舉例而言，有機雜草管理強調的是抑制生長，以代替常規農業用合成除草劑消除雜草的方法。

此外有證據表明，有機農業可能比常規方法更可以節省能源。羅代爾研究所進行了一項為期三十年的研究，他們在嚴格控制的條件下種植常規和有機玉米，並記錄了兩者的能源消耗量，得到令人震撼的結果。相對於有機玉米，以常規方法種植一公頃的玉米需要耗用多71%的能量。他們歸因於使用氮基肥料，造成巨大的能量需求差異。常規種植的玉米所使用的合成氮肥，需要以大量的石油物質來生產 [5]。雖然有機作物也需要氮，但可以從堆肥、固氮作物（豆類）和天然肥料等處得到。由此看來，有機農業可以顯著減少碳足跡。

有機食品的價格肯定是高於傳統種植的農作物，消費者要自行決定這額外投資是否值得。有機食品的代價還包括較低的產量、較長的生產週期和較小的農場。儘管有越來越多的證據表明有機產品在健康和營養方面效益不彰，但有機農業對環境還是有廣泛好處；而且有機食品通常味道更佳。



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In the past century, the Earth's temperature has risen around 0.5 °C per year, which has translated to about a 2.6 inch rise in global sea levels between 1993 and 2014 due to melting ice caps. At this rate, experts believe it will take five thousand years to melt all five million cubic miles of ice on Earth. The precious coastlines and landscape we take for granted will soon be at the demise by our own hands. Thus, the effort in slowing down rising sea levels is extremely important.

融冰之後

What Would Happen if All of Earth's Ice Melted?

By Twinkle Poon 潘晴

Much of Earth's land mass is comprised of ice caps in the Arctic and Antarctica. The latter alone consists of an average ice thickness of 2133 m. If all of Earth's ice caps defrosted, the total rise in sea level will likely reach 70 m [1]. This means that entire cities will be submerged. In addition, continents and shorelines will be changed. New York, Tokyo, Shanghai, Jakarta and Hong Kong are all coastal cities that will be wiped out. In fact, a mere rise of 10 m in current sea levels will displace more than 600 million people (nearly 10% of the world's population). The entire state of Florida will be drowned, as well as many areas in Asia and a new inland sea will be created in Australia. Half of the population in the world who live near coasts will be homeless.

In addition to humans, the habitats of polar bears, seals, walruses and penguins will undoubtedly disappear as these organisms rely on ice caps to survive. According to the United Nations Global Biodiversity Outlook, the loss of ice in the Arctic threatens biodiversity across an entire biome and most species will be unable to adapt to a habitat without ice caps.

That being said, the temperature in Antarctica rarely ever fluctuates above freezing point, which protects the ice caps from melting. At present, what is most concerning to rising sea levels is actually the Arctic, where ice floats atop the Ocean and is more prone to melting. In addition, melting ice caps in Greenland contribute to rising sea levels significantly as it is geographically

在過去一個世紀，地球溫度平均每年上升約0.5攝氏度；與此相呼應，在1993年到2014年間，全球海平面因為冰蓋融化而上升了約2.6英吋。按照這個速度，專家相信地球上500萬立方英里的冰層，將在5,000年內完全融化。寶貴的海岸線和我們熟悉的風景，不久將會因人類的作為而消逝。當務之急是要減慢海面上升的速度。

located farther toward the equator with higher temperatures.

Climate scientists at Climate Central, Ben Strauss and his group, attempted to correlate the burning of fossil fuels and carbon emissions with the rise of sea levels. By analysing massive amounts of data accumulated over the years, they plotted sea levels against carbon emissions and temperature, and were able to determine ratios between the factors. They concluded that "burning [just] one gallon of gasoline translates to adding 400 gallons of water volume to the ocean" [2]. Consider extrapolating that into global consumption – The United States alone burns a daily average of around 385 million gallons of gasoline.

Reducing carbon emissions is perhaps the most intuitive way to decrease the rate of sea level rising. However, according to a study from the National Center on Atmospheric Research, this might already be too little too late. While certain forecasts are more optimistic than others, the general consensus appears to agree that the rise of sea levels is inevitable. What seems to be a more useful solution is to embrace the ability of humanity to adapt to the changing environment and to impede melting ice caps to allow time for this adaptation to occur.

