SCIENCE FOCUS 科言

Issue 016, 2019

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Science Focus Issue 016, 2019

Message from the Editor-in-Chief 主編的話

Dear Readers,

Welcome to the latest issue of *Science Focus*. This issue marked our first major collaboration with an external party, the creators of the very popular Japanese comic series *Cells at Work*! We hope the animation programs and our article will motivate you to learn more about how blood cells keep us alive and kicking. We also cover the intriguing chemistry on products that we put on our skin. On physics, we present a lighter treatment on quantum mechanics. Finally, many of you have learned the Pythagoras theorem. But as a mathematician, was Pythagoras always right? Please head to the Science in History section for answer.

We encourage you to continue visiting our social media pages on Facebook and Instagram. Earlier this summer, we have identified the first winner of our Instagram Photo Competition. Congratulations to Fontaine Gibbs from the German Swiss International School. Her interpretation of neural development as being "green" really stood out. Please stay tuned for our next round of competition!

Finally, I would like to wish you success in the new school year. Stay curious!

Yours faithfully,
Prof. Ho Yi Mak
Editor-in-Chief

親愛的讀者：

歡迎閱讀最新一期《科言》！今期我們與日本人氣動漫《工作細胞》合作，亦是《科言》首次與其他機構舉辦的聯乘活動。我們希望這套動畫和今期相關的文章會使您對血液學產生興趣，並嘗試了解血細胞們如何使我們能精力充沛地過每一天。此外，您們對塗在皮膚上的產品，例如唇膏和太陽油，背後的化學原理了解有多深？在物理科學方面，我們會深入淺出地向您展現「入門版」的量子力學。最後，您們都有學過畢氏定理吧；但作為一個數學家，畢達哥拉斯是否永遠都是對的呢？您可以在「昔日科學」的部分找出答案。

我們鼓勵大家繼續留意我們的 Facebook 和 Instagram。在較早前我們已經選出了《科言》Instagram 攝影比賽的第一位優勝者：恭喜德瑞國際學校的學生 Fontaine Gibbs！她巧妙地把神經發展詮釋為「綠色（green）」的過程，其論述脫穎而出，確實值得嘉許。請大家也要密切留意下回比賽的最新消息。

最後，我希望大家有一個愉快的新學年，也要時常保持對事物的好奇心啊！

主編 麥晧怡教授
敬上

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WHAT'S HAPPENING IN HONG KONG ?

Fun in Fall Science Activities

Any plans for this fall? Check out these science activities!

秋季的科學好節目

計劃好這個秋天的好去處了嗎？不妨考慮以下活動！

Wonders of the Moon

Did you know that corals spawn according to the lunar cycle? Want to know what "blood moon" and "super moon" are? The Hong Kong Space Museum will show the astronomy movie, "Wonders of the Moon", which unravels every aspect and the science of the moon.

Date: September 21, 2019 (Saturday)

Time: 4:00 PM to 5:00 PM

Venue: Lecture Hall, Hong Kong Space Museum

Remarks: Free admission. Narrated in English with Chinese subtitles.

月亮奇蹟

有想過珊瑚的繁殖會受月亮週期影響嗎？想知道甚麼是「血月」和「超級月亮」？香港太空館將會播放天文電影《月亮奇蹟》，讓您認識到月亮最真實的一面和背後的科學。

日期：2019年9月21日（星期六）

時間：下午4時至5時

地點：香港太空館演講廳

備註：免費入座；英語旁述（配以中文字幕）

Becoming Jane – Inspiring a Shared Planet

Dr. Jane Goodall is a well-known environmentalist and humanitarian. She spent many years in the wild observing the behavior of chimpanzees in her early career. In recent decades, she realized the damage caused by human activities to the environment, and therefore devotes herself to educating the public about the importance of environmental protection.

This interactive exhibition in the Hong Kong Science Museum showcases Dr. Goodall's early scientific discoveries in the jungle, as well as her contributions to environmental conservation. The organizer especially hopes to encourage the teenagers in Hong Kong to put the idea of environmental protection into practice.

Date: Now – October 2, 2019

Venue: G/F Exhibition Hall, Hong Kong Science Museum

珍古德的叢林啟迪

珍古德博士是著名的環保主義和人道主義者。她在早年曾花多年時間在野外研究黑猩猩的行為和習性。最近數十年由於意識到人類活動對環境造成的破壞，因而致力於教育大眾保護環境的重要性。

這次香港科學館的專題展覽以互動形式向公眾展示珍古德博士早期在叢林的科學發現，以及她在環境保育方面的貢獻。主辦機構尤其希望鼓勵香港青少年身體力行，主動在日常生活上為保護環境出一分力。

展期：即日至2019年10月2日

地點：香港科學館地下展覽廳

Winter Games

Did you yearn for winter during the boiling days? The Hong Kong Science Museum is now ready to provide you with the experience of many winter sports! The "Winter Games" exhibition features 20 interactive exhibits, including ice hockey and curling. You can learn the history, rules and scientific principles of those sports, while experience being a winter sports athlete.

Date: Now – October 16, 2019

Venue: Special Exhibition Hall, Hong Kong Science Museum

冬季冰運會

有沒有在汗流浹背的日子期盼著冬天的來臨？香港科學館已率先把多種冬季運動帶到你眼前！「冬季冰運會」展覽設有包括冰球、冰壺等二十組互動展品，讓您在體驗這些運動的同時，了解每項運動的歷史、比賽形式和規則，以及這些運動背後的科學原理。

展期：即日至2019年10月16日

地點：香港科學館特備展覽廳

香港科技活動

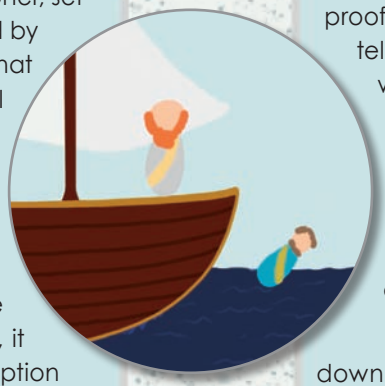
The Square Root of Two – at the Cost of a Life

Our life is surrounded by numbers, to be more specific, integers. "I have 3 courses today." "Apples cost 15 dollars per 2 kilograms." In the latter case, 1 kg of apples costs 7.5, or 15/2 dollars. This kind of number expressed as ratio of two integers are called rational numbers. Research shows that integers and rational numbers actually came from daily life's counting. They were just symbols invented by our ancestors to make records of the amounts of objects thousand years ago.

Around fifth century BC, ancient Greece. Pythagoras of Samos, a famous mathematician and philosopher, set up the so-called Pythagorean School. Influenced by religious and daily experience, his theory stated that everything in the universe is made out of natural numbers. And ratio can be used to express the relationship between any two things — from the rules of planetary motion to the arrangement of musical notes [1]. Scientists now believe that the Pythagorean scholars arrived at this thought based on their belief that there are infinite number of rational numbers. Accordingly, it is reasonable for Pythagoras to make the assumption that an infinite amount of numbers is enough to describe the whole world [2].

A question about this was quickly raised by Hippasus of Metapotum, one of Pythagoras' students. He noticed that the length of diagonal of a square, of which each side has the length of 1, might not be represented by ratios of two integers. According to Pythagoras' own theory, this number should be equal to the square root of 2. Hippasus tried hard to express this number as a ratio of integers, but in vain [3]. It was the first time that someone noticed that Pythagoras might be wrong. Hippasus then took a bold move. Instead of giving up on this annoying number, he tried to prove that it didn't equal to the ratio of any two integers.

Although we don't know much about his method, most of mathematicians believe that he actually succeeded. The proof itself was not too complicated as any undergraduate student in math can proof it nowadays. But for Pythagoras and his followers, the result was unacceptable. This discovery did not only prove that Pythagoras' concept of "all is (rational) number" was wrong mathematically, it shook the philosophy behind his entire explanation of the world. Pythagoras thus ordered Hippasus to keep this result as a secret. But Hippasus was too excited to be quiet – imagine a physics student rigorously proved that Einstein was wrong (in math nothing counts but rigorous proof), it must be impossible for him to not tell anyone about his breakthrough. The wrath of Pythagoras burst out when he knew Hippasus "revealed" the result to some of his close friends. It is generally believed that this young student was then condemned to death by being thrown overboard during a sea voyage [1-4].



The murder did not settle things down. Not long after Pythagoras' demise, the idea of irrational numbers quickly took its position in the world of mathematics. Not only in Greece, mathematicians in India also discovered and announced the existence of irrational numbers decades later. Euclid, one of the most important mathematicians in human history, proved $\sqrt{2}$ is irrational in 3rd century BC, which was recognized as the first formal proof of this result by modern mathematics [1]. More complex irrational numbers were discovered and carefully studied since then. Important irrational numbers such as π and e, nowadays play an important role in mathematics study and research.

