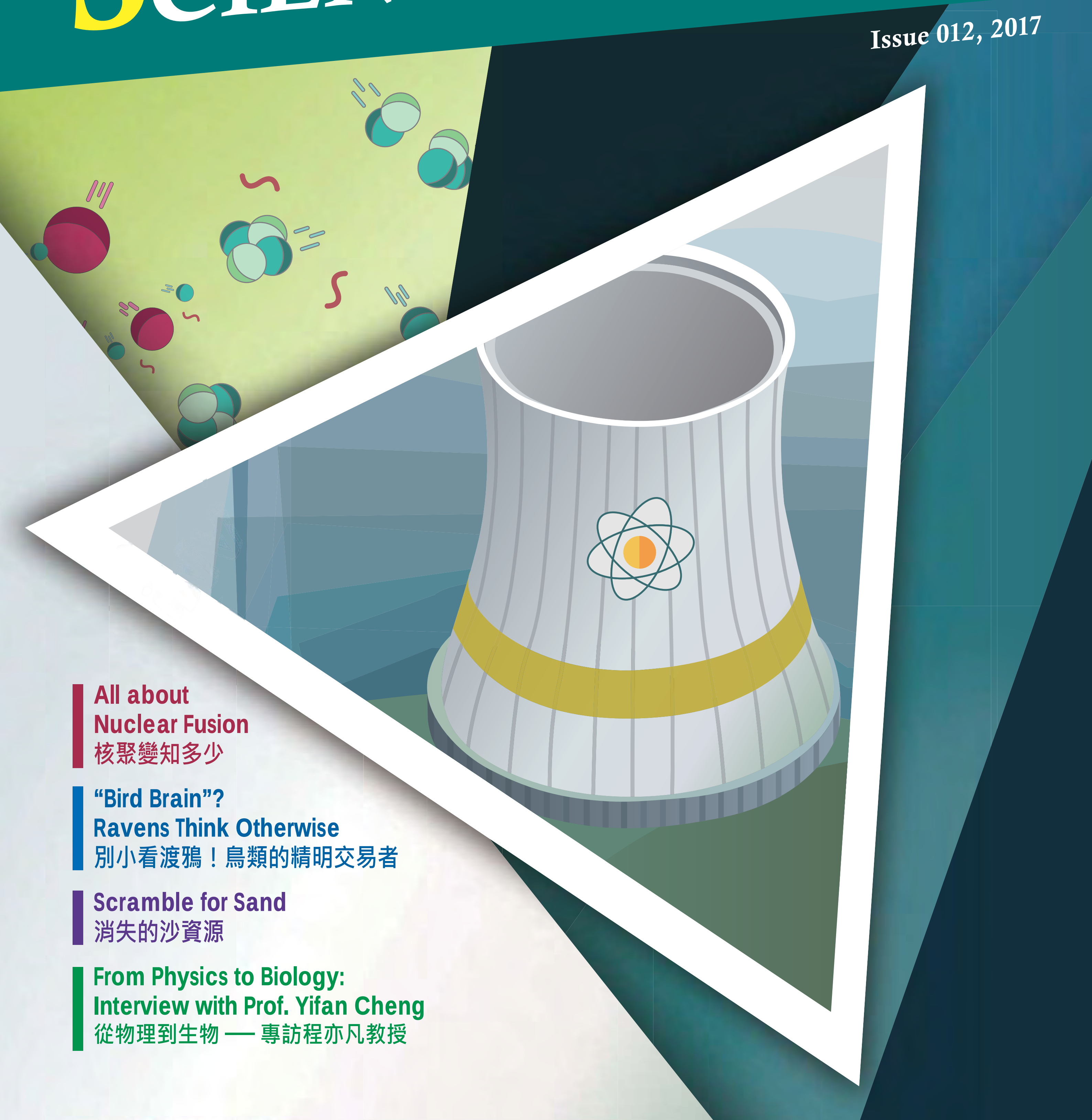
Science Focus 科言

Issue 012, 2017



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核聚變知多少

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Message from the Editor-in-Chief 主編話語

Dear Readers,

Welcome to the twelfth issue of *Science Focus*! People often associate winter weather with colds. Your parents may tell you to avoid getting a cold by keeping yourself warm. Is it true that cold weather makes you catch a cold? It is up to debate. In this issue, one of our articles looks into this "Cold Case". This article, along with another article on nuclear fusion, is taken from our Student Web Blog. They are among the most popular pieces on the website. For more great science articles, check out the website *http://sciencefocus.ust.hk*.

Apart from these two articles, this issue also covers hot topics such as wireless charging and the scarcity of sand resource. Do not forget to check them out!

If you are interested in science and writing, please do not hesitate to send your science article to us! Selected articles will be published and you may have a chance to win an iPad. You may visit our website for more details.

Enjoy your *Science Focus*!

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

親愛的讀者：

歡迎閱讀第十二期《科言》！你的家人或會提醒你，在冬天要多注意保暖。冬天的天氣往往令人聯想到傷風。寒冷天氣是否真的會令人患上傷風？答案至今仍有爭議。今期《科言》的其中一篇文章便探討了這一說法。這篇文章和今期另一篇關於核聚變的文章，都是出自我們網站的學生部落格，在網站上相當受讀者喜愛。如果你有興趣閱讀更多學生部落格的精彩科學文章，可到我們的網站看看：*http://sciencefocus.ust.hk/zh-hk/*。

除了以上提到的兩篇文章，今期內容亦涵蓋了一些熱門議題，例如無線充電和沙資源短缺。千萬不要錯過這些精彩文章！

如果你對科學和寫作有興趣，我們誠邀你參加「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 iPad 一部。詳情可參看我們的網站。

希望你喜歡今期《科言》！

主編 王殷厚教授
敬上

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WHAT'S HAPPENING IN HONG KONG ?

SCIENCE

Fun in winter science activities

Any plans for the Christmas and New Year holidays?
Check out these science activities!

冬季的科學好節目

計劃好聖誕節和新年的好去處了嗎？不妨考慮以下活動！

The Shaw Prize 2017 Exhibition

Established in 2002, the Shaw Prize recognizes scientists with recent significant breakthrough in scientific work. It consists of 3 annual prizes: Mathematical Sciences, Life Science and Medicine, and Astronomy. In the exhibition, you can learn more about the 2017 Shaw Laureates and their scientific research.

Venue: Science News Corner,
Hong Kong Science Museum

Date: now – 27/12/2017

2017邵逸夫獎展覽

「邵逸夫獎」於2002年設立，設有三個獎項：數學科學獎、生命科學與醫學獎和天文學獎，分別頒發給在相關學術領域有傑出貢獻或在近期有突破性成果的科學家。透過今次展覽，你可以更深入認識今年的得獎者以及他們的科研工作。

地點：香港科學館科訊廊

展期：至12月27日

Aurora at Space Museum

Screening of the Sky Show "KAGAYA's Aurora" will end in January, so grab the chance to see "aurora" in Hong Kong while you can!

Screening date: now – 31/1/2018

For details, please visit
http://goo.gl/HC8G12

太空館的極光

太空館天象節目《夢幻極光》的映期將於一月結束，記得把握機會到太空館，不要錯過在香港欣賞「極光」的機會！

映期：現在至2018年1月31日

詳情請參閱網址 *http://goo.gl/HC8G12*

Hong Kong Black Kite Festival and Hong Kong Raptor Festival

We can see the black kite everywhere in Hong Kong. However, do you know that Hong Kong has the highest density of the black kite around the world? The Festival held by Eco-Education & Resources Centre is going to show you the key features of the birds and the conservation situation with interactive activities. Please stay tuned to announcements from the Facebook page of the Centre for details.

香港麻鷹節暨香港猛禽節

麻鷹在香港並不罕見，然而你知道香港的麻鷹密度在世界可謂數一數二嗎？生態教育及資源中心舉辦的「香港麻鷹節暨香港猛禽節」將助你了解牠們的特徵和保育狀況。詳情請留意中心的專頁。

香港科技活動

MARYAM MIRZAKHANI:

the Female Mathematician Who Made History

創造歷史的女數學家 —— 瑪麗安·米爾札哈尼

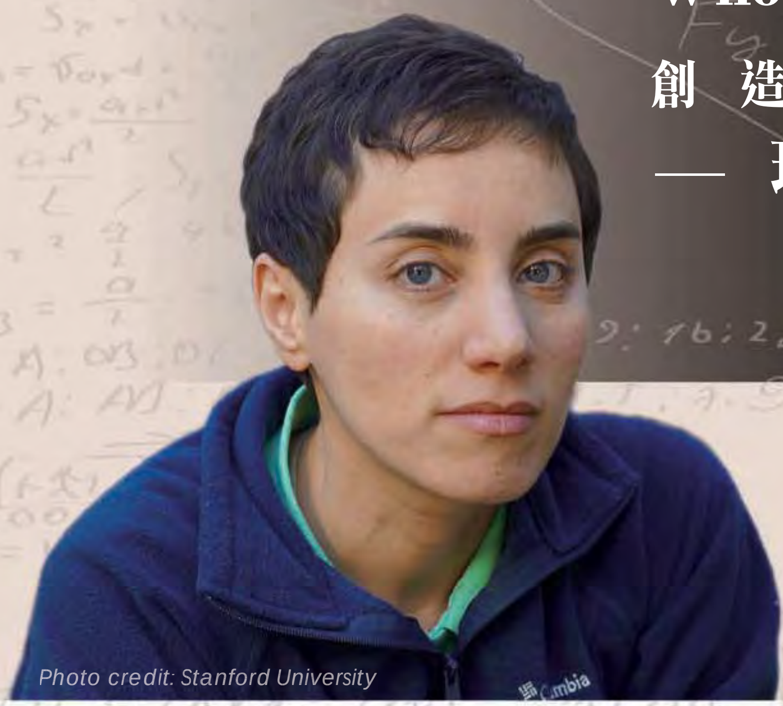

Photo credit: Stanford University

By Long Him Cheung 張朗謙

菲爾茲獎往往被認為是數學界最負盛名的獎項，或是數學界的諾貝爾獎。自其成立而來的逾七十年間，得獎者全部都是男性。這景象終在2014年改變，當年，瑪麗安·米爾札哈尼因她對

The Fields Medal is often considered to be the most prestigious award in mathematics, or the mathematics equivalent of the Nobel Prize. For more than 70 years since its inception, the prize had been awarded to men only. That changed in 2014, when Maryam Mirzakhani became the very first woman to receive the prize for her outstanding contribution to abstract geometry [1].