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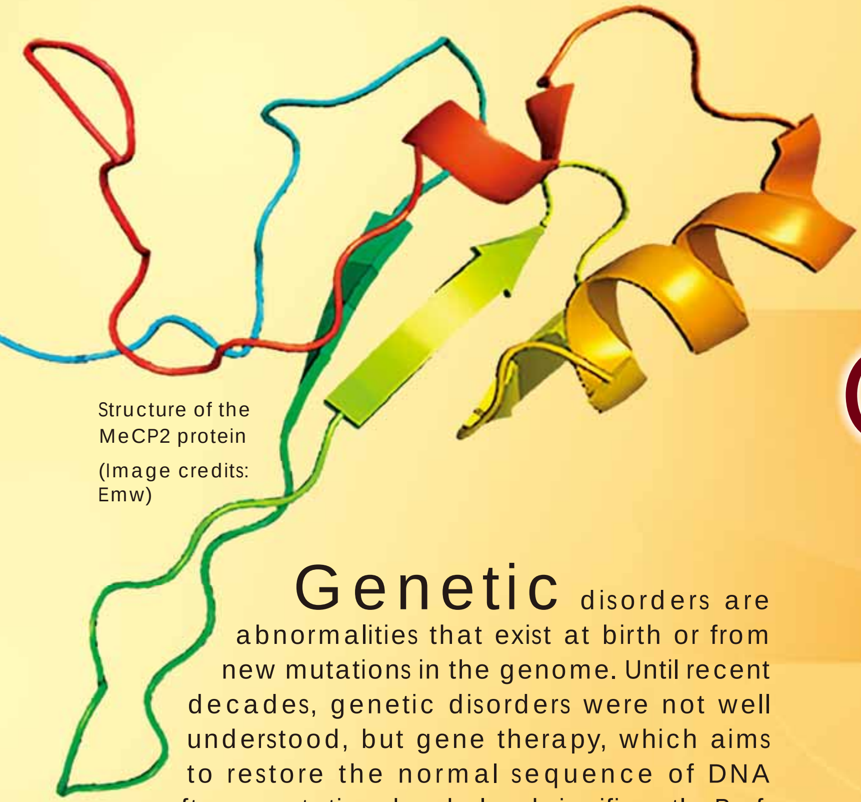
南北極的冰蓋佔了地球質量的大部份，單是南極冰蓋的平均厚度就有2,133米。假設地球上的冰蓋全部融化，海平面上升的總和將會達到70米 [1]。這意味著許多城市都會被海水掩蓋。此外，各大陸和海岸線都會出現變化，紐約、東京、上海、雅加達以及香港等沿海城市將隨之而消失。水位上升即使只有10米，也會導致6億人口流離失所（近10%的世界人口）。整個佛羅里達州以及亞洲不少地區和國家都會淹沒，澳大利亞將會出現新內陸海，靠岸人口將有一半無家可歸。

除了人類，依靠冰蓋存活的北極熊、海豹、海象和企鵝的棲息地也肯定會消失。根據聯合國發表的「全球生物多樣性展望」，北極冰層流失正威脅著整個生物群落，許多物種將無法適應沒有冰蓋的棲息地。

話說回來，南極的溫度甚少高於冰點，冰蓋得以保全。目前，最令人擔心的是北極的海平面。那裡的冰層漂浮在海洋之上，較容易融化。此外，格陵蘭的地理位置較接近赤道，溫度相對較高，融化的冰蓋會顯著提升海平面。

美國氣候中心的氣候科學家本傑明．施特勞斯和他的團隊，嘗試找出燃燒化石燃料和碳排放與海平面上升的關係。他們分析多年積累下來的數據，得到海平面和碳排放量及全球溫度之間的比率，作出結論：(僅僅）燃燒一加侖汽油，就等於在海洋注入400加侖水 [2]。試將結果延伸至全球的消耗量──單是美國平均每天燃燒的汽油就差不多有3.85億加侖。

減少碳排放或許是減緩海平面上升速度的最直觀方法；然而，美國國家大氣研究中心認為這遠遠不夠，而且太遲。雖然有些預測相對樂觀，但普遍的共識是海平面上升已是無法避免。看來更實際的對策是要施展人類應對變化環境的能力，同時要阻止冰蓋融化以爭取足夠的時間來適應。