Although the details of the work done by Hippasus is not clear today, mathematicians still consider him as the first one who discovered irrational numbers. He was admired not only for his work, but also for his spirits of curiosity, perseverance and questioning the authority, which is precisely the soul of math. As for Pythagoras, on one hand, mathematicians are grateful for his job of clarifying the system of rational numbers and some famous results in various disciplines of math. On the other hand, his arrogance, refusal to new ideas and being terrified to admit making mistakes are considered to be the most harmful characteristics for not just mathematicians, but scientists in every subject.

根號 2 — 探求真理的代價

By Jack Long 龍眾

我們的生活離不開數字，尤其是整數。「我今天上了 3 堂課。」「蘋果 15 元 2 公斤。」這樣一來 1 公斤蘋果就是 7.5 元，或者說 15/2 元。這種以兩個整數的比例來表示的數就是有理數。研究表明，整數和有理數其實起源於日常的數數行為。它們只是我們祖先發明的一些符號，於數千年前用來記錄物件的數量。

公元前五世紀左右，在古希臘，一位名叫畢達哥拉斯 (Pythagoras of Samos) 的著名數學家兼哲學家創立了自己的學派 —— 畢達哥拉斯學派。受到宗教以及日常經驗的影響，他的理論指出世間的萬事萬物無不由自然數組成，而比例則可以用於表達任何兩樣物件之間的關係 —— 從日月流轉的規律，到音符的排列 [1]。現代學者相信，畢達哥拉斯學派的想法很可能是基於有理數的數量是無限這一事實得出的。因此，他假設數量如此繁多的有理數足以描述整個世界，其實也不無道理 [2]。

然而質疑聲很快出現了。他門下一位名叫希帕索斯 (Hippasus of Metapotum) 的學生注意到，如果一個正方形的邊長為 1，其對角線的長度似乎並不能被表示為由兩個整數組成的比例。根據畢達哥拉斯定理 (即畢氏定理)，這個長度應該等於根號 2。可不管希帕索斯如何嘗試，他都無法將這個數字表示為由整數組成的比例 [3]。這是第一次有人意識到畢達哥拉斯可能是錯的。希帕索斯沒有就此放棄這個棘手的數；相反地，他決定大膽地嘗試證明根號 2 這個數不能被表示成任何兩個整數組成的比例。

儘管他證明中的細節難以被考證，絕大多數當代數學家都相信希帕索斯成功了。這個難度不大的證明如今已是大多數數學系本科生的必修內容。然而在當時，這一成果對畢達哥拉斯和他的忠實信徒們來說卻好像晴空霹靂。這發現不旦在數學上推翻了畢達哥拉斯「萬物皆 (有理) 數」的理論，進而直接動搖了其學說對於世上萬物解釋的哲學根基。畢達哥拉斯因此命令希帕索斯要對此保密。然而，欣喜若狂的希帕索斯還是把事情洩露了 — 想像如果一個物理系學生能嚴謹地證明愛因斯坦是錯的一樣 (數學上只有嚴謹的證明是重要的)，他根本不可能不告訴別人如此具突破性的發現。當畢達哥拉斯知道希帕索斯把這一結論告知了數位好友的時候，他勃然大怒。一般相信希帕索斯因而被判處死刑，並在一次出海時被扔進海中溺死 [1-4]。

可是這次謀殺並未使風波平息。畢達哥拉斯去世後不久，無理數的概念迅速地在數學界萌芽。不止是希臘，印度的數學家們在數十年後也發現並宣告了無理數的存在。公元前三世紀，人類歷史上其中一位重要的數學家歐幾裡得 (Euclid) 給出了根號 2 不是有理數的嚴謹證明，這一證明亦被認為是最早以現代數學來證實這結果的正式證明 [1]。在此之後，越來越多的無理數陸續被發現，然後被小心地研究。類似圓周率 π 和自然對數底 *e* 這些重要的無理數，在現代數學研究中都扮演著舉足輕重的角色。

儘管希帕索斯證明中的細節已經被淹沒在歷史中，科學家們仍然認為希帕索斯是第一個發現無理數存在的人。他令人敬佩的不光是其學術成果，還有的是好奇心、毅力和勇於質疑權威的精神。這些難能可貴的素質也正是數學的靈魂。反觀畢達哥拉斯，一方面，數學家們很感謝他闡釋了整個有理數的系統，而且對數學的不同領域都帶來了著名的學術理論；然而他的傲慢、迂腐以及羞於承認錯誤的態度也被認為是對作為數學家，以及其他領域科學家百害而無一利的致命傷。

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[1] Gaskin, D. (1999). *An Ancient Mathematical Crisis.* Retrieved from *https://denisegaskins.com/2008/05/27/ancient-mathematical-crisis/*

[2] Taylor, P. (2014). *Discovery of Irrational Numbers.* Retrieved from *https://brilliant.org/discussions/thread/discovery-of-irrational-numbers/*

[3] Gupta, H. (2017). *How Were Irrational Numbers Discovered?* Retrieved from *https://www.scienceabc.com/pure-sciences/how-irrational-numbers-discovered-mathematician-killed-hippasus.html*

[4] Esoterx. (2014). *Murder by Math: The Irrational Demise of Hippasus.* Retrieved from *https://esoterx.com/2014/12/03/murder-by-math-the-irrational-demise-of-hippasus/*

Nowadays, touch screens are ubiquitous in our lives. Everywhere we go, there's always a touch screen: be it at the restaurants or directories or even in your own pocket in the form of a smartphone. It's something we rely on every minute of our lives. It's amazing how a piece of glass responds to your touch so quickly and accurately, but have you ever given much thought to why and how it works as it does? This article will dive into the "how" and the "why" on the workings of the touch screen.

In fact, there are two commonly used touch screens. One works based on the principle of resistance. The resistive touch screen actually contains two flexible conductive layers separated by an air gap. The upper outward-facing layer is coated with a thin, scratch-resistant material while the inner layer is braced against a rigid layer, usually glass. When the touch screen is in operation, electrical currents run through these two conductive layers. When you touch the screen, pressure is applied. This pressure dents the upper conductive layer momentarily such that it comes into contact with the lower conductive layer. This brief contact of the layers alters the resistance in the area. Such a change in resistance is readily detected by sensors in the touch screen and the precise location of the touch can be calculated. As such, your touch is registered by the machine and the touch screen can be operated with ease.

However, sometimes these touch screens refuse to budge even after constant prodding. This is because older generations of this touch screen can only register one touch at a time; if you press two different locations at the same time, the sensor will be confused as to where you are actually touching, leading to non-responsiveness. Thankfully, newer models of the resistive touch screen have been upgraded to be able to sense more than one touch at the same time.

The other type of touch screen relies on the principle of capacitance. To start off, capacitance is a property defined as the ability to hold electrical charges. In capacitive touch screens, the topmost layer is made up of a large network of tiny fine wires that are able to hold an electric charge. This network of wires holds electricity at all times. It so happens that human skin is also a capacitor. So when your finger touches the screen, a minute amount of electricity is transferred from the network to your finger. This disturbs the original electrostatic field in the network, which is signaled by a drop in voltage at that precise location. Again, this drop is sensed by the machine and the location registers your touch to perform downstream tasks. As this type of technology relies on the transfer of electricity from the screen to the human finger, it well explains why capacitive touch screens cannot work when we touch it whilst wearing non-conductive materials, such as gloves.

Comparatively, resistive touch screens are less costly to produce than capacitive touch screens. As such, this has made the former more commonly used in society, such as the touch screens at canteens or directories. However, as you may have noticed, those touch screens are not as sensitive to your touch as your own electronic devices. (You only need to compare the canteen ordering machine to your own mobile phone.) This is because handheld devices usually utilize capacitive touch screens, which have a noticeably higher touch sensitivity than resistive touch screens. And besides, capacitive touch screens have a brighter and sharper display than resistive touch screens as the former does not have air gaps in between layers. Due to these pros, capacitive touch screens are becoming more and more popular.

So there you have it, the working principles of touch screens. So next time you play games on your phone or order food on a restaurant tablet, remember it was the magic of touch screens that allowed us to perform such simple but pivotal tasks.

[Editor's remark: This article describes the two most common types of touch screens. Nevertheless, additional, less widely used touch screen technologies exist.]