Born and raised in Tehran, Iran, Maryam Mirzakhani did not aspire to be a mathematician when she was little. Instead, she had a love for words and read avidly, dreaming to become a writer someday. She did not perform well in the mathematics class when she started middle school. Her teacher did not consider her particularly talented in the subject either, and she lost interest in it [2]. However, she met another more encouraging teacher the year that followed, and began to perform much better.

At the time when Mirzakhani was in an all-girls high school, there was no other girl participating in the Iranian International Mathematical Olympiad team. Nonetheless, with the strong support from the principal, Mirzakhani received training in solving mathematics problems and represented Iran in the 1994 and 1995 International Mathematical Olympiad. She performed exceptionally well and won the gold medal in both competitions, even hitting the perfect score in the second year.

Mirzakhani continued to shine as a mathematics talent afterwards. Mirzakhani pursued her Ph.D. in Harvard University. In 2004, she received her doctorate for her thesis, which demonstrated a creative way to combine different mathematical tools for studying properties and solving mysteries about abstract geometry. Her doctoral thesis was so impactful that it gave rise to articles in three top mathematics journals. She joined the Stanford University as a professor of mathematics in 2009.

Mirzakhani specializes in theoretical mathematics, such as Ergodic theory, symplectic geometry and hyperbolic geometry [3]. She once mentioned in an interview that she was particularly interested in hyperbolic geometry. Hyperbolic geometry is different from the geometry that you are used to seeing in secondary school. Usually, when there are a straight line L and a given point P, there could only be one line passing through P

抽象幾何的傑出貢獻而成為第一個獲得菲爾茲獎的女性[1]。

瑪麗安·米爾札哈尼在伊朗德黑蘭出生長大。小時候，她熱愛文字和閱讀，希望成為作家，而不是數學家。中學階段，她數學的成績表現起初並不突出，老師亦不認為她有數學的天賦，她便對數學失去興趣 [2]。可是，米爾札哈尼之後受到另一位老師鼓勵，數學成績開始突飛猛進。後來她進入一間女子高中，當時伊朗的數學奧林匹克代表隊是「全男班」，從未有任何女孩子加入；然而，米爾札哈尼的校長不遺餘力地支持她，助她接受數學奧林匹克的解題訓練。最終，米爾札哈尼成功加入了數學奧林匹克代表隊，並在1994年及1995年的國際數學奧林匹克比賽中大放異彩。她連續兩年獲得金牌，並且在第二年取得滿分佳績。

後來，米爾札哈尼前往哈佛大學攻讀博士學位。到了2004年，米爾札哈尼獲頒授博士學位，她的博士論文展示了一種具創意、嶄新的方法，結合不同的數學工具以研究抽象幾何相關的特性，並解決相關問題。這篇論文對數學界影響不小，衍生出的論文分別刊登於三份頂尖數學期刊。2009年，米爾札哈尼成為了史丹福大學的數學教授。

米爾札哈尼擅於遍歷理論、辛幾何和雙曲幾何等方面的數學[3]。她曾在訪問裡提到自己對雙曲幾何尤其有興趣。何謂雙曲幾何？雙曲幾何和中學一般學到的幾何並不一樣。一般來說，若L是直線而P是點，能通過P並且和L平行的線應該只有一條。但在雙曲幾何的世界裡，能通過P並且和L平行的線，數量是無限的！這些理論聽起來可能很抽象、古怪，但它們對不同範疇的科學研究都大有幫助。舉個例子，愛因斯坦的相對論研究就運用了雙曲幾何。

大眾心中想像的數學家可能都是在黑板或紙上奮筆疾書的人。儘管米爾札哈尼在數學上取得驕人的成就，她卻表示自己是一名緩慢的思考家。她把自己的研究方式比喻為森林的冒險，當你在森林迷路，你必須利用已有的知識來構造工具、創作新技術，直至有一刻你突然發現，自己已經到達山頂，把一切都看得一清二楚 [4]。

2014年，她被授予菲爾茲獎，以表揚她對抽象幾何的貢獻，抽象幾何可以應用在其他領域，如動力學、計算機科學和宇宙學 [1]。令人遺憾的是，米爾札哈尼與癌症戰鬥了4年，最終於2017年7月逝世，享年40歲 [3]。

毫無疑問，米爾札哈尼是一位傑出的數學家，為其他人留下了不可思議的成果和工具，令人們可以建基於她的成就上，繼續尋求新發現。除此之外，米爾札哈尼不僅是一個貢獻良多的學者，而且是希望投身科研的女性的榜樣。一顆數學之星雖然已逝，但她所留下的影響將會長存。

that is parallel to L. When it comes to hyperbolic geometry, however, there is an indefinite number of lines passing through P that are parallel to L! While these theoretical concepts may sound abstract or even alien to you, these concepts indeed can vastly help scientists in various fields of study. For instance, Albert Einstein applied hyperbolic geometry in his works about relativity.

You may imagine that mathematicians solve problems one after another by writing on boards or papers at bullet speed. But that is absolutely not the case for Mirzakhani.

The mathematician claimed that she is actually a slow thinker. She described her work as an adventure in a forest – when lost in a forest, you have to gather knowledge to come up with new tricks until you suddenly reach a hilltop and “see everything clearly” [4].

In 2014, Mirzakhani became the first female Fields Medallist for her contribution to abstract geometry, which could be broadly applied to multiple disciplines including dynamics, computer science, and cosmology [1]. Unfortunately, Mirzakhani passed away at the age of 40 in July 2017 after a 4-year combat against cancer [4].

Mirzakhani is not merely an outstanding scholar who has left incredible results and tools for others to continue to make breakthroughs and discoveries. She is also a role model for women all over the world who are passionate in mathematics or other fields of science. A star in mathematics has faded, but her inspiration remains.

References 參考資料：

1) Bridson, M. (2017). Maryam Mirzakhani obituary. [online] *The Guardian*. Retrieved from *https://www.theguardian.com/science/2017/jul/19/maryam-mirzakhani-obituary* [Accessed 29 Sep. 2017].
2) Clay Mathematics Institute. (2014). Maryam Mirzakhani: ‘The More I Spent on Maths, the More Excited I Got’. *The Guardian*. Retrieved from *https://www.theguardian.com/science/2014/aug/13/interview-maryam-mirzakhani-fields-medal-winner-mathematician*
3) Myers, A., Carey B. (2017). Maryam Mirzakhani, mathematician and Fields Medal winner, dies at Stanford | Stanford News. [online] *Stanford News*. Retrieved from: *http://news.stanford.edu/2017/07/15/maryam-mirzakhani-stanford-mathematician-and-fields-medal-winner-dies/* [Accessed 29 Sep. 2017].
4) Economist.com. (2017). Orbituary: Maryam Mirzakhani Died on July 14th. *The Economist*. [online] Retrieved from *https://www.economist.com/news/obituary/21725270-worlds-leading-female-mathematician-was-40-obituary-maryam-mirzakhani-died-july-14th* [Accessed 29 Sep. 2017].

"Bird Brain"? Ravens Think Otherwise

What comes to your mind when being asked "which animal is the smartest beside human beings"? Your answer might be chimpanzees, dogs or dolphins. But do not count ravens out of the picture yet. Studies have found that they have the brainpower strong enough to give those smart mammals a run for their money [4,5]. For instance, ravens are able to use tools to manipulate their surroundings [3]; they can remember how to perform a complex series of actions [3] and even make sophisticated gestures to communicate [4].

But how can birds be as smart as the said mammals, even though their brains are much smaller? One thing to note is that brain weight has nothing to do with cognitive skills. Moreover, despite using different parts of the brain to think – apes use the neocortex while birds use the pallium – both classes of animals faced similar challenges during evolution, which boosted their brains' cognitive performance [1].

As an example of how smart ravens can be, a recent study by researchers from institutes including the Lund University and the University of Vienna discovered their ravishing abilities to make judgments to cope with their complex social life [2]. These large and heavily built crows can somehow assess a deal as either "fair" or "unfair". To test this hypothesis, Müller et al (2017) taught nine captive ravens to trade bread, a low-quality food, for cheese, a high-quality food.

First, a trainer presents a raven with a "fair" deal; they gave the bird a piece of bread from one end of its cage. If the bird brought the bread to the other end of its cage, the trainer then exchanged it with a piece of cheese. On the next set of experiments, however, the raven was given an "unfair" deal. Instead of exchanging food items, a new trainer ate the cheese and took the piece of bread away. After two days, the experiment was conducted again with the "fair" trainer, the "unfair" trainer, and a new "neutral" trainer. The "neutral" trainer would return the bread when a bird decided to trade with her, allowing the bird to choose again with whom to exchange. Out of seven birds tested, six of them traded with the "fair" trainer, while only one chose the "unfair" trainer.