Structure of the MeCP2 protein

(Image credits: Emw)

Gene Therapy *with*

Genetic disorders are abnormalities that exist at birth or from new mutations in the genome. Until recent decades, genetic disorders were not well understood, but gene therapy, which aims to restore the normal sequence of DNA after a mutation, has helped significantly. Prof. Adrian Bird, 2016 Shaw Laureate in Life Science and Medicine, shared the Shaw Prize with Prof. Huda Y. Zoghbi, in making substantial advances in treating a particular genetic disorder known as Rett syndrome, which affects the grey matter in the brain. They discovered the encoded proteins that recognise a chemical modification of the DNA which influences gene control as the basis of the developmental disorder.

Rett syndrome is brought about by mutations in the gene MeCP2 on the X chromosome and can cause developmental problems in babies such as small hands and feet as well as microcephaly in some cases (slowed rate of head growth). Prof. Bird found that mice with MeCP2 mutations also displayed similar clinical features of Rett syndrome. In both humans and mice, the syndrome causes neurons to be smaller and less active. Prof. Bird attempted to correct the mutation by replacing the missing MeCP2 protein in mice, yielding positive results after gene restoration. The experiment established that Rett syndrome is, at least in principle, a treatable condition.

This elegant solution has been predicted to be adapted for human treatment in the near future. Prof. Bird and his collaboration with scientists from the U.S. have recently attempted to engineer gene therapy in mice. The MeCP2 gene would be delivered using a virus as a vector, an approach that would in theory be adaptable to humans. Mice treated with this therapy showed marked improvement in symptoms. However, there is still a long way to go before their experiment can be applied to human clinical trials.

While ground-breaking and undoubtedly exciting, gene therapy has historically encountered numerous setbacks. Prof. Bird said:

> “*Perseverance, imaginative and patience are some of the prerequisites for being a scientist.*”

He discovered the MeCP2 protein back in 1992 but many of its functions are still shrouded in mystery to be unraveled. He believes that the best way of conducting research is to test hypotheses rather than to continuously collect biological data as a means to gain real knowledge. Thus, he insists on bold experiments and is not afraid of destroying hypotheses that he holds dear.

> “*My dream is that I am still doing science when this distressing disorder is finally cured.*”

Prof. Bird's laboratory remains interested in genome organization and, in particular, in how epigenetic markers are laid down to assist and manage gene activity. Part of his group works on CpG islands and DNA methylation. Their research on Rett syndrome is ongoing and they have plans to test new hypotheses about MeCP2 and its correlation to Rett syndrome. The ultimate goal is aimed at making Rett syndrome gene therapy a reality.

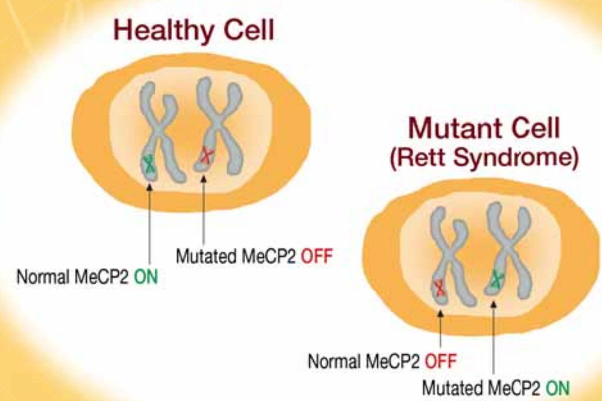
基因治療與
阿德里安·伯德教授
Prof. Adrian Bird

By Teresa Ming Shan Fan 樊銘姍

Photo credits: Jane Gitschier

遺傳性疾病是指在出生時已出現或由於基因組的新突變而造成的異常。直到近幾十年，對遺傳疾病的認識還是不多，但因為有基因治療，情況大為改善。基因治療的目的是將經過突變的脫氧核醣核酸(DNA)恢復到正常序列。艾德里安•伯德和胡達•佐格比兩位教授共享2016年度邵逸夫生命科學與醫學獎殊榮，他們的發現讓蕾特氏症治療取得實質性進展。蕾特氏症是一種影響大腦灰質的遺傳病。他們發現一類蛋白能夠識別一種影響基因調控的DNA化學修飾，並確立編碼這類蛋白的基因發生突變，就會導致發育障礙疾病蕾特氏症。