TOUCH SCREENS
輕觸式屏幕

By Henry Lau 劉以軒

現在，輕觸式屏幕在我們的生活中無處不在。不管我們走到哪裡，附近都總有一個：無論是餐廳裡的點餐機、商場裡的電子告示牌，還是你口袋裡的智能手機。它是我們生活中每一刻都不能缺少的東西。一塊玻璃屏幕能對你的觸碰作出如此迅速和準確的反應的確十分神奇，但是你有沒有想過它是如何運作的？下文將探討輕觸式屏幕的運作原理。

常見的輕觸式屏幕可以分為兩種。第一種是利用電阻的原理運作的。電阻式觸控屏由兩塊柔軟的導電層組成，中間由空氣層隔開。上面朝外的導電層另外覆蓋著一層薄而防刮的物料；下面的內層則由一層堅硬的物料（通常是玻璃）所支撐著。觸控屏運作時，電流會通過這兩個導電層。當你觸摸屏幕時，產生的壓力會使上面的導電層凹陷，令其與下面的導電層接觸。這種短暫的接觸改變了該位置的電阻，觸控屏內的探測器很快便會探測到電阻的變化，使觸碰的精確位置得以被計算出來。因此，觸控屏可以辨識到你的觸摸動作，令你可以輕鬆操作。

然而，有時無論你如何點擊屏幕，它卻沒有任何反應：這是因為較舊的觸控屏一次只能感應單點觸控。如果你同時按下兩個不同的位置，探測器便不能分辨你觸摸的位置，以致不能作出反應。幸好較新的電阻式觸控屏已經能夠支援多點觸控了。

另一種觸控屏利用了電容的原理。電容是物質儲存電荷的能力。在電容式觸控屏中，最上層是由幼細金屬絲組成的網絡，它能夠儲存電荷，換言之亦即是它們無時無刻也儲存著電能。人類的皮膚也一樣是電容器，所以當你的手指接觸屏幕時，微量的電能會從金屬絲網絡轉移到你的手指上。這干擾了金屬絲網絡原來的靜電場，使該位置電壓下降。同樣地，觸控屏能探測電壓的下降，然後根據觸碰的位置執行之後的程序。由於這種技術需要將電從屏幕轉移到手指，這解釋了為什麼我們在戴著手套等非導電材料時無法操作電容式觸控屏。

相比之下，電阻式觸控屏的生產成本低於電容式觸控屏。因此，前者會更常被用於公共設施上，例如飯堂裡的點餐機或一些電子告示牌。可是，你可能已經注意到，那些輕觸式屏幕的靈敏度並不如你的個人電子產品（你只需比較一下點餐機的屏幕和自己手機）。這是因為手提式設備通常使用電容式觸控屏，其靈敏度明顯比電阻式觸控屏的高。此外，由於電容式觸控屏裡沒有空氣層，所以相比電阻式觸控屏，它的畫面會更為明亮和銳利。正因為這些優點，電容式觸控屏變得越來越普遍。

現在你應該明白輕觸式屏幕的運作原理了吧。下次當你玩手機遊戲，或在餐廳的平板電腦上點餐時，請記住這個能讓我們輕鬆完成重要事情背後的祕密！

[編按：本文介紹了兩種最常見的輕觸式屏幕，不過其實還有一些較為少見的觸控技術。]

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可以食用的「水樽」 Edible Water Bottle

By Teresa Fan 樊銘姍

The recent trend of long-distance running has caused a lifestyle revolution of many Hongkongers. In 2018, more than 130 long-distance races were held in Hong Kong [1]. Nevertheless, some environmentalists concern whether the plastic bottles being disposed of in such sporting events place a burden on our planet, for example, about 920,000 plastic bottles were generated in the 2018 London Marathon [2, 3]. It is worth noting that recycling facilities are not always available in large-scale events like the marathon. Apart from the production of plastic waste, Lucy Ashe, a British distance runner, suggested that the amount of water provided by a plastic bottle is much more than sufficient to keep them hydrated during the race [4]. So, are there any better choices?

The edible water bottle can provide a perfect solution to the problems. First invented by a Spanish chef for the use in molecular gastronomy, scientists have adopted this technique, called spherification, to produce the biodegradable and fully edible water bottle. The water bottle can be made from the two edible chemicals, sodium alginate and calcium chloride ($CaCl_2$). As both chemicals are soluble in water, we can first dissolve them in two bowls of water separately. By adding drops of sodium alginate solution into the calcium chloride solution, caviar-like beads form – that's the "edible water droplet"!

Nevertheless, that is still far from being a "water bottle" – the droplet is too small that the runners probably won't find it satisfying. To make a bigger water pouch, we can first freeze the drinking water so that it becomes an ice ball comparable to the size of a tennis ball. By dipping the ice ball into the calcium chloride solution and the warm sodium alginate solution sequentially, a chemical reaction starts, and a soft membrane form around the ice ball. After the ice thaws, it becomes the "water bottle" with the ideal size.

What magic has been done by the solutions? Let's explore the chemistry behind!

It is clear that the membrane forms whenever the solutions of sodium alginate and calcium chloride come into contact. Sodium alginate, usually derived from seaweed, is the sodium salt of alginic acid. Alginic acid is a long-chain polysaccharide (a carbohydrate), which contains many carboxyl groups ($-COO^-H^+$). In sodium alginate, sodium ions (Na^+) with a single positive charge neutralize the negative charge of the anionic groups ($-COO^-$) instead of hydrogen ions (H^+) – forming a kind of sodium carboxylate ($-COO^-Na^+$).

How about replacing the sodium ions (Na^+) with calcium ions (Ca^{2+}), which have two positive charges? Then, each calcium ion will bind to two anionic groups ($-COO^-$) at a time instead of one. That means, the two "hands" of each calcium ion (Ca^{2+}) can now hold two long alginate chains of different molecules simultaneously and join them together, which is technically called the formation of crosslink. An extensive network of molecules is therefore formed, and it is not surprising that this large structure is not soluble in water anymore – this forms the membrane of the water bottle.

The biodegradable alginate membrane will not burden the landfill sites even if you choose to dispose of it, instead of swallowing it. While a plastic bottle takes up to 450 years to decompose [5], the film naturally breaks down within 4 to 6 weeks [3]. Therefore, the edible water bottle can possibly replace plastic bottles in major sporting events and reduce disposable waste.

However, the novel container does have some intrinsic weaknesses comparing to its conventional counterpart.

For instance, the membrane is too fragile that it can be pierced easily, making the pouches difficult to tolerate the rigors during transportation. In addition, the gel-like membrane degrades over time, restricting its replacement of the plastic water bottle on store shelves.

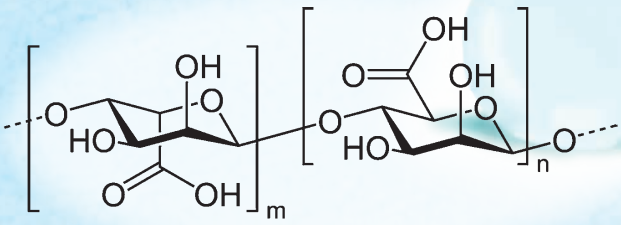
Recently, the edible sachets have carved out another niche in restaurants, mainly for carrying the sauces for takeout orders [6]. Let's be open to innovation, and remember that reducing plastic waste demands our efforts!

近年長跑運動風氣的盛行改變了不少香港人的生活。在 2018 年，香港舉行了逾 130 場長跑賽事 [1]。可是，有環保人士擔心在這些大型體育活動中丟棄的塑料瓶會為地球帶來沈重負擔，例如在 2018 年的倫敦馬拉松中就產生了大約 920,000 個塑料瓶 [2, 3]，然而卻不是每個大型活動（如馬拉松等）都設有回收設施。除了產生塑膠廢料外，英國長跑運動員 Lucy Ashe 表示塑料瓶所提供的水量大大超過運動員所需 [4]。其實，我們還有更好的選擇嗎？

可食用水樽正正可以為這些問題提供完美的解決方案。源於一位西班牙廚師在分子料理的發明，科學家採用了這種稱為「球化（spherification）」的技術來生產可生物降解和可完全食用的水樽。他們可以使用以下兩種可食用的化學物質：海藻酸鈉（sodium alginate）和氯化鈣（$CaCl_2$）。由於這兩種化學物質都可溶於水，我們可以先將它們分別溶解在兩碗水中。透過把氯化鈣溶液滴進海藻酸鈉溶液，一顆顆魚子狀的小球便會形成 — 這就是「食用水滴」了！

然而，這與「水樽」還有一段距離：液滴太小，大概不能為跑手解渴。為了製作更大的「水袋」，我們可以先雪藏飲用水，使其成為一個與網球大小相當的冰球。通過將冰球依次浸入氯化鈣溶液和溫熱的海藻酸鈉溶液，產生的化學反應會令冰球周圍形成軟膜。待冰融化後，它就成為大小適中的「水樽」了。

這兩種溶液到底施了甚麼魔法？讓我們來探索背後的化學反應吧！



Alginic acid 海藻酸

我們清楚知道只要海藻酸鈉溶液和氯化鈣溶液接觸，就會產生薄膜。海藻酸鈉是海藻酸（alginic acid）的鈉鹽，通常提取自海藻。海藻酸是一種長鏈多糖（碳水化合物的一種），而且含有許多羧基（$-COO^-H^+$）；在海藻酸鈉中，陰離子基團（$-COO^-$）的負電荷被具有單正電荷的鈉離子（Na^+）中和，而不是氫離子（H^+），因而形成一種羧酸鈉（$-COO^-Na^+$）。