In one month, the experiment was repeated again in the same manner. Out of all nine birds tested, seven traded with the "fair" trainer, one with the "unfair" trainer, and the remaining one chose a new

References 參考資料：

[1] Fernandez, C. 2016. Not bird-brained at all! Crows and ravens are 'just as clever as apes' when it comes to thinking logically and using tools. *Mail Online* (web), retrieved from: *http://www.dailymail.co.uk/sciencetech/article-3476525/Not-bird-brained-Crows-ravens-just-clever-apes-comes-thinking-logically-using-tools.html*

[2] Gibbens, S. 2017. Ravens Hold Grudges Against Cheaters. *National Geographic* (web), retrieved from: *http://news.nationalgeographic.com/2017/06/ravens-memory-unfair-trade/*

[3] Heinrich, B., Bugnyar, T. 2007. Just How Smart Are Ravens? *Scientific American* (web), retrieved from: *https://www.theguardian.com/science/2007/apr/29/theobserversuknewspages.uknews1*

"neutral" trainer. However, when an "observer" bird was put in a different cage adjacent to where the experiment was conducted, it did not show as strong of a preference to the "fair" trainer as the "first-hand-experiencer" bird did.

This experiment showed that the ravens remembered who was the reliable "fair" trainer and who was not, which led to insights of how the birds' complex social structure evolved [6]. Bear in mind that the bread-cheese trade in this controlled experiment does not occur normally in the wild, but this study does lead to a further understanding on how smart ravens could be.

By Rinaldi Gotama 李嘉德

別小看渡鴉！鳥類的精明交易者

除了人類之外，甚麼動物最聰明？你可能會想起黑猩猩、狗或者海豚，但也別忘了一班渡鴉。有研究發現，渡鴉相當聰明 [4，5]。牠們懂得利用工具 [3]、做出一連串的繁複的動作 [3]，甚至能以複雜的動作溝通 [4]。

你可能會好奇，渡鴉的大腦比黑猩猩和狗等等的動物細小得多，牠們的聰敏程度怎麼可能相比呢？其實，動物大腦的重量和牠們的認知能力並無關聯。科學家發現，儘管猩猩和鳥類思考時運用的大腦部位並不相同，但兩種動物在漫長的進化過程中都面對着相似的挑戰，促使牠們大腦在認知方面的發展 [1]。

來自Lund University和University of Vienna的科學家早前發現，渡鴉擁有一定的判斷能力，以應付牠們複雜的社交生活 [2]。科學家Müller和他的團隊(2017) 的實驗結果顯示，渡鴉可以分辨交易是否「公平」。

研究人員發現了渡鴉喜歡芝士多於麵包。在實驗中，他們先向渡鴉進行「公平」的交易：研究員從籠子的一邊給渡鴉一塊麵包，如果渡鴉把麵包傳到籠子的另一邊，一位「公平」的研究員會給牠芝士以作交換。接着渡鴉會經歷「不公平」的交易：「騙子」研究員不會和渡鴉交換食物，而是自己把芝士吃掉，並拿走渡鴉的麵包。兩日後，研究人員和渡鴉進行同樣的實驗。除了之前的「公平」研究員和「騙子」研究員，還多了一位「中立」研究員參與實驗，假如渡鴉選擇和「中立」研究員交易，她會把麵包還給渡鴉，讓牠重新選擇交易對象。參與實驗的七隻渡鴉當中，六隻渡鴉和「公平」的研究員進行交易，只有一隻渡鴉選擇了「騙子」。

大約一個月後，同樣的實驗再次進行。參與實驗的九隻渡鴉當中，七隻選擇和「公平」的研究員交易，一隻選擇了「騙子」，另一隻則選擇了新的「中立」研究員。此外，實驗進行時，科學家把一隻渡鴉放在另一個籠子裡，讓牠觀察實驗過程。他們發現，和曾經參與交易的渡鴉相比，作為「觀察者」的渡鴉對「公平」研究員的偏好相對較低。

實驗顯示，這些渡鴉記得誰是「公平」研究員，誰是「騙子」[6]。儘管麵包和芝士的交易在大自然中並不存在，這個實驗的確增加了我們對渡鴉的認識。

[4] Lazendorfer, J. 2016. 10 Fascinating Facts About Ravens. *Mental Floss* (web), retrieved from: *http://mentalfloss.com/article/53295/10-fascinating-facts-about-ravens*

[5] Montanari, S. 2017. We Knew Ravens Are Smart, But Not This Smart. *National Geographic* (web), retrieved from: *http://news.nationalgeographic.com/2017/07/ravens-problem-solving-smart-birds/*

[6] Müller, J.J.A., Massen, J. J. M., Bugnyar, T., Osvath, M. 2017. Ravens remember the nature of a single reciprocal interaction sequence over 2 days and even after a month. Animal Behaviour, 128:69-78.

SCRAMBLE FOR SAND

消失的沙資源

By Thomas Lee 李浩賢

Humans have been scrambling for resources since the history of man began. Freshwater, food, and land have been our top concerns over the past decades; yet there is a shortage of one natural resource that we often miss out: sand. We may often associate sand with deserts, beaches and parks. Believe it or not, sand can also be viewed as a scarce natural resource as freshwater. Sand plays a much more vital role in our society than you may expect. Its scarcity affects us all, whether you are a beach lover or not. Sand seems so abundant. How could the world be scrambling for it?

Sand and gravel are mostly composed of quartz. With a general formula of silicon dioxide (SiO_2), quartz is consisted of a continuous framework of silicon-oxygen tetrahedral. Sand is primarily formed from weathering boulders. In the process of weathering, the weaker minerals in boulders are leached. Then the more impervious quartz is eventually ground down to various grain sizes. In time, the sand grains reach and accumulate in a low-lying area or form dune fields which later become deserts.

Sand is more than just constituents of beaches. It is involved in the making of everything from paint, bricks, shingles, cement to water filtration systems. Quartz in the sand is particularly valuable as it can make optical-quality glass and computer chips. In fact, sand is the most broadly used natural resource after water, according to Pascal Peduzzi, director of science at the United Nations Environment Programme's Division of Early Warning and Assessment. A 2014 report by the Programme also suggests that sand and

gravel are the most extracted resources in the world, accounting for up to 85% of all materials mined around the world in one year [1]. Sand is so significant as an industrial and construction commodity that it is not an exaggeration to say that our modern society is built on sand.

Though sand penetrates almost all landscapes of our lives, most of it is not suitable for commercial purposes: desert sand, for example, is too smooth for construction uses and the purity of silica in the sand may not be up to par. Developing countries are among the biggest consumers of sand. China, for example, used more cement between 2011 and 2013 than the US did in the entire 20th century [2]. The global demand for the resource has prompted the rise of unregulated mining, which could lead to destruction of habitats like riverbeds and disruption of biodiversity [3].

Instead of crushing more rocks and mountains, industries are considering some more eco-friendly options, for instance, recycling glass and concrete. However, concrete in buildings could hardly be recycled unless the buildings are torn down, so that portion of sand is taken out of the recycling cycle almost permanently. Some companies are also considering alternatives, such as straw and wood for house construction, and mud for reclamation.

The scramble for sand and gravel has caused unprecedented damage to our fragile environment, destroying wildlife and food webs, eroding habitats and communities, and creating more pollution [4]. Global effort is needed to conserve our lands, and our future.

自文明開始，人類便依靠尋找資源來維持生活。但在過去數十年，正當大眾擔心會否有一天缺乏淡水、食物和土地時，人們忽視了一種看似平平無奇的資源：沙。說起沙石，我們或只會想起沙漠、沙灘和公園的沙池。你可能覺得沙難以和淡水等珍貴資源相比，不過，沙資源在我們社會扮演的角色或比你想像中重要得多。沙資源缺乏的問題和我們息息相關。沙石彷彿隨處可見，為什麼會有短缺的一天呢？

沙和礫石主要由石英組成。石英的化學式為二氧化矽（SiO_2），由矽氧四面體所構成。沙主要由風化的巨石而成。在風化過程中，較弱的礦物會首先流失。然後，較堅固的石英被磨碎成各種大小的沙粒。隨著時間流逝，沙粒堆積在低窪地區，又或是形成沙丘，其後成為沙漠。

沙不單單是沙灘重要的一部分。從油漆、磚頭、水泥，以至過濾系統等等，這些東西的製造都需要沙。沙石中的石英尤其珍貴，因為它和光學玻璃和電腦晶片的生產有關。事實上，根據聯合國環境規劃署預警和評估部門的科學總監帕斯卡爾·佩杜茲，在各種各樣的天然資源中，沙的使用量僅次於水。聯合國2014年的報告亦指出，沙和礫石是全球開採量最大的資源，佔全球一年開採量高達85% [1]。沙是製造業和工業的必需品，我們的現代社會可說是建築於沙資源之上。

雖然沙子幾乎隨處可見，但它們大多數都不適合用於商業用途。沙漠的沙粒太幼，不適合建築使用，而且部分沙子的石英純度可能達不到要求。發展中國家是沙資源的最大消耗者之一。中國在2011至2013年期間使用的水泥，比美國上世紀時使用的還要多 [2]。全球對沙資源的需求日增，導致未受監管的採沙活動日漸增多，或會破壞河床等的自然生態環境，影響生物多樣性 [3]。

與其粉碎更多石頭，相關行業正考慮一些更環保的選擇，例如回收玻璃和混凝土。不過，除非人們拆除建築物，否則建築物的混凝土難以被回收。此外，部分公司正尋求替代品，例如使用禾稈和木材建造房屋，或是用泥漿填海。

過度採沙對我們的環境造成前所未有的破壞，危害野生動物和食物網，摧毀棲息地和社區，造成更多的污染 [4]。全球需合作保護環境，保護人類的將來。

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Conventional wisdom has it that the onset of winter and cooler weather brings forth an inundation of flu cases. Runny noses, sore throats and incessant coughing are among the common symptoms for those unfortunate enough to fall ill to the common cold, most often caused by a virus known as the rhinovirus. With runny noses being more frequent in cold environments, the association between cold weather and the common cold was bound to happen. The truth behind whether this illness rears its head more prominently during wintertime, however, is very much up for debate.