蕾特氏症是由X染色體上的MeCP2基因突變引起，可以在嬰兒期引發多種發育問題，例如：肢體發育障礙，有些案例出現小頭症(也就是頭部生長速度減慢)。伯德教授發現帶有MeCP2突變的小鼠，也出現類似特徵。在蕾特氏症患者和小鼠實驗模型中，神經細胞數量減少而且活性不足。伯德教授嘗試修正突變，補充小鼠模型中缺失的MeCP2蛋白質，在修復基因後得到良好的結果。這實驗說明了蕾特氏症在原則上是可以治癒的。



預期在不久將來，這漂亮的方案就可以用於治療蕾特氏症。伯德教授最近和美國科學家合作，試圖以小鼠為模型設計基因治療。他們使用病毒載體遞送MeCP2基因，理論上這方法亦可以用於人體。接受這療法的小鼠，症狀有明顯改善，不過在進入人類臨床試驗之前，還有漫漫長路要走。

這項突破無疑是振奮人心，但過往基因治療曾遇過許多挫折。伯德教授說：

> 「*科學家必須要有毅力、想像力和耐心。*」

其實，他早在1992年已發現了MeCP2蛋白質，但其許多功能還是有待破解。他認為研究的最佳途徑是驗證假設，而非只靠不停收集生物數據來求取真知。因此，他主張大膽作實驗，不怕推翻那些他看重的假設。

> 「*我的夢想是，當這種讓人受苦的疾病終於能夠被治癒時，我依然在從事科學。*」

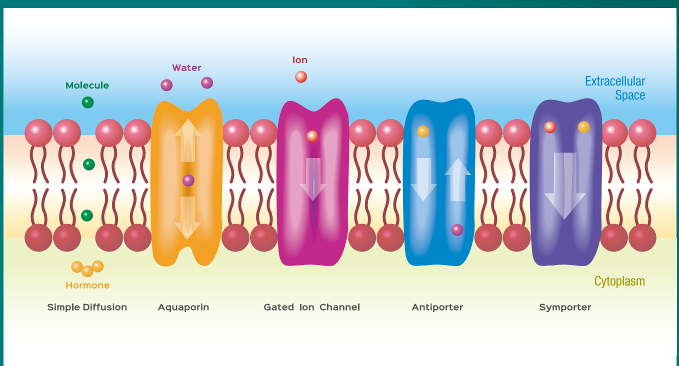
伯德教授實驗室仍然致力研究基因組的組織，特別是關於表觀遺傳學標記，如何佈置以協助和管理基因活動。部分成員的研究集中在CpG島和DNA甲基化。與蕾特氏症相關的研究還在進行中，並有計劃測試關於MeCP2的新假說及其與蕾特氏症的關係，最終目標是要實現蕾特氏症的基因治療。

For more than two decades, Prof. Randy Schekman had been a Howard Hughes Medical Institute Investigator at the University of California, Berkeley. He and his collaborators made pioneering breakthroughs and discoveries of targeted vesicular transport in eukaryotic cells, and found that malfunctions in yeast cells arose due to genetic defects. In 2013, Prof. Schekman shared a Nobel Prize in Physiology or Medicine with Prof. Thomas Südhof, whom we interviewed back in the first issue of *Science Focus*.

Prof. Schekman's passion for science began early. Stemming from a toy microscope that he received as a gift, he would examine the water retrieved from a nearby creek to find a world of creatures swimming under the lens. His passion for being a scientist was magnified when he saved up enough money to purchase his first professional microscope, a treasure held dear to him until he left for university. Those findings would be reported in a yearly independent science fair project. A career path of research seemed natural.

For the past 20 years, Prof. Schekman has been working on cell communication in the form of an extracellular vesicle, or exosome, which contains membrane proteins and a set of RNAs that convey information to control signalling and gene expression in a target cell. He found that exosomes capture selected microRNAs that form on the surface of an endosome inside a donor cell. Thus, Prof. Schekman's lab has devised a biochemical approach to study the mechanism of RNA sorting into exosomes, but the role of the extracellular RNA contained within exosomes that delivers such information remains uncertain.