那麼，如果用帶兩個正電荷的鈣離子（Ca^{2+}）代替鈉離子（Na^+）呢？這樣每個鈣離子每次便會與兩個陰離子基團（$-COO^-$）結合，而不止是一個。換句話說，每個鈣離子（Ca^{2+}）的兩隻「手」可以同時抓住兩條海藻酸鹽長鏈，並把它們連結在一起，這在技術上稱為交聯 (crosslink) 的形成。大面積的分子網絡因此形成，這種大型的結構不再可溶於水亦是意料中事，這形成了水樽的薄膜。

即使你選擇把它用完即棄，而不是整個吃掉，可生物降解的藻酸鹽膜也不會為堆填區造成負擔。普通塑料瓶需要 450 年才能分解 [5]，但藻酸鹽膜卻可以在四至六週內自然分解 [3]。因此，可食用水樽有潛質可以取代大型體育賽事中的塑料瓶，從而減少產生即棄廢物。

可是，與傳統塑料瓶相比，這個新穎的設計卻有著一些根本的缺點。例如，藻酸鹽膜會因太脆弱而容易被刺穿，令水樽難以抵受長距離運輸的巔峰。此外，由於凝膠狀的薄膜會自然分解，使其難以取代商店貨架上的瓶裝水。

最近，可食用水樽又在餐廳裡擔當著另一個新角色：盛載外賣餐點附送的醬料 [6]。這亦再一次提醒我們：我們應常對新觀念和新科技持開放態度，當然還要記住減少塑料浪費需要大家的努力！

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The Science of Sunscreen

防曬霜的科學

By
Chantelle Sullivan
蘇盈安

To catch the tail end of summer, visits to the beach and outdoor activities are a definite must on the list of things to do – and sunscreen is something we often take for granted in situations like these. We are often simply told that the higher the SPF the better. But what does the SPF represent?

SPF stands for Sun Protection Factor. Most sunscreens on the market have an SPF between 15 and 50. Those that are higher than 50 have not been confirmed to be more effective at shielding the skin from ultraviolet (UV) radiation. In addition, no sunscreen is 100% effective in protecting the skin from being penetrated by UV. The SPF number gives a rough indication as to how long the skin stays protected after application. For example, a sunscreen with SPF 30 prevents skin from burning for 30 times longer than usual. It is important to note that even high SPF sunscreens need reapplications to ensure sufficient protection.

You may have also noticed sunscreens being advertised as "broad spectrum" – meaning that they protect against both UVA and UVB radiation. But what are they? They are the ultraviolet rays emitted by the sun, which are categorized into three subgroups: UVA, UVB and UVC.

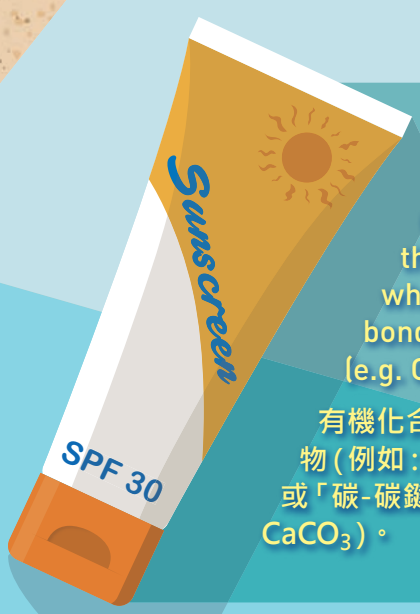
UVA has a wavelength ranging from 315-400 nanometers (nm; i.e. 10^{-9} m) and accounts for 95% of solar ultraviolet radiation that reaches the surface of Earth. It can penetrate past the skin into connective tissue and cause indirect damage to DNA through the generation of reactive oxygen species (ROS). The energy within ultraviolet radiation gives it the ability to "knock off" an electron from molecules such as water, resulting in a highly reactive and unstable molecule, also known as a free radical. Their toxicity to our cells is due to their unpaired electron. This molecule can then attack important biomolecules such as DNA, leading to base mutations. Therefore, ROS generation can increase the probability of obtaining harmful mutations in the skin and connective tissue, which has the potential to develop into skin cancer.

The second type of ultraviolet radiation, UVB, with a wavelength from 280-315 nanometers, does direct damage to DNA by inducing a bend or kink to the double helix. It accounts for 5% of total UV radiation that reaches Earth. A majority is absorbed by the atmosphere, but it is the main culprit behind sunburn. This subtype of UV radiation also causes an increase in melanin (a dark pigment) production by the skin upon exposure.

Fortunately, the third subtype UVC, with the shortest wavelength of 100-280 nm, does not pose a threat against our skin since it is fully absorbed by the ozone layer.

Sunscreens contain both inorganic and organic chemicals as the main active ingredients to protect our skin against the sun's UV radiation. Most inorganic chemicals act as a physical barrier and can reflect the UV rays that hit the surface of our skin. The most common types of inorganic chemicals used in sunscreen are titanium dioxide and zinc oxide. They are added to sunscreen in the form of nanoparticles of 20-40 nm. Their high refractive index coupled with their ability to scatter both UVA and UVB rays makes them the perfect candidate for use in sunscreens.

On the other hand, organic chemicals such as oxybenzone absorb ultraviolet radiation and dissipate it as heat which is a rather harmless form of energy. However, such active ingredients vary in photostability, which is their stability when exposed to UV. Therefore, certain organic chemicals are prone to breakdown as they absorb UV radiation within their bonds. Because of this phenomenon, and to replenish the sunscreen that has been washed away by water and sweat, it is crucial



Did You Know? 你知道嗎？

Organic compounds are generally defined as carbon-compounds that usually contain C-H or C-C bonds (e.g. CH_4, CH_3COOH), whereas inorganic compounds usually do not contain C-H or C-C bonds (e.g. ZnO, TiO_2), although they can still contain carbon atoms (e.g. CO, $CaCO_3$).

有機化合物普遍被定義為一些擁有「碳-氫鍵C-H」或「碳-碳鍵C-C」的碳化合物（例如：CH_4、CH_3COOH）；相反地，無機化合物通常並不擁有「碳-氫鍵C-H」或「碳-碳鍵C-C」（例如：ZnO、TiO_2），儘管它們可能含有碳原子（例如：CO、$CaCO_3$）。

to reapply every few hours to ensure that enough active chemicals are present on the surface of your skin to protect it from UV damage.

要捉緊夏天的尾巴，不少人會選擇到沙灘嬉水或進行其他戶外活動 — 而防曬霜在這些時候是不可缺少的。我們經常聽說防曬用品的 SPF 愈高愈好，但其實 SPF 代表甚麼呢？

SPF 指的是防曬系數（Sun Protection Factor）。市面上大部分防曬霜的 SPF 都在 15 至 50 之間，然而卻沒有足夠證據顯示那些高於 50 的產品能更有效阻隔紫外線（ultraviolet radiation 或 UV）。除此之外，沒有防曬霜能完全有效阻止紫外線穿透皮膚。防曬系數只是一個粗略的估算，指出該防曬產品能在塗抹後使皮膚受到保護的時間，例如 SPF 30 的防曬霜能使皮膚在比平時長三十倍的時間後才開始曬傷。值得注意的是，防曬系數再高的防曬霜也需要定時補塗，以提供足夠的保護。

你可能聽過有些防曬霜以「廣譜」（broad spectrum）作為賣點，這是指產品能針對 UVA 和 UVB 提供保護。但它們其實是甚麼？那些都是由太陽射出的紫外線，可以分為 UVA、UVB 和 UVC 三種。

UVA 的波長為 315 至 400 納米（nm；即 10^{-9} 米），佔到達地面紫外線的 95%。UVA 可以穿過皮膚進入結締組織，並透過產生活性含氧物（reactive oxygen species 或 ROS）而對 DNA 造成間接損害。紫外線的能量可以把一些分子（例如水）中的電子「踢走」，使其變成高度活躍而不穩定的分子 — 亦即自由基。自由基對細胞的毒性在於當中的不成對電子，令它們能夠攻擊例如 DNA 等的重要的生物分子，可以引致鹼基變異（即突變）。因此，活性含氧物的產生能增加皮膚及結締組織遭受有害突變的機會，最終有可能導致皮膚癌。

第二種紫外線是 UVB，波長為 280 至 315 納米，它能透過扭曲 DNA 的雙螺旋結構而直接對 DNA 造成損害，佔到達地表紫外線的 5%。雖然大多都被大氣層吸收，它卻是導致曬傷的主要元兇。另外，曝露在這種紫外線下會使皮膚產生更多的黑色素。

第三種紫外線 UVC 擁有三者之中最短波長:100 至 280 納米。由於它會被臭氧層完全吸收，因此不會對我們的皮膚構成傷害。

防曬霜同時含有無機和有機的化學物質作為其有效成分，以保護皮膚免受陽光中紫外線的傷害。大多的無機化合物都扮演著物理屏障的角色，反射照在皮膚表面的紫外線。防曬霜中最常見的無機化合物有二氧化鈦（titanium dioxide）和氧化鋅（zinc oxide），生產商會把直徑為 20 至 40 納米的化合物粒子加進防曬霜。正因為這兩種化合物的高折射率（reflective index）可使 UVA 及 UVB 向不同方向散射，令它們成為防曬霜成分的理想之選。

另一方面，有機化合物，例如二苯甲酮（oxybenzone），能吸收紫外線並把其轉化成相對無害的熱能。可是，這些有機成分的耐光性不一，亦即是它們在紫外線下的有著不同的穩定性。因此，有些有機化合物會較容易因為分子內的鍵吸收了紫外線而分解。正因為這個現象，加上要補充因為被水或汗水沖走的防曬霜，每隔數小時補塗一次非常重要，這樣能確保皮膚上有足夠的防曬物質保護你的皮膚免受紫外線傷害。

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Cells at Work! 工作細胞 — 認識血液學 —All About Hematology

By Clara Tung 董卓衡

Introduction 引言

"*In the human body, there are about 37.2 trillion cells working 24/7 and energetically.*" This informative and inspiring prologue of the animation, *Cells at Work!*, suggested that every part of our bodies has to "work" coordinately, and some constantly. The vivid visualization of the cells categorized by the adorable characters has given us a clearer understanding of the interaction and major functions of body cells.