Initial efforts to discover the cause of the cold began with Walter Kruse in January 1914. When one of his colleagues showed up to work with a cold, Kruse took samples of his nasal secretions and diluted them fifteen-fold with saline. He then passed the mixture through a fine ceramic Berkfeld filter to remove any bacteria (viruses are often much smaller in size than bacteria and would therefore pass through). Kruse gave samples to twelve of his colleagues to inhale and four of them developed colds after incubation for 1-3 days (talk about team spirit). The crude experiment proved that the cold was not caused by bacteria, but by a virus [1]. While this information seems archaic compared to what we know today, whether viruses really caused sickness went unanswered at the time. Further experimentation seemed necessary.

Chimpanzees were purported to catch colds from their zookeepers, making them ideal test subjects. Chimps that were kept in isolation from one another were given bacteria-free filtrates of nasal secretions from humans who had contracted the common cold. These chimps developed human-like symptoms of the cold. Test subjects that were given filtered nasal secretions from healthy humans did not, confirming the hypothesis that a virus was indeed responsible for colds and was, in fact, contagious [2]. It wasn't until 1956 that the cold virus was isolated and cultivated. Two competing strains were discovered in the same year and appeared to possess slightly different characteristics. Both, however, induced mild respiratory symptoms that resembled a cold [3].

One of the first studies to challenge the convention that low temperatures increase susceptibility to a cold appeared in 1968. The experiment involved 44 American male prisoners. The newly discovered cold virus was dripped into the noses of 27 "volunteers" (the question of ethics for this experiment perhaps warrants an article on its own). They were then subjected to temperature conditions of either 4 °C or 32°C during infection, incubation, peak of illness and recovery. The authors concluded "no significant differences" regarding the probability and severity of infection between those deliberately infected and the control group [4].

Yet even with this seemingly convincing experimental evidence, the jury is still out. Cold temperatures constrict blood vessels in the nasal canal to maintain body temperature. Vasoconstriction drives defensive mucus in the nasal passage, which is designed to trap pathogens, but which also lowers respiratory defenses [5]. This is because, should breathing take place through the mouth instead of the nose, the defenses of the nasal mucosa are bypassed entirely. Low humidity, a hallmark of winter season, also expedites the travel of infected mucus droplets in the air. The lower the humidity, the more rapidly water evaporates, creating a more streamlined projectile with a greater lingering period following a sneeze or a cough. In addition to these biological reasons for keeping the debate open, one popular school of thought suggests that cold weather motivates people to congregate in close indoor quarters. This would have the effect of increasing proximity to the sick thus potentially facilitating contagions; recycled indoor air exacerbates this situation still further. The theory would also predict an increased prevalence of the common cold during colder weather.

Most scientists would agree that cold weather itself does not cause a cold, but that the cold is caused by a collection of rhinoviruses, each having its own virility in cold temperatures and the other conditions that accompany winter weather. Our habits in cold weather may also indirectly contribute to the spread of the virus. The best prevention is to cover your mouth and nose during sneezes and coughs, wash your hands thoroughly, and exercise regularly. In the meantime, perhaps it wouldn't hurt to keep warm.

A COLD Case
「著涼」真有其事？

By David Ren
任大偉

傳統智慧告訴我們，當冬季來臨，天氣轉涼時，傷風病例便會湧現。傷風一般是由鼻病毒所引起，不幸染上就會出現症狀如：流鼻水、喉嚨痛和咳嗽。在寒冷的環境中經常會流鼻水，自然會聯想到天冷與傷風有緊密的關係，但真相到底是怎樣？讓我們看看不同論據。

追尋傷風病因的研究可以追溯到1914年一月。當時科學家瓦爾特·克魯斯的一位同事帶病上班，克魯斯收集他的鼻腔分泌物，以鹽水稀釋15倍，再用細陶瓷貝克費爾德濾器隔除細菌（病毒通常比細菌小得多，可以通過濾器）。克魯斯讓12位同事吸入樣品；其中4位在1至3天之後染上傷風（可謂充分發揮團隊精神）。實驗雖然粗糙，卻證明了傷風是由病毒而非細菌引起 [1]。這在今日看來固然並非新知，但在當時卻未能完全肯定病毒是致病元兇，還需要更多的實驗。

據說黑猩猩可從飼養員感染傷風，所以成為理想的研究對象。黑猩猩被隔離後，吸入傷風患者鼻腔分泌物的無菌濾液，結果出現人類傷風的種種症狀。另一組吸入健康人類鼻腔分泌物的黑猩猩沒有患病，確立了病毒是傷風的病源，而且帶有傳染性 [2]。直到1956年，傷風病毒才被分離培養。在同一年發現兩種競爭性病毒株，雖然略有不同，卻都可以引起輕度呼吸道症狀 [3]。

早在1968年，開始有研究反駁低溫增加傷風患病機會的觀點。有44位美國男性囚犯參與試驗，其中27名「志願者」鼻腔被滴入新發現的傷風病毒（涉及的道德議題可能須要另闢專文討論）。在病毒的感染和潛伏期，以及病情的高峰和恢復期，囚室的溫度保持在攝氏4度或攝氏32度。研究結論表示，實驗組與對照組在感染機率和嚴重程度上，並無顯著的差異 [4]。

雖然如此，對於傷風和氣溫的關係，人們至今仍未有一致的看法。鼻腔血管在低溫情況下會收縮以保持體溫，原本阻止病原體入侵的黏液在鼻道或會減弱呼吸道的防衛機能 [5]。因為若以口代鼻呼吸，這些防線會完全被繞過。冬季天氣乾燥，人們打噴嚏或咳嗽後，含病毒的飛沫水份蒸發較快，可以長時間飄浮，有利於病毒在空氣中傳播。此外，另一個常見的說法是，人們天冷時傾向聚集在空氣不流通的室內，縮短了與患者的距離，加速病毒在人群擴散。室內空氣循環使用，也會加劇感染。這理論似乎解釋了為甚麼在冬天容易患傷風。

許多科學家同意寒冷天氣不會導致傷風；傷風是由不同的鼻病毒所引起，在冬季的低溫及其他相應情況下，各有不同的繁殖能力。我們在冷天的習慣也有可能間接傳播病毒。最好的預防措施包括：打噴嚏或咳嗽時掩著口鼻、徹底洗淨雙手，以及經常鍛煉身體。不過，注意保暖大概也沒有害處，所以小心不要著涼了！

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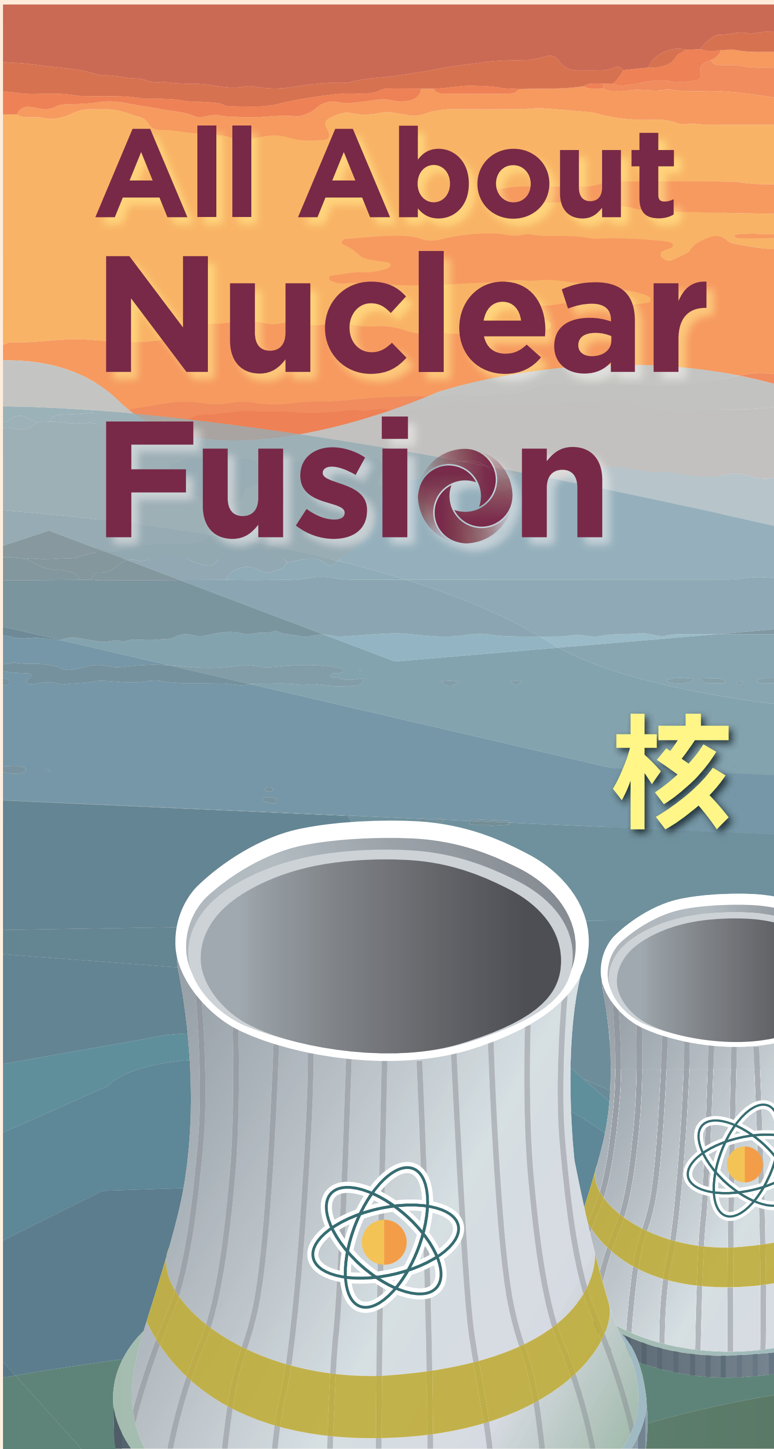
Energy sustainability is a key contemporary issue. However, clean, renewable energy options are plagued by low energy density and cost inefficiency, propelling the continuous search for sustainable alternatives. A breakthrough in nuclear fusion offers a new paradigm for the development of renewable energy. Much like in the cores of stars, the combination of hydrogen atoms (the most abundant element in the universe) to form helium yields an enormous quantity of energy. Although there are significant kinks to iron out (to say the least), the first steps in making nuclear fusion a viable method of power generation have undoubtedly been made around the world.