Their research has helped the biotechnology industry make significant advances. The knowledge of transport and communication of cells reveal ways in which drug delivery can be made more streamlined and efficient. Insulin and human growth hormone, for instance, can be released by yeast. Additionally, their mapping identified how nerve cells release neurotransmitters. The research has far-reaching future implications as well, particularly in the application of treating metastatic cancer, or the development of progressive neurological disorders such as Alzheimer's disease and Parkinson's disease. According to Prof. Schekman, it is hopeful that exosomes could be engineered to deliver small molecules or RNAs that control pathological processes in targeted cells.



Prof. Schekman's philosophy for facing the inevitable setbacks and difficulties in research is to maintain a patient attitude and to always meticulously plan in case one approach fails.

> *"It is easy to become frustrated with the usual failure of experiments, but one must remain motivated by the main goals and approaches, and be willing to re-examine an approach to find a new way forward."*

Not surprisingly, Prof. Schekman has received generous and continuous support for his research from the U.S. National Science Foundation, the U.S. National Institutes of Health and the Howard Hughes Medical Institute. It is likely that he will continue to work on membrane assembly, vesicular transport and secretory pathways until he chooses to retire.

> *"My keenest interest is in establishing the molecular basis of miRNA sorting into exosomes and to seek evidence for or against a role for the small RNAs within exosomes in delivering information from a donor to a target cell."*

蘭迪‧謝克曼博士是加州大學柏克萊分校教授，同時任職霍華德‧休斯醫學研究所超過20年。他與合作者在真核細胞的靶向囊泡運輸研究方面，作出了開拓性的貢獻，並且發現遺傳缺陷造成酵母細胞的功能障礙。謝克曼教授與

2013 Nobel Laureate in Physiology or Medicine
2013年度諾貝爾生理學或醫學獎得主

Cellular Transportation with Prof. Randy W. Schekman

與蘭迪·謝克曼教授談細胞運輸

托馬斯•聚德霍夫教授於2013年共同獲得諾貝爾生理學或醫學獎。我們有幸曾訪問聚德霍夫教授，刊於「科言」第一期。

謝克曼教授從小就熱愛科學。他在童年時收到了一份禮物，是一台玩具顯微鏡。透過鏡片，他看見從附近小溪採集的水樣包羅眾生。當他攢夠了錢，買了第一台專業顯微鏡時，他就更醉心於科學探索，每年都有成果在科學展覽展出。這台顯微鏡一直是他的寶貝，直到他離家上大學。對他來說，踏上科研路是自然不過的。

在過去20年，謝克曼教授一直研究通過胞外囊泡或外泌體進行的細胞通訊。這些外泌體含有膜蛋白和載著資訊的RNA，可以在靶細胞調控信號轉導和基因表達。他發現外泌體可以從母細胞的內體表面摘取指定的微RNA。謝克曼教授試驗室特地設計了一套生物化學方法研究分選RNA到外泌體的機制，至於外泌體中的胞外RNA的機制仍然是不肯定。

他們的研究讓生物技術業取得了重大的進展。有了細胞運輸和通訊方面的知識，就可以研發更精簡有效的藥物傳輸方法；例如，胰島素和人類生長激素可以通過酵母釋放。他們的工作也說明了神經細胞如何釋放神經遞質。這項研究對未來還有深遠的影響，特別是應用在治療轉移性癌症、或進行性發展的神經系統疾病如阿爾茨海默氏病和帕金森病。謝克曼教授認為外泌體經改造後，有可能用於遞送小分子或RNA到靶細胞，控制病理過程。

研究中免不了會遇對挫折和困難，謝克曼教授的哲學是要保持耐性，失敗之後要細心籌謀。

> *“實驗經常會失敗，很容易會因此而氣餒，但必須要繼續往目標前進，並且願意重新檢討以求找到新出路。”*

讓人慶幸的是，謝克曼教授一直得到美國國家科學基金會、美國國立衛生研究院和霍華德•休斯醫學研究所的慷慨支持，應該可以繼續研究膜組裝、囊泡運輸和分泌途徑，直到他選擇退休為止。

> *“我最大的興趣是要建立微RNA分選到外泌體機制的分子基礎；及要尋找證據說明外泌體中的小RNA在細胞之間的信息傳遞是否起作用。”*

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