「在人體內，大約有37兆2千億個細胞，每天二十四小時、精力充沛地在工作。」這句來自動畫《工作細胞》的開場白說明 —— 我們身體的每個部分都需要互相分工合作，有些更要無間斷地工作。可愛的動畫人物生動地形象化了各種細胞，讓我們更清楚了解體內細胞的主要功能和它們之間的相互作用。

Meet the Characters 角色介紹

Transport 運輸 Defense 防禦 Hemostasis 止血

Red Blood Cell (RBC) 紅血球

In the Animation

- Energetic and responsible in her job
- Easily lose her direction
- Need to go through the narrowest road and deliver oxygen to the corresponding "residents" which represent body cells of various organs (Indeed, in reality, capillaries are super narrow that only one RBC can pass through each time!)

In Reality

Background:

- Account for 45% of the blood components by volume [1]
- Color: Bright red when carrying oxygen; dark red when not carrying oxygen
- Shape: Biconcave disc with no nucleus when mature
- Each RBC contains 300 million hemoglobin molecules [2]. Each hemoglobin contains four hemes and the central iron atom in each heme can bind one oxygen molecule. Therefore, each hemoglobin can carry four oxygen molecules.

Main function:

- Transport oxygen from lungs to cells

在動畫中

- 精力充沛並對自己的工作認真盡責
- 經常迷路
- 需要穿過最狹窄的通道為代表身體細胞的「住客」輸送氧氣 (在現實上，微血管的確非常狹窄，每次只可以容許一個紅血球通過！)

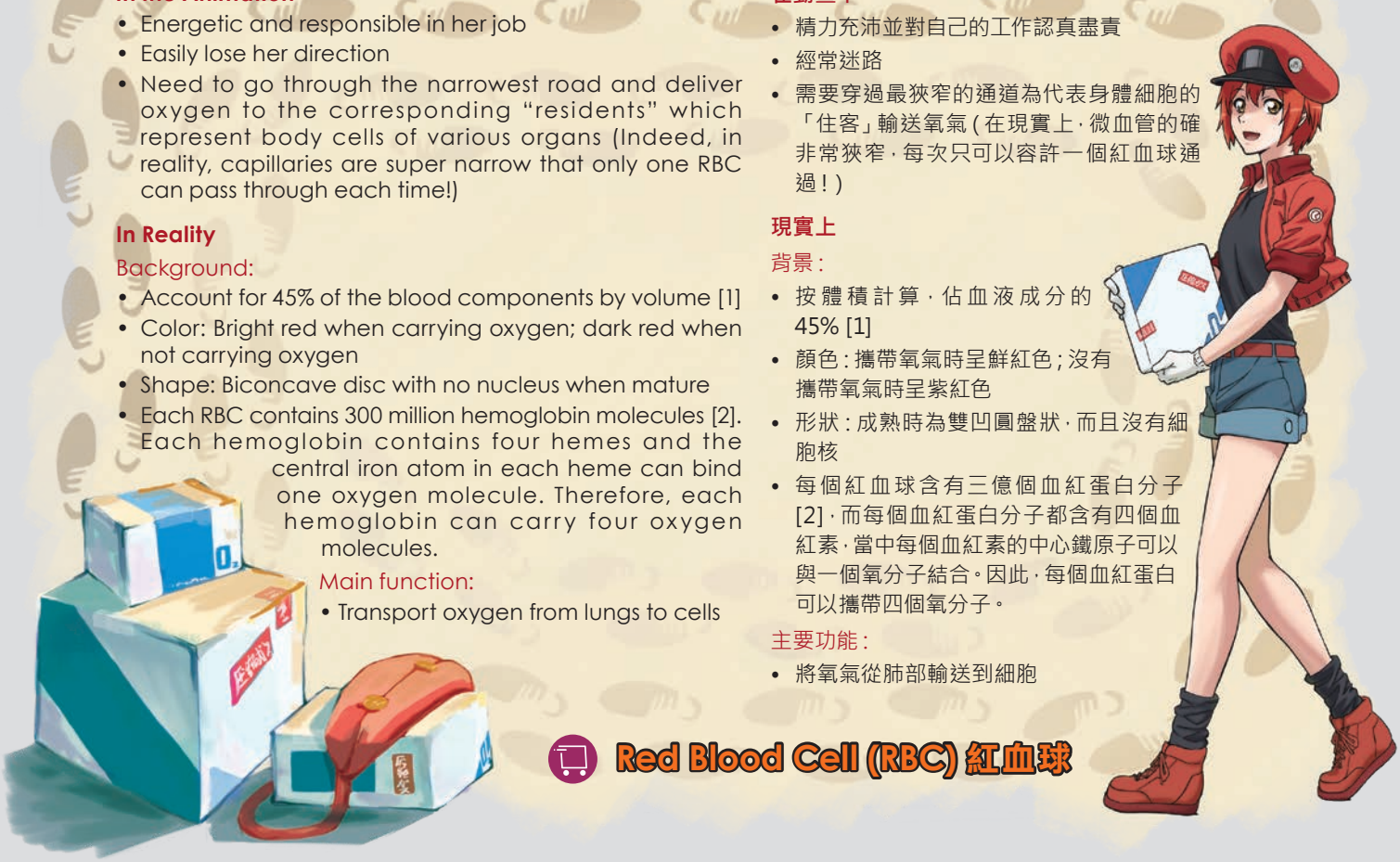
現實上

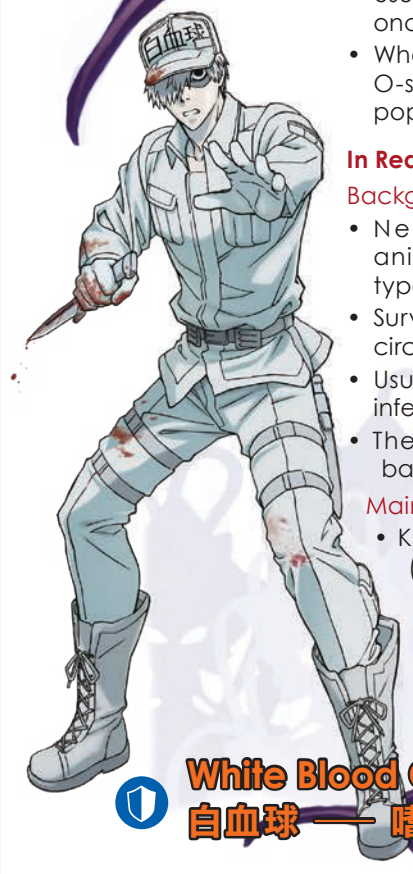
背景：

- 按體積計算，佔血液成分的 45% [1]
- 顏色：攜帶氧氣時呈鮮紅色；沒有攜帶氧氣時呈紫紅色
- 形狀：成熟時為雙凹圓盤狀，而且沒有細胞核
- 每個紅血球含有三億個血紅蛋白分子 [2]，而每個血紅蛋白分子都含有四個血紅素，當中每個血紅素的中心鐵原子可以與一個氧分子結合。因此，每個血紅蛋白可以攜帶四個氧分子。

主要功能：

- 將氧氣從肺部輸送到細胞





White Blood Cell (WBC) — Neutrophil
白血球 —— 嗜中性白血球（嗜中性球）

In the Animation
- Usually calm but won't spare the enemies once he notices them
- When he senses the enemies, the sign with an O-shaped pattern on his hat (receptor) will pop up.