Nuclear fusion should not be confused with nuclear fission, which involves the splitting of large atoms into smaller ones. It is an established means of generating power in nuclear power plants. In contrast, pure nuclear fusion does not release radioactive by-products. This advantage eliminates the problems caused by nuclear waste and the challenges posed by proper disposal. The energy released during nuclear fission is also three to four times smaller than the energy released during nuclear fusion, which is the epicentre of its attractiveness in energy development.

Nuclear fusion essentially involves fusing two nuclei together (generally hydrogen nuclei) to form a larger nucleus. While this process seems conceptually simple, it requires overcoming the Coulomb repulsion force between the two nuclei so that the nuclear force is able to hold the nuclei together. Thus, equilibrium must be established between the repulsive Coulomb force and the attractive strong force to hold this new nucleus together. For nuclei smaller than nickel-62, the process of nuclear fusion releases energy known as the binding energy [1].

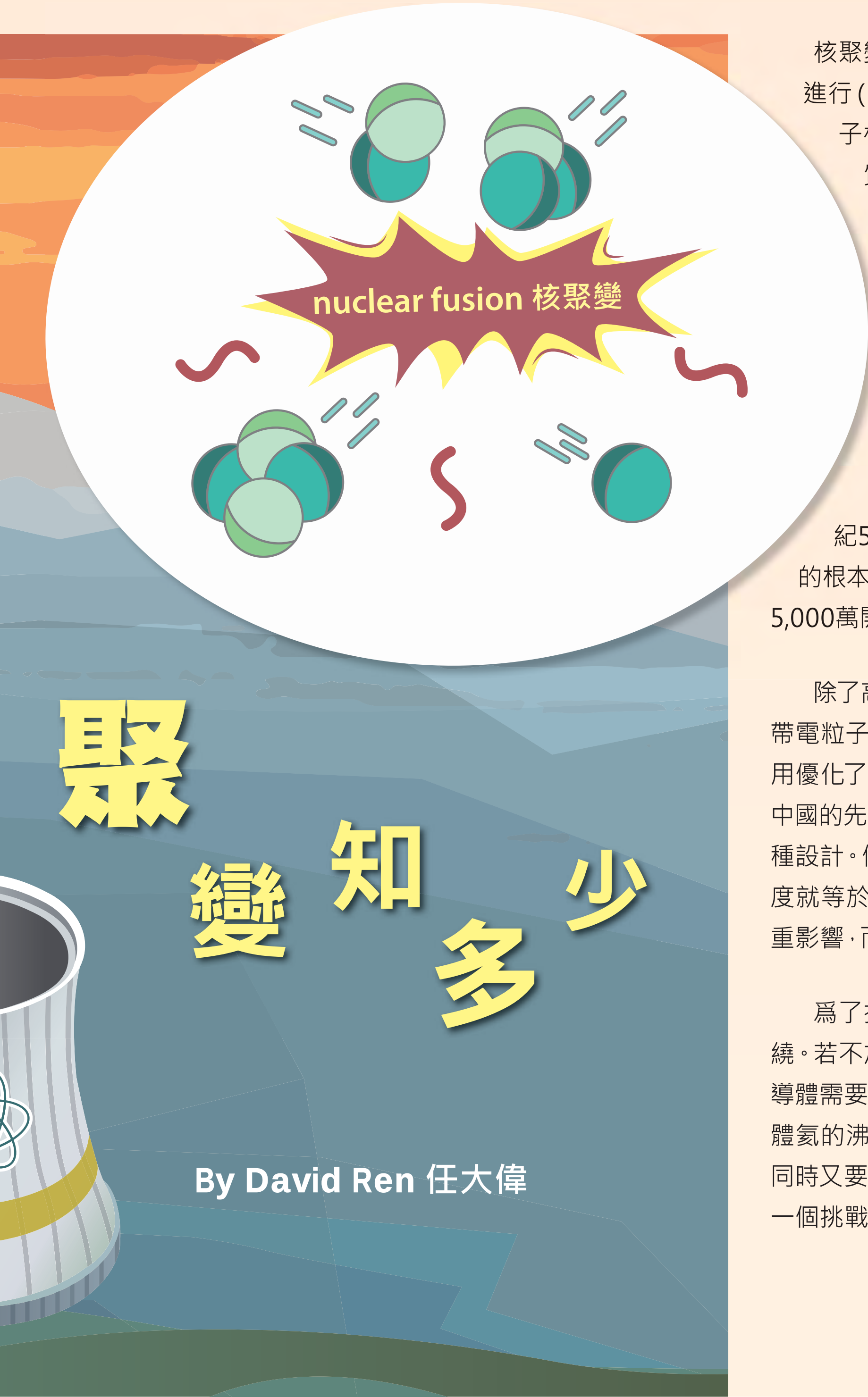
Nickel-62 has the greatest average nuclear binding energy per nucleon than any other atom, meaning it requires the most energy per nucleon to split apart [2]. Lighter atoms tend to fuse towards Nickel-62 because the nuclei involved lose energy with each fusion. Heavier elements absorb energy to fuse as the resultant nuclei possess a greater energy than that of the reactant nuclei.

The problem with nuclear fusion is that sustainable fusion takes place at temperatures beyond 5×10^7 Kelvin (the temperature of the outermost layout of the sun is 5×10^5 Kelvin or more). The repulsive Coulomb force between protons forces reactors to bring nuclei within $10^{-15} m$ together so that the nuclear force overpowers the repulsion. Even in the ideal trajectory, protons zoom around at 20,000,000ms^{-1}. At sub-optimal temperatures, a small number of highly energetic particles may still be sufficient to participate in nuclear fusion. International Thermonuclear Experimental Reactor (ITER) is aiming for 1.5×10^8 Kelvin to ensure the plasma is not self-neutralising and to ensure that nuclei have sufficient energy to overcome Coulomb repulsion.



聚變知多少

By David Ren 任大偉



能源可持續性是現今的重要課題，但目前各種清潔而可再生的能源，能量密度及成本效率都是偏低，所以我們必須繼續尋找其他可再生能源。在核聚變領域所取得的突破，正好為可再生能源的發展提供了新方向。氫原子是宇宙中含量最豐富的元素，結合成為氦的話，會產生巨大的能量。雖然有許多難題尚待破解，各國已展開核聚變發電的研究。

小心不要將核聚變與核裂變混淆，後者是指由大原子分裂成為較小的原子，也是目前核電廠用以生產能量的方法。純粹的核聚變反應不會釋出放射性副產品，免除了因處理放射性廢料而引起的諸多問題。而且核裂變所釋放的能量比核聚變低三至四倍，所以核聚變在能源開發領域中極具吸引力。

核聚變主要是要將兩個原子核（通常是氫原子核）融合而成一個較大的核。過程看似簡單，卻要克服原子核之間的庫侖斥力，讓核力可以將原子核束縛在一起。斥力和引力必須要取得平衡，新原子核才能穩定下來。鎳-62以下的原子核在核聚變過程中釋放的能量則被稱為結合能 [1]。

鎳-62的核子擁有最高的平均結合能，也就是說分裂要用最多的能量 [2]。較輕的原子傾向往鎳-62方向進行融合反應，因為每次融合都可以放出能量。較重的元素卻要吸收能量才能進行融合，得到能量較高的原子核。

核聚變反應只能在5,000萬開爾文以上的高溫才能持續進行（而太陽最外層的溫度可達50萬開爾文或以上）。原子核之間的距離必須要小於$10^{-15}m$，核力才可以克服質子之間的庫侖斥力。質子在理想軌跡的移動速度則約為$20,000,000ms^{-1}$。平均溫度或未達到所需的溫度，然而溫度是粒子平均動能的量度，部分帶有高能量的粒子還是可以進行融合。國際熱核聚變實驗堆（ITER）正以1.5×10^8開爾文為目標，以確保等離子體（離子化氣體）不會自己中和，並且原子核有足夠能量去克服庫侖斥力。

在室溫進行核聚變的主意固然吸引，不過，20世紀50年代出現的「冷聚變」說法已全然被推翻。這構思的根本問題在於如何能有效地遏制等離子體——即在超過5,000萬開爾文之下產生的離子化氣體（氫和氦）——擴散。

除了高溫外，有沒有其他的方法？事實上，離子化氣體是帶電粒子，可以受磁場及電場操縱。托卡馬克反應堆就是利用優化了的磁場來約束等離子體 [3]。法國的ITER實驗以及中國的先進超導托卡馬克實驗裝置（EAST）實驗都是運用這種設計。假設反應器在1億開爾文操作，氘核（2H）的平均速度就等於$1,000,000ms^{-1}$。在這溫度下，等離子體受紊流嚴重影響，而變得極不穩定。

爲了提供足夠強度的磁場，托卡馬克環被超導電纜纏繞。若不加上超導電纜，磁場的操作效率就會太低。但是超導體需要冷卻到4.2 開爾文（即攝氏-269度）左右，也就是液體氦的沸點。一方面要將溫度提升至5,000萬 開爾文以上，同時又要在等離子體附近保持接近零開爾文的溫度，實在是一個挑戰。

It would be ideal if we could sustain nuclear fusion at room temperature. Unfortunately, claims of 'cold fusion' in the 1950s have been entirely debunked. The fundamental issue here is the challenge of plasma confinement. In other words, the ionised gas (plasma) of hydrogen and helium at temperatures above 5×10^7 Kelvin must be reliably contained.

Fortunately, ionised gases are charged particles and can be manipulated by magnetic as well as electric fields. A design that optimises magnetic fields for plasma confinement is the tokamak reactor [3], as used in the ITER experiment in France as well as the Experimental Advanced Superconducting Tokamak (EAST) experiment in China. If the reactor operates at 10^8 Kelvin, deuterium nuclei (2H) has an average velocity of 1,000,000ms^{-1}. The plasma at these temperatures is extremely unstable due to severe plasma turbulence.

To provide adequately strong magnetic fields, superconducting cables are laced around the tokamak ring. Without superconducting cables, the magnetic field would be too energy inefficient to operate – but superconductors require cooling to around 4.2 K (or -269 °C), which is also the boiling point of liquid helium. To achieve temperatures more than 5×10^7 Kelvin while requiring near-zero temperatures to run alongside plasma is a challenge, to say the least.

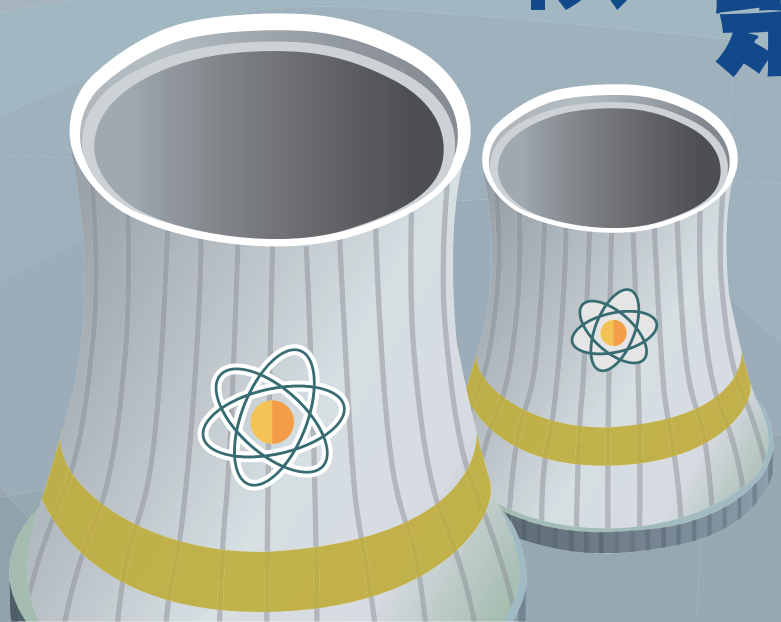
Nevertheless, the EAST team has managed to sustain a hydrogen plasma chamber at 5×10^7 Kelvin for over 102 seconds [4]. Germany's Wendelstein 7-X reactor has also achieved an impressive 8×10^7 Kelvin plasma for 15 seconds.

For researchers dubious of tokamak-based fusion reactors, the National Ignition Facility (NIF) at the Lawrence Livermore Laboratory uses 192 lasers to combust deuterium-tritium fuel pellets to spark fusion [5]. Alternatively, inertial confinement fusion involves ignition of the outer layer of deuterium-tritium fuel so that the resulting explosion causes a chain reaction, burning the remainder of the fuel [6].

While a neat idea, nuclear fusion is a classic example of "easier said than done." In comparison to sending men to the moon or climbing Mount Everest, nuclear fusion has proven to be the toughest challenge yet, but nations are realising the potential it offers. For now, nature's very own fusion reactor remains unbeaten and is responsible for providing all energy on Earth.

All About Nuclear Fusion

核聚變知多少



儘管如此，EAST團隊已成功把氫等離子體的溫度，維持在5,000萬開爾文達102秒之久 [4]。德國的溫德爾施泰因7-X反應堆也可以維持8,000萬開爾文高溫達15秒。

此外，勞倫斯利弗莫爾國家實驗室國家點燃設施的科學家以另一種方法誘發核融合反應。他們以192束激光燃燒氘-氚燃料球 [5]。而慣性約束核聚變則是透過燃點氘-氚燃料的外層，引起連鎖反應，燃燒餘下的燃料 [6]。

雖然核聚變有許多優點，要付諸實行卻不易。相對於遠征月球或攀登珠穆朗瑪峰，核聚變堪稱是最嚴峻的挑戰。不過，許多國家已意識到核聚變的潛力。至於現在，我們仍要仰賴大自然的核聚變反應堆 —— 太陽。

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The Wireless World

By Twinkle Poon 潘晴

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

You would not want to mess up the beginning of the day by failing to locate the right charging cable for your smartphone. Although it has only been a few years since smartphone manufacturers embraced wireless charging, the technology is not exactly new. It has been applied in bathroom electrical appliances such as rechargeable toothbrushes and shavers since the 1990s. As a matter of fact, its early concept has been around for more than a century!

試想像，當你急需為電話充電，桌上卻佈滿各種纏繞在一起的充電線，要花一番功夫才能把電話和充電線成功「配對」，這種麻煩事，誰都不希望遇到。然而，隨著無線充電技術的普及，我們或將不會再遇上這種糟糕的事情。儘管無線充電技術的功能在近年才應用於智能電話等等的電子產品，但它其實並不算是一種嶄新的技術。早於九十年代，無線充電便已應用至浴室電子產品，例如電動牙刷和電動剃鬚刀。更讓人意想不到的是，無線充電背後的基本科學原理早在一百多年前就被發現了！

Wireless charging is sometimes called inductive charging because it works by a phenomenon called electromagnetic induction, which British scientist Michael Faraday discovered in the 19th century. It is primarily based on the Faraday's Law of Induction. Simple electromagnetic induction involves a magnet and a coil of wires. If you keep moving a magnet back and forth within a coil of wire, an electric current could be produced. The faster the magnet moves, the higher the voltage is. Once the magnet stops moving, however, no electricity is induced. In other words, a magnetic field does not induce electricity – a changing field does!

Conversely, if you apply a current on a coil of wires, a magnetic field is generated. If the current applied is a direct current (DC), the magnetic field points in one direction. If it is an alternating current (AC), which constantly changes its direction, the field also points in alternating directions.

The modern wireless charging system involves a base station or a charging mat, which has an inbuilt coil of wire. When the base station is plugged, the alternating current from the main electricity supply runs through the coil, generating a magnetic field that is also constantly changing in direction. When you place your device onto the base station, the coil of wire inside the device is "reached" by the field and a current is induced.

Unlike wired charging, inductive charging does not require the conducting material to be exposed, making it a safer option for bathroom appliances. Nevertheless, the technology currently does come with some downsides. The base station and the device being charged have to be in close proximity. While you can hold your smartphone and move around with the charger wire still plugged to the phone, wireless charging requires your device to stay on a specific position. In other words, charging on the go may not be feasible. As the technology improves, however, wireless charging may soon become a standard feature for smart gadgets, home electrical appliances and even electric cars. It could totally change our experience with devices.

無　線　的　世　界

無線充電又被稱為感應充電，因其背後運用了電磁感應原理。這原理由英國科學家法拉第在十九世紀發現，而和這科學原理相關的定律亦被稱為「法拉第電磁感應定律」。簡單來說，要做到電磁感應，只要讓磁鐵在電線圈中前後移動，電流便會產生，並流動於線圈。磁鐵移動的速度愈快，電壓便愈高。假如磁鐵停止移動，線圈便不會產生電流。換言之，一直不變的磁場無法產生感應電流，要產生感應電流，磁場必須維持變化。

假如我們讓電流通過電線圈，周圍便會出現磁場，而磁場會受電流方向影響，如果使用直流電，磁場會維持單一方向，反之，如果使用交流電，即電流的方向不斷交替更改，磁場亦會不斷改變方向。

現在讓我們看一看現代的無線充電系統。無線充電底座或充電板內裡裝有電線圈，當底座接上電源，插座的交流電會通過電線圈，產生出不斷改變方向的磁場。支援無線充電技術的電器內裡亦會裝有電線圈，當它被放在底座上，便會受底座的磁場影響，產生電流。

和有線充電相比，無線充電的電器不需要外露導電部份，用戶不必擔心電器因濺到水而發生漏電意外，因此浴室電子產品往往採用無線充電技術。現今的無線充電技術看似方便安全，但亦有其不足之處。要運用無線充電，電子產品需要放在底座或充電板。假如用戶希望在充電期間使用產品，或帶其出門的話，充電線暫時依然是個較好的選擇。不過，隨著充電技術急速發展，無線充電相信將會成為智能產品、家用電器，甚至是電動汽車的必備功能，我們的電子智能生活，或將被無線充電技術大大改變。

The Physics of Poop : Why It Matters

By David Iu 姚誠鵠

Pooping might be a rather unsavory subject to discuss. Yet, study of feces could often provide us with valuable information about one's health. Many gastro-intestinal diseases, like irritable bowel syndrome and gastrointestinal infections, are manifest in abnormal size, shape, color or texture of excrement. They affect millions of people worldwide, and cost billions of dollars annually [1].

Fluid dynamicist Professor David Hu of Georgia Institute of Technology and his PhD student Patricia Yang joined hands with colorectal surgeon Daniel Chu, and the then undergraduates Candice Kaminski and Morgan LaMarca to dive into the science of pooping. The research group set out to look into the size, density, viscosity, smell and the duration of poop across different species, and built a mathematical model of the duration of defecation. The intrepid scientists literally took the matter into their hands – Kaminski and LaMarca filmed animals defecating and hand-picked feces from 34 mammalian species at Zoo Atlanta.