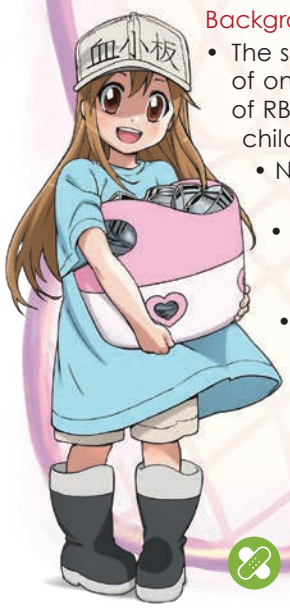
In Reality
Background:
- Neutrophil, the WBC depicted in the animation, represents the most abundant type (~70%) of WBC in the blood [3].
- Survive only for a few hours to several days in circulation [4, 5]
- Usually the first cells to migrate to the site of infection
- There are other types of WBC: eosinophil, basophil, lymphocyte and monocyte

Main function:
- Kill invading microbes by ① phagocytosis (engulfing and digesting), ② degranulation (releasing antimicrobial substances) and ③ "neutrophil extracellular traps" (NETs; throwing a DNA net with antimicrobial substances to trap and kill the microbes while sacrificing itself) [3]

在動畫中
- 平時表現冷靜；一旦發現敵人時卻絕不會饒恕它們
- 當感覺到敵人存在的時候，帽子上帶O形圖案的標誌（受體）會彈起

現實上
背景：
- 動畫中所描繪的白血球，是血液中含量最豐富（~70%）的白血球類型 —— 嗜中性白血球 [3]
- 只能在血液循環中存活數小時到數天 [4, 5]
- 通常是第一個到達受感染部位的細胞
- 還有其他類型的白血球：嗜酸性球，嗜鹼性球，淋巴細胞和單核球

主要功能：
- 通過①吞噬作用（吞沒及消化）、②去顆粒作用（釋放抗微生物物質）和③「嗜中性白血球胞外網狀結構」（neutrophil extracellular traps或NETs；投擲含有抗微生物物質的DNA網以捕獲並殺死微生物，但同時犧牲自身）來殺死入侵的微生物 [3]。



Platelet 血小板

In the Animation
- Petite and adorable; depicted like a little girl
- Tools and equipment: a yellow "no entry" flag, a whistle and different repair materials

In Reality
Background:
- The smallest "blood cell" with a diameter of only 2-3 μm (only 20% of the diameter of RBC – that's why they are depicted as children)
  - Not a true cell, but cell debris without nucleus
  - Produced from the fragmentation of megakaryocytes (a large nucleated bone marrow cell) [6]
  - Can be stimulated by the breakage in blood vessel wall

Main function:
- Participate in the formation of blood clot to stop further bleeding and invasion of pathogens

在動畫中
- 嬌小可愛；被描繪得像小女孩
- 工具和裝備：黃色的「不准進入」旗幟、哨子和不同的修補材料

現實上
背景：
- 最小的「血細胞」，直徑只有2-3微米（這只是紅血球直徑的20% —— 因此它們被描繪成兒童）
- 只是一些沒有細胞核的細胞碎片，因此不算是真正的細胞
- 由巨核細胞（有核的大型骨髓細胞）的破碎化所產生 [6]
- 可以因血管壁破裂而被活化

主要功能：
- 參與血凝塊的形成，以阻止進一步的出血和病原體的入侵

Cells at Work! 工作細胞 — 認識血液學 —All About Hematology

In the Animation

- Depicted like an elegant young lady, but contrary to her appearance, she has a great ability to beat and kill invaders with her large weapons, such as mallet and axe.
- Be the teacher of erythroblasts (immature RBCs) in the "red bone marrow school"

In Reality

Background:

- Differentiate from monocyte; mature into macrophage after monocyte leaves blood vessel and migrates into tissue

Main functions:

- Kill pathogens by phagocytosis
- Help recruit other immune cells in an immune response.
- Support the development of erythroblasts

在動畫中

- 被描繪得像優雅少女，但與她外表相反的是她擁有很強的攻擊能力。她會使用大型武器，如槌和斧頭等，攻擊並殺死入侵者。
- 在「紅骨髓學校」中為幼紅血球（erythroblast；未成熟的紅血球）的老師

現實上

背景：

- 從單核球分化而成；當單核球離開血管並遷移到組織後，可以成熟成為巨噬細胞

主要功能：

- 通過吞噬作用殺死病原體
- 在免疫反應中幫助召集其他免疫細胞
- 支持幼紅血球的發育

Macrophage 巨噬細胞

In the Animation

- Obnoxious and irritable
- Look like a muscular soldier and involve in hand-to-hand combat to exert control

In Reality

Background:

- Differentiate in bone marrow and mature in thymus

Main function:

- Bind to cancerous or infected cells and kill them. One way is to release proteins that poke holes on the plasma membrane of the target cell.

在動畫中

- 粗魯無禮和脾氣暴躁
- 外表像強壯的軍人，因控制場面而要參與肉搏戰

現實上

背景：

- 在骨髓分化並在胸腺成熟

主要功能：

- 與癌細胞或受感染細胞結合並把它們殺死，其中一個方法是釋放一些會在目標細胞的細胞膜上戳洞的蛋白質。

Killer T Cell (Cytotoxic T Cell) 殺手T細胞（細胞毒性T細胞）

Case Study 個案分析

The Red Bone Marrow School — Macrophage and Erythroblast

The functions of macrophage are not merely about the immune defense in our body; macrophage also plays a critical role in erythropoiesis, in other words, RBC development. In episode 6, the process is depicted as the "schooling of RBC". Let's focus on the following two important concepts mentioned!

The First Concept: Macrophage as a Teacher of RBC

- *What is the "school of RBCs" in reality?*

  The "school" in the animation represents the red bone marrow, where RBCs are produced. In the red bone marrow, there are structures called "erythroblastic islands" where many erythroblasts surround a central macrophage. The central macrophage is similar to the teacher at school and it nurtures the nearby erythroblasts. [7]

- *What exactly does macrophage "teach" erythroblasts?*

  It is suggested that macrophages actively assist in the development of erythroblasts by providing iron (recycled from the aged or damaged RBCs) for heme synthesis [7, 8]. They also provide proliferative and survival signals to the erythroblasts, and are involved in erythroblast enucleation [7].

紅骨髓學校 —— 巨噬細胞和幼紅血球

巨噬細胞的功能不止是與體內的免疫防禦有關，它在紅血球生成 (erythropoiesis；即紅血球的成長) 中也起著關鍵作用。在第六集中，這過程被描述為「紅血球的教育」。以下將會討論其中兩個重要概念：

概念一：紅血球的老師 —— 巨噬細胞

- *現實中「紅血球的學校」是什麼？*

  動畫中的「學校」代表紅骨髓，那裡是紅血球生成的地方。在紅骨髓中，有一些稱為「幼紅細胞島」(erythroblastic islands) 的結構，許多幼紅血球會在這裡圍繞著位於中央的巨噬細胞。中央巨噬細胞的角色類似於學校裡的老師，會培育圍繞着它的幼紅血球 [7]。

- *巨噬細胞實際上怎樣「教育」幼紅血球？*

  有研究提出巨噬細胞會透過向幼紅血球提供鐵 (從老化或受損的紅血球中回收得來的)，供其合成血紅素之用，從而積極協助幼紅血球的發育 [7, 8]。它們還為幼紅血球提供增生和生存信號，並參與幼紅血球的脫核過程 [7]。

The Second Concept: Erythroblast Enucleation

- *How does macrophage help with the erythroblast enucleation (removal of nucleus)?*

  In the final stage of RBC maturation, erythroblast has to expel its nucleus, and macrophage helps phagocytose the expelled nucleus [7]. In the animation, this is depicted as the graduation ceremony in which the fur balls on the students' berets are removed by the teacher (macrophage).

- *What is the importance of the removal of nucleus?*

  After enucleation, RBC will have extra capacity for more hemoglobin, and hence, more oxygen. It also allows RBC to turn into its distinctive biconcave shape which facilitates the diffusion of oxygen by increasing the surface area to volume ratio and shortening the diffusion distance from outside to the center of the cell. Also, it allows RBC to squeeze itself in order to travel through the narrow blood capillaries all over the body.

概念二：幼紅血球的脫核

- *巨噬細胞如何幫助幼紅血球脫核？*

  在紅血球成熟的最後階段，幼紅血球必須排出其細胞核，而巨噬細胞則會吞噬排出的細胞核 [7]。在動畫中，這被描繪成一個畢業典禮，當中學生所戴著的貝雷帽上的毛球被老師 (巨噬細胞) 移除。

- *去除細胞核的重要性是什麼？*

  脫核後，紅血球將擁有額外的空間容納更多血紅蛋白，因此可以攜帶更多的氧。它還允許紅血球變成其獨特的雙凹圓盤狀，通過增加表面積與體積比及縮短從外部到細胞中心的擴散距離，促進氧氣的擴散。此外，這亦有助紅血球擠進狹窄的微血管，並得以走遍全身。

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Behind the Transformative Power of Lipsticks

綻放生命色彩的唇膏

By Eunice Lam 林杏妍

If office ladies are asked to put only one cosmetic product on their faces, many of them will choose to have lipstick as it drastically increases the redness of their lips, making them appear more vibrant. To produce a high-quality lipstick, a variety of chemicals are specifically chosen in the formulation to achieve the desired texture and color.

Beeswax and cocoa butter are two of the most commonly used ingredients in lipsticks that together make up the bulk of the product. Lipsticks need to be soft enough to slide over our lips but stiff enough to stay intact during their application. A group of scientists investigated the effect of varying the proportions of these ingredients: they found that hardness depended upon the amount of beeswax and spreadability depended upon that of cocoa butter [1]. Thus, having the right ratio of these two ingredients will give the perfect lipstick.

The secret behind this "golden ratio" lies in the chemistry of these two major substances. Beeswax is largely consisted of saturated esters[1], such as triacontanyl palmitate (***Figure 1***). In this beeswax ester, both components feature long and saturated hydrocarbon chains (a C_{30} alcohol[2] & a C_{16} acid). Cocoa butter, on the other hand, is mostly made up of triglyceride[3] (fat) molecules. A common triglyceride in cocoa butter (***Figure 2***) features palmitic acid (C_{16}, saturated); stearic acid (C_{18}, saturated) and oleic acid (C18, monounsaturated).

The hardness of these substances at room temperature is linked to their melting points. Melting point is the temperature at which the molecules have sufficient kinetic energy to break free from the intermolecular forces holding them together as a solid. The strength of the intermolecular forces in this case, lies within the molecules' ability to pack tightly: since the

如果我們要辦公室女士們只選擇使用一種化妝品，大部分人都會選擇唇膏，因為它能大幅提升嘴唇的紅潤度，瞬間營造神采飛揚的容顏。要製造高質素的唇膏，我們需要特別挑選不同的化學物質，並以特定的比例調配，方可造出理想的質感和顏色。

蜂蠟和可可脂是兩種最常使用到的唇膏材料，亦是構成唇膏的主要成分。一枝唇膏要有能輕鬆滑過嘴唇的軟度和在塗抹時不會折斷的硬度。一組科學家曾經研究不同比例的蜂蠟和可可脂對唇膏硬度的影響：他們發現，蜂蠟的份量決定唇膏的硬度，而可可脂的分量則決定唇膏是否能容易地塗上嘴唇 [1]。因此，兩者需要有一個理想的「黃金比例」才能造出一枝完美的唇膏。

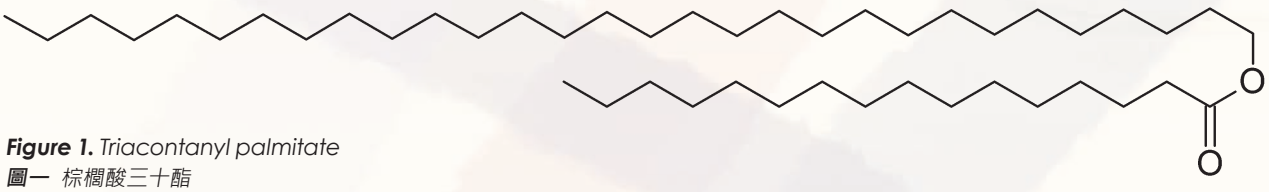


Figure 1. *Triacontanyl palmitate*
圖一 *棕櫚酸三十酯*

closer they can get, the stronger the attractive forces they could then exert onto each other.

In the cocoa butter triglyceride, the presence of oleic acid's *cis*-double bond in one of three "arms" can disrupt molecular packing with a rigid "kink". You may imagine this as the troublesome irregular block in the *Tetris* game. Whereas the saturated chains of

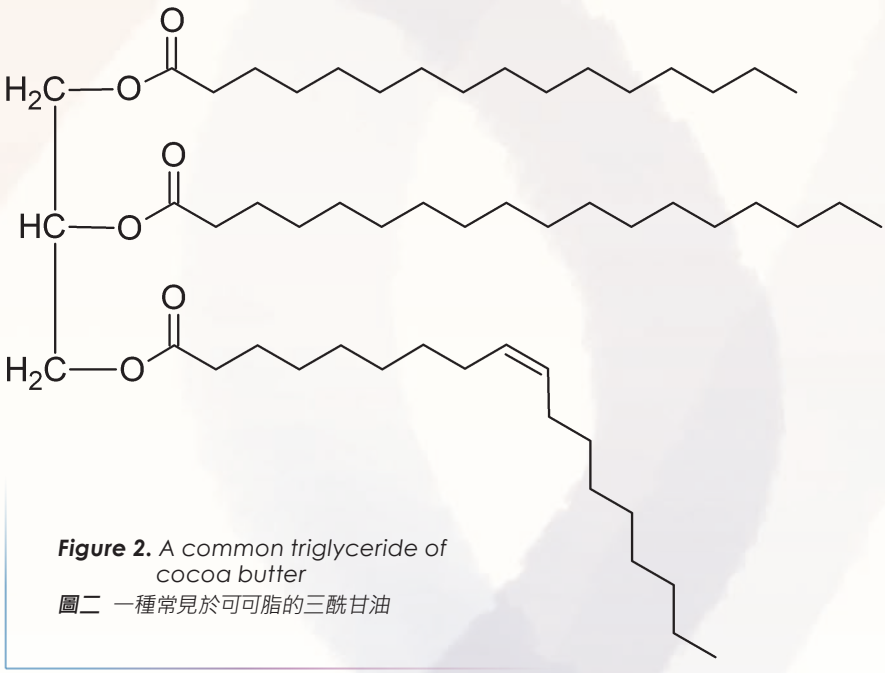


Figure 2. *A common triglyceride of cocoa butter*
圖二 *一種常見於可可脂的三酰甘油*

這個「黃金比例」的秘密在於這兩種主要材料背後的化學。蜂蠟主要含有飽和脂肪[1]，例如棕櫚酸三十酯（***圖一***），它的兩個組成部分都有很長的飽和碳氫鏈（分別是 C_{30} 醇[2]和 C_{16} 酸）。另一方面，可可脂主要由三酰甘油[3]（脂肪）分子組成。一種常見於可可脂的三酰甘油（***圖二***）中含有棕櫚酸（C_{16} 飽和脂肪酸）、硬脂酸（C_{18} 飽和脂肪酸）和油酸（C_{18} 單不飽和脂肪酸）。

這些物質在室溫下的硬度其實與其熔點有關。熔點是令分子的動能足以掙脫分子間作用力所需的溫度，分子間作用力在這個溫度下不再足以把分子拉住並把物質保持在固態。在這個例子中，分子間作用力的強弱取決於分子能否緊密排列，因為分子的排列越緊密，它們互相施加的吸引力便會越強。

在可可脂的三酰甘油中，由於其三個脂肪酸中含有油酸，當中的順式雙鍵 (*cis*-double bond) 為三酰甘油分子帶來一個剛硬的彎曲結構，就好像俄羅斯方塊中棘手的不規則方塊，它可以破壞分子的緊密結構。然而，蜂蠟中酯類分子的飽和長鏈卻有助它們形成緊密而有秩序的結構，使唇膏變得更硬。

在不同比例的混合物中，我們再不能觀察到清晰的熔點 —— 它們傾向在特定溫度範圍內慢慢軟化和融解。蜂蠟和可可脂在正確的混合比例下是一種較為複雜的混合物，在室溫下會呈現半融化的狀態，使唇膏軟硬適中 —— 既不會硬得像石頭，也不會稀得像溶化的雪糕。

鮮艷的顏色往往是女士對唇膏心醉的原因。昔日還未有人造色素的時候，人類只能從大自然中找尋他們想要的

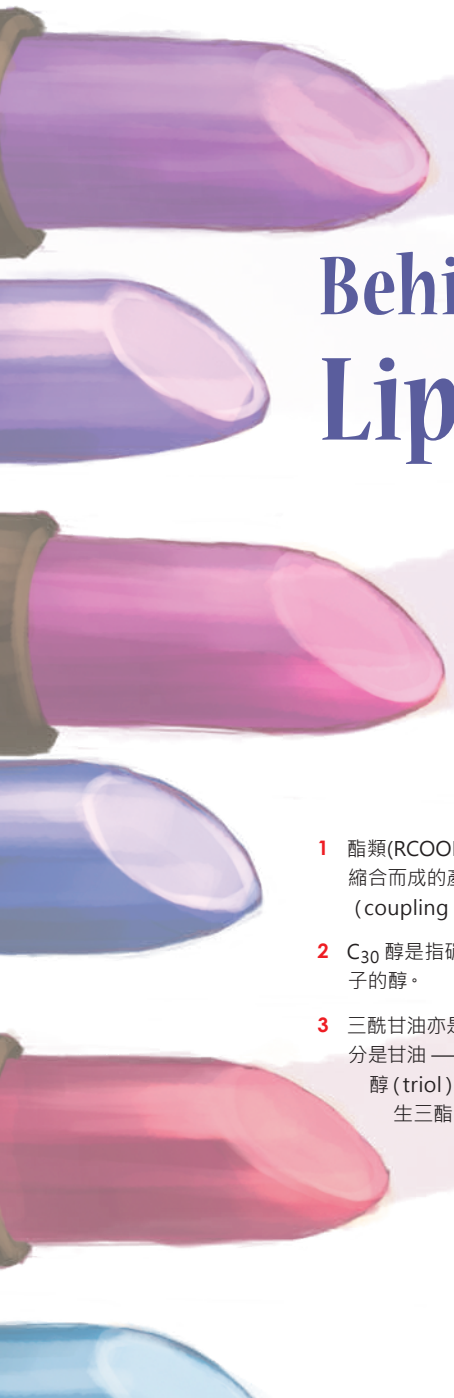
the beeswax ester molecules allow them to pack tightly together in a regular manner, thus giving a harder structure.