The “poop-analysis” yielded intriguing results. Through measuring the density of the feces collected, the scientists found that the feces could be separated into two classes: “sinkers” and “floaters”. “Sinkers”, denser than water, are usually from carnivores like tigers and lions. “Floaters”, on the other hand, are usually from herbivores like elephants.

Despite their wide range of body sizes, the majority of mammals share a stunning consistency

排便或是一個難登大雅之堂的話題，但這不代表我們應該忽視它就我們健康所提供的有用資訊。許多腸胃疾病，如腸易激綜合症和腸胃炎等，在排泄物的異常大小、形狀、顏色和質地中都有跡可尋。這些疾病每年不僅影響全球數以百萬計的人，更造成數以億計的經濟損失 [1]。由此可見，排便的研究確有其重要性。

喬治亞理工學院的流體力學教授David Hu、其博士生Patricia Yang 與結直腸外科醫生Daniel Chu，以及當時為學生的Candice Kaminski和 Morgan LaMarca合作，進行大便相關的研究。他們進行了一系列的實驗，觀察不同動物糞便的大小、密度、黏度、氣味和排便時間的長短，並建立一個關於排便時間長短的數學模型。這些科學家為研究可謂親力親為 —— Kaminski 和LaMarca 在阿特蘭大動物園拍攝動物排便的過程，又親手採集了34種哺乳類動物的糞便。

這些關於糞便的分析產生了不少有趣的結論。透過量度糞便的密度，科學家發現動物糞便大致可分成下沉的和浮起的兩種。密度比水高的糞便會下沉，而且通常來自肉食性動物，如老虎和獅子。另一方面，會浮起的糞便通常來自草食性動物，例如大象。

研究發現，儘管涉及研究的動物大小相差很遠，牠們排便所花的時間卻出乎意料地一致。假設鐘形曲線分佈的話，不論是碩大如象，或是細小如貓，對大約三分之二的哺乳類動物來說，排便所需時間均介乎5至19秒。

when it comes to poop time, the study suggests. It takes about two-thirds of mammals – small cats and large elephants included – between 5 and 19 seconds to poop, assuming a bell curve distribution.

Body mass seemed to positively correlate with defecation rate. An elephant defecates at 6 cm per second, three times as fast as the average human. The volume of feces varies hugely from animal to animal. The average elephant stool has a volume of 20 liters, several hundred times that of an average human defecates per day [2].

Defecation duration is relatively constant, even though the volume varies extensively. How can big animals defecate at such high speed? The answer lies in the properties of the mucus lining of the colorectal walls.

Instead of being squeezed like toothpaste out of a tube, feces move along the large intestine like “a sled sliding down a chute” by a layer of mucus. Since the mucus is more than 100 times less viscous than feces, it serves as a lubricant and helps push the much more viscous feces out. This could explain why bigger mammals could defecate at high speed despite their longer feces, as they often have a thicker layer of mucus in their large intestine. On the other hand, a thinner mucus or abnormal changes in the mucus may lead to defecation difficulties and ailments.

You may wonder if the “poop-analysis” has any practical value or significance. Indeed, the defecation data could be applied in aspects such as engineering and medicine. For example, a new adult diaper that keeps feces away from direct skin contact was designed, so that astronauts could stay in their space suits for a longer duration. In medicine, the experimental results could shed light on alterations in mucus during bacterial infections like a *C. difficile* infection of the gastrointestinal tract [3].

See, the study of poop is no stinky science at all!

此外，動物身體質量似乎跟排便速率成正相關。大象排便的速度為每秒6厘米，比一般人類快三倍。不同種類動物的排便量可以相差甚遠。大象糞便平均的容積高達20公升，比一個人類平均一天的排便量還要多幾百倍 [2]。

儘管動物的排便量相差甚遠，排便時間卻相對穩定。為何大型動物的排便速度如此快？箇中答案或藏身於結直腸的黏膜特性。

糞便在大腸的黏膜間，是有如雪橇在滑道中般移動，而不是像牙膏般被擠出來。由於黏膜的黏度比糞便低超過100倍，黏膜可發揮潤滑的作用，有助糞便排出。這亦解釋了為何較大型的動物即使排出的大便較長，排便速度亦能如此快：因為牠們的大腸往往有較厚的黏膜。另一方面，較薄的黏膜，或是異常的黏膜可能會導致排便困難和相關疾病。

你或覺得大便的研究似乎沒有甚麼特別的實用價值。實際上，這些數據可應用於工程和醫學等方面，例如早前研究人員設計了一款能避免糞便和皮膚直接接觸的新式成人尿片，讓太空人可以在太空衣內逗留更長的時間。醫學方面，研究可以為黏膜在腸胃感染時的變化提供線索，讓我們更深入了解艱難梭菌等細菌感染對腸胃的影響 [3]。

這系列的實驗正正可以證明，即使是像「排便」這些看似瑣碎無聊的研究命題，亦可以有顯著的實際用途。

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Perfume: the Chemistry of Attraction

香氣的秘密

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。

From shampoo, air refreshers to body spray and perfume, fragrance is an indispensable part of modern daily life. Perfume has existed for over 4000 years according to recorded history. Before synthetic compounds began to be discovered in the 19th century, fragrance ingredients were extracted from natural sources, from common plants like flowers, herbs, to weird, exotic animals like male deer secretion and beaver scent glands [1]. Nowadays, the main components of perfume include a complicated mixture of volatile fragrance compounds, alcohol and water.

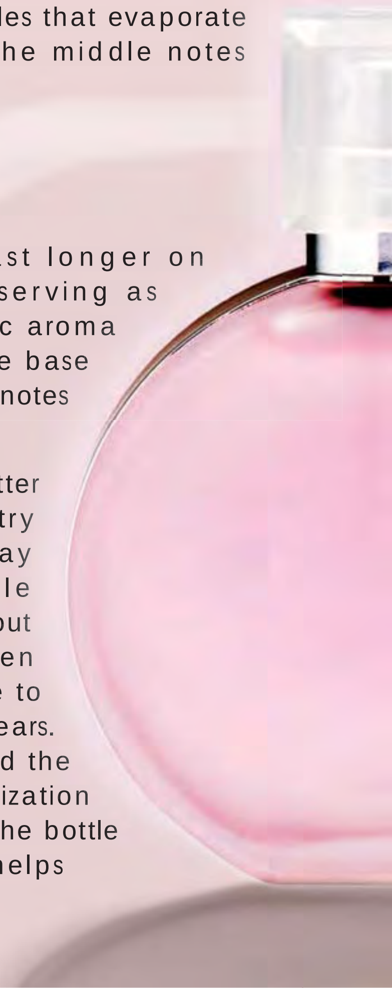
Distilled water (H_2O) and ethyl alcohol (C_2H_6O) are among the most commonly used "carriers", which serve as solvents for the scent-bearing compounds. The fragrance compounds are small and have a low molecular weight (usually smaller than 300 Daltons), so that they are light enough to float and disperse in the air [2]. When the molecules pass through the nose, receptors will send electrical signals to the brain, which then leads to a perception of the odour.

Some of you may have heard of the chemical term "aromatic compounds". While aromatic compounds are often used in the making of fragrance, the word "aromatic" here has little to do with smell. Aromatic compounds are a large category of unsaturated organic compounds that contains at least one benzene ring (C_6H_6). A compound is classified as aromatic only because of its chemical structure, but not its smell.

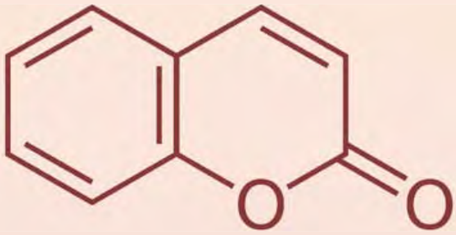
Not every aromatic compound gives a strong distinctive odour. Not every odorant chemical compound belongs to the aromatic family either. Ammonia (NH_3), for instance, is inorganic and gives a fishy smell. Ethyl butyrate ($C_6H_{12}O_2$) is a natural ester that smells like pineapple.

The odour of chemicals varies hugely from compound to compound. Some are pungent and unpleasant, while some are sweet or fruity. Naphthalene ($C_{10}H_8$), for example, is the compound that gives moth balls their strong smell. Toluene (C_7H_8) is responsible for the distinct scent of paint. Vanillin ($C_8H_8O_3$) and anisole (C_7H_8O), as you may guess from the names, give the pleasing smell of vanilla and anise.

A perfume is usually consisted of three parts: top notes, middle notes and base notes. Top notes are considered as the first noticeable smell, made up of molecules that evaporate most quickly. The middle notes last longer on the skin, serving as the main and characteristic aroma of the fragrance. Finally, the base notes emerge as the middle notes dissipate [3].



Now that you have a better idea of the basic chemistry behind fragrance, you may understand the rationale behind common advices about fragrance. People are often advised to apply fragrance to their wrists and behind their ears. These areas are warmer and the heat could enhance vaporization of molecules. Also, keeping the bottle in a cool, shaded place helps



Coumarin, which has a sweet odour

lengthen the lifespan of a fragrance as it avoids oxidation catalyzed by sunlight and heat.

Chemists have been working to synthetically replicate different kinds of smell, opening up countless possibilities of scent applications. Maybe someday you will be able to spray your room with a fragrance that mimics the smell of your favourite food, or a scent that reminds you of your treasured childhood memories. The making of fragrance is a creative craft combining art and science together.