In mixtures, a sharp melting point is not observed, but they tend to gradually soften and melt over a temperature range. The correct mix of beeswax and cocoa butter is a complex mixture that would be in a partially molten state at room temperature, making it just soft enough and neither rock hard nor a puddle.

Color is another important characteristic of lipsticks. Back when synthetic dyes were not yet known, people could only look to nature for the colors they desired. The major red pigment used back then (and nowadays!) was carmine (also called cochineal, carminic acid, E120 and CI 75470). This blood red dye is extracted in a literally bloody process, by grinding the dried female cochineal insect, *Dactylopius coccus*, which live as parasites on cacti [2]. I believe it may scare many of you that what you are applying onto your lips were made from crushed insect bodies. Besides, although carmine is widely used in cosmetics, it has been known to cause allergic reactions in a very small number of people [3]. Luckily, there are also carmine-free products available in the market for vegans and people who are allergic to it.

A more recent pigment used in lipsticks is eosin, which creates a long-lasting sharp red color only after application because it reacts with amine groups (NH_2) present on skin surface proteins [4].

Color-changing lipsticks are recently in fashion and they rely on color-changing chemistry. Some of them employ color masking, in which an originally light-colored dye (such as eosin) would be initially masked by a darker pigment so the lipsticks do not appear



Behind the Transformative Power of Lipsticks

顏色。當時主要的色素(現在也是!)是胭脂紅(carmine,亦稱胭脂蟲紅(cochineal)、胭脂紅酸(carminic acid)、E120 或 CI 75470)。這種血紅色色素的提煉方式確實很血腥,那是透過磨碎烘乾了的雌性胭脂蟲 *Dactylopius coccus*(一種仙人掌上的寄生蟲)來提取的 [2]。你有沒有因為自己曾塗過由磨碎蟲屍製成的產品而感到一絲心寒呢?順帶一提,雖然胭脂紅被廣泛使用於化妝品裡,但是一小部分的人還是會對胭脂紅敏感 [3]。幸好,現在市面上已經有一些不含胭脂紅的產品供純素食主義者(vegans)和敏感者使用。

另一種較近期用於唇膏裡的色素是伊紅(又稱曙紅),它能透過與皮膚表面蛋白質的氨基(NH_2)發生化學作用,只在塗抹後變出持久的鮮紅色唇妝 [4]。

最近流行的變色唇膏背後其實也是靠著化學的原理。有一些唇膏利用顏色掩蓋技術,用更深的色素掩蓋原本淺

1 酯類(RCOOR')是由羥基(OH)和羧基(COOH)縮合而成的產物;在縮合作用這個偶合反應(coupling reaction)中水分子會被釋出。

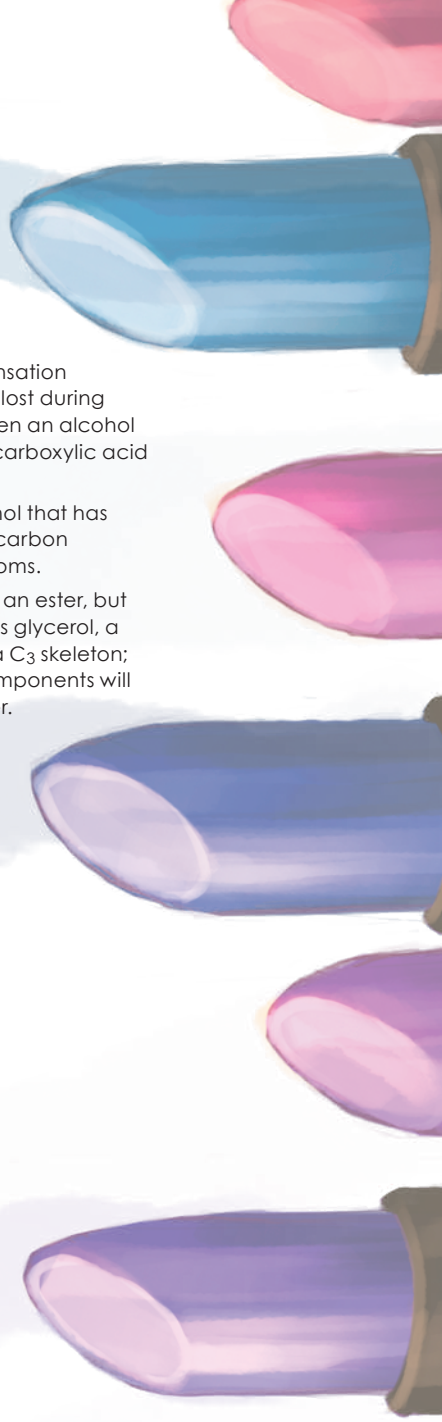
2 C_{30} 醇是指碳鏈(又稱碳骨架)中含有30個碳原子的醇。

3 三酰甘油亦是酯類化合物的一種,但當中醇的部分是甘油 —— 一個在C_3骨架上有三個羥基的三元醇(triol);三個羧酸分子因此可以與其縮合產生三酯(triester)。

red at first. Some may use humidity to trigger a color change too: for example a colorless dye, Red 27, turns pink after reacting with moisture on the lips. Another popular variation, known as "mood lipstick", uses pH-sensitive dyes. As the pH of the lips could vary due to different physiological conditions (e.g. stress, hormonal fluctuation), a "personalized" red color would appear on the lips [4].

Apart from organic colorants, inorganic compounds are also used. Iron (III) oxide (Fe_2O_3) is often added to lipsticks – the hydrated form of which ($Fe_2O_3 \cdot xH_2O$) is rust as we commonly know it. Commercial colorants' shade can be tuned by controlling synthesis procedures, giving for example, iron oxides with a wide range of colors. The use of iron oxide colorants is a much safer and environmentally-friendlier choice than many organic dyes.

Understanding what is inside a lipstick is very important as a smart consumer. Next time when you buy a new lipstick, remember to check the labels first!



1 An ester (RCOOR') is a condensation product (meaning that H_2O is lost during the coupling reaction) between an alcohol (OH) functional group and a carboxylic acid (COOH) functional group.

2 C_{30} alcohol refers to the alcohol that has a carbon chain (or known as carbon backbone) with 30 carbon atoms.

3 A triglyceride molecule is also an ester, but here the alcohol component is glycerol, a triol with three OH groups on a C_3 skeleton; thus three carboxylic acid components will condense with it form a triester.

綻放生命色彩的唇膏

色的色素 (例如伊紅) ，因此塗上嘴唇前的顏色未必是紅色。又有些唇膏以濕度引發變色 : 比如透明色素「紅色 27 號」在與嘴唇上的水份產生作用後會變成粉紅色。還有一種熱賣的「變種」——「心情唇膏」用上了對酸鹼度敏感的色素 : 由於嘴唇的酸鹼值會因應用家不同生理狀況 (包括壓力、荷爾蒙分泌起伏等) 而改變，「心情唇膏」可以變出個人化的唇色 [4]。

除了有機調色劑外，也有機會用到無機調色劑。經常被使用在唇膏上的有氧化鐵 (III) (Fe_2O_3) ，相信大家都很熟識它的水合式 ($Fe_2O_3 \cdot xH_2O$) ，那正正是常見的鏽。商業用調色劑的色調可以透過控制合成的步驟來改變，製造出來的例如有不同顏色的氧化鐵。以氧化鐵作為調色劑是比用有機調色劑更安全和環保的選擇。

作為精明的消費者，了解唇膏當中的成分是十分重要的。下次購買新唇膏前，記著要先查閱它的成分啊 !

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QUANTUM MECHANICS – YOUR EYES CAN KILL SCHRÖDINGER'S CAT

Introduction

Imagine if we were casted a spell and shrank to the size of an atom, we would see a completely different "quantum world" that cannot be explained by common sense. How bizarre it could be? Let's discard our common sense and dive into the realm of quantum mechanics.

Double-Slit Experiment & Wave-Particle Duality – Is It Wave or Particle?

Whenever we talked about quantum mechanics, we must mention the iconic double-slit experiment because it directly demonstrates the strangeness of quantum mechanics.

Let's assume that we use an electron gun to shoot electrons one at a time to a wall at random angles, and the electrons have to pass through