無論是洗頭水、空氣清新劑、身體噴劑或是香水，香氣成分是不少產品不可或缺的一部分。香水距今已有 4000 多年的歷史。在人造成分在 19 世紀開始被製造之前，香水的成分往往由大自然而來，來源包羅萬有，例如花草等植物，以及公鹿分泌物和河狸腺體等的奇怪成分 [1]。時至今日，香水主要由酒精、水和一些易揮發的香氣化合物而組成。

蒸餾水 (H_2O) 和乙醇 (C_2H_6O) 是最常用的材料，用作一些散發香氣的化合物的溶劑。香氣化合物相當細小，分子重量輕 (通常小於 300 達爾頓)，所以它們可以在空中飄散 [2]。當它們進入我們的鼻子，鼻的嗅覺受體會把訊息傳到腦部，所以我們能感受氣味。

你可能聽過一個名為「芳香族化合物」的化學詞彙。雖然芳香族化合物常用於製作香水，「芳香族」這名字和氣味其實並無關係。芳香族化合物是一種有至少一個苯環的不飽和有機化合物的總稱。化合物是否具芳香性，取決於其化學構造，而非其氣味。

並非所有芳香族化合物都有強烈的氣味，另一方面，並非所有帶氣味的化合物都具芳香性。以阿摩尼亞 (NH_3) 為例，它是一種刺鼻的無機化合物，而丁酸乙酯則 ($C_6H_{12}O_2$) 是一種帶菠蘿氣味的自然酯類。

不同化合物的氣味可以相差甚遠，有些化合物氣味刺鼻又不討好，有些則帶水果的氣味。例如防蟲丸的強烈氣味是來自萘 ($C_{10}H_8$)，油漆的氣味來自甲苯 (C_7H_8)。香草精 ($C_8H_8O_3$) 和茴香醚 (C_7H_8O) 則顧名思義，帶有香草和茴香的氣味。

香水通常由 3 部份組成：前調、中調和基調。前調是我們首先會注意到的氣味，由最快消散的分子組成，而中調逗留在皮膚上的時間較長，是香水主要的氣味，基調則隨著中調消失而出現 [3]。

有些人認為香氣產品較適合噴在手腕或耳後。這些位置較溫暖，有助分子消散。此外，把香水放置在陰涼地方可有助延長產品壽命，因為這樣可減低產品因陽光和熱力而氧化的機會。

化學家一直研發人工製造各種氣味的方法，開啟了氣味應用的不同可能性。也許有一天，你可以在房間噴灑你最愛食物的氣味，或是令你回想起珍貴童年回憶的氣味。香味的製造可說是一門結合藝術和科學的創意工藝。

Linalool, which has a floral scent

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From Physics to Biology:
Interview with Professor Yifan Cheng

By Teresa Ming Shan Fan 樊銘姍

At first glance, physics and biology may seem like two entirely different subjects. Professor Yifan Cheng, who is now a professor of biochemistry and biophysics at the University of California, San Francisco, had spent years in the field of physics before becoming a biologist. We sat down and talked with Prof. Cheng after his recent visit to the HKUST.

Prof. Cheng has studied and worked in the field of physics for more than ten years. It was during those years that he met a biologist who was working on a technology called cryo-EM, short for cryo-electron microscopy. The more he learnt about it, the more amazed he felt. Prof. Cheng recalled, "He painted me a very rosy, beautiful picture. He said, 'our mission is to improve human health, such as curing cancer.' And I thought 'that's fascinating!'"

Prof. Cheng's life as a scientist changed dramatically not long afterwards, as the world went through unusual, significant changes. As the arms race between the United States and the Soviet Union ended, funding for a lot of physics projects dropped significantly and many physicists had trouble looking for jobs, he explained. Finding himself in an era of great turbulence, he made an unusual decision. He decided to turn his research focus to biology, based on his chance encounter of the cryo-EM specialist. "The biological system is probably the most complex system. It is so complicated that there are still many unknowns. Therefore, every single thing you work on may lead to a new discovery," the scientist said. "The complexity of the problem, the logic... it's so beautiful."

Prof. Cheng specializes in using cryo-EM to "look" at protein structures at unprecedented atomic resolution. You probably have tried using microscopes at the school laboratory to look at biological samples that are too small to be seen with the naked eye. Image formation is based on the interaction between light waves and the sample. Nevertheless, when it comes to the observation of biomolecules at the atomic level, the wavelength of visible light is simply too long. The wavelength of electrons, however, is much shorter. Therefore, tiny structures – even atoms – could be observed under the electron microscope. Cryo-EM could facilitate a wide spectrum of scientific research, including that of medicine. It allows scientists to have a better look at large protein ensembles that may be disrupted in human diseases, and provide clues to the development of better drugs and medical treatment. Protein structures may also be highly relevant to daily lives. For example, Prof. Cheng's laboratory recently determined the structure of a protein that allows us to feel pain after consuming chili-pepper.

For Prof. Cheng, switching his field of research meant getting a faculty position much later than usual, but he never regretted his decision. "Now I still feel very happy, and very proud of working in this field."

When asked for his advice to students, he stressed the importance of perseverance and likened scientific research to running a marathon. Although there may be times when you want to give up, you can overcome all challenges and eventually accomplish something if you keep on running. "The things that really drive you to go through difficulty is your passion, and the fact that you are curious about the unknown, that you don't want to give up, that you want to find out what is going on... And that I think, is probably the most important thing."

從物理到生物 —— 專訪程亦凡教授

物理和生物看起來是毫不相關的學科，然而，加州大學舊金山分校的生物化學及生物物理教授程亦凡教授，在成為生物學家之前曾花了不少時間從事物理方面的研究工作。早前程教授到訪香港科技大學，我們有幸和程教授見面，認識他從物理學家變成生物學家背後的故事。

程教授花了超過十年時間學習物理和從事物理方面的研究。當時他遇到了一名從事冷凍電子顯微鏡相關研究的生物學家，程教授愈認識這技術，心裡愈發入迷：「他描繪了一個十分美好的景象，他說：『我們的任務是改善人類健康，例如治療癌症。』我心想：『那真是太好了！』」

其後，隨著世界經歷重大又特殊的轉變，程教授的科學家生涯亦大大改變。美國和蘇聯的軍備競賽結束，不少物理研究計劃的資金大幅減少，很多物理學家都難以找到工作。如此特殊的情況下，再加上早前和生物學家的相遇，程教授作出了不一般的決定：轉行到生物研究。「生物系統可能是最複雜的系統，現在還有很多未知的東西，所以你研究的每一項事物也可能帶給你新的發現。問題的複雜性、邏輯……真的很美。」

程教授專長於運用冷凍電子顯微鏡技術，以原子程度清晰度去「觀看」蛋白結構。你大概試過在學校用顯微鏡觀察肉眼難以看見的生物樣本。藉著光波和樣本的關係，我們可透過顯微鏡看見影像。可是，要以原子程度觀看生物分子，可見光波的波長實在太長了。相比之下，電子的波長短得多，因此，細小的結構 — 甚至是原子 — 也可透過電子顯微鏡看得到。冷凍電子顯微鏡技術有助不少科研發展，包括醫學研究。透過這技術，科學家可更認識一些有可能受人類疾病影響的大型蛋白組合，發展出更好的藥物和醫療技術。此外，蛋白結構和日常生活亦息息相關。程教授的實驗室最近就找到了一種蛋白質的結構，這種物質讓我們吃辣椒後感到痛楚。

對程教授來說，儘管轉行使他比其他人較遲得到大學教席，但他從不後悔轉行的決定。他說：「我至今依然十分快樂，依然為這一行的工作感到十分驕傲。」

被問到有什麼給學生的建議時，程教授強調堅毅的重要。他把科研和跑馬拉松相比，雖然路程當中，有時你會希望放棄，但假如你能夠堅持下去，你終能跨過難關，得到成果。「能夠推動你經歷困難向前的，是你的熱情、對未知事物的好奇心、不願放棄、希望了解周遭發生什麼事的心……我想，那是最為重要的。」

Did you know:

The Nobel Prize in Chemistry 2017 is awarded to Jacques Dubochet, Joachim Frank and Richard Henderson "for developing cryo-electron microscopy for the high-resolution structure determination of biomolecules in solution".

Learn more about the work of the three scientists at *https://www.nobelprize.org/nobel_prizes/chemistry/laureates/2017/press.html*

你知道嗎：

Jacques Dubochet、Joachim Frank 和 Richard Henderson 三名科學家因「發展冷凍電子顯微鏡以觀察溶液中生物分子的高清結構」而獲得2017年的諾貝爾化學獎。

有興趣更了解他們的研究的同學，可參閱網頁 *https://www.nobelprize.org/nobel_prizes/chemistry/laureates/2017/press.html*

Science News 科學新聞

First Interstellar Asteroid Spotted

On 19 October, an asteroid from interstellar space was spotted dashing through our solar system. It is the first time astronomers have studied an interstellar asteroid. First spotted by the Pan-STARRS 1 telescope in Hawaii, the asteroid is believed to had been travelling for millions of years before its chance encounter with the solar system. The object is estimated to be at least 400 meters long. It has been named ‘Oumuamua, which means “a messenger from afar arriving first” in Hawaiian.

來自太陽系外的「星際訪客」

位於夏威夷的 Pan-STARRS 1 望遠鏡在10月19日發現一顆星際小行星，而這是科學家第一次追蹤研究星際小行星。科學家相信它在和我們「相遇」之前已飛行數以百萬年計的時間。小行星估計至少長400米。它已被命名為「'Oumuamua」，在夏威夷語有「遠方來的信使」的意思。

Artist’s impression of the interstellar asteroid ‘Oumuamua (European Southern Observatory, M. Kornmesser)

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Acknowledgements 特別致謝

Financial Support

The HK Electronic Industries Association Ltd. 香港電子業商會有限公司
The HK Electronic Industries Association Education Foundation Ltd. 香港電子業商會教育基金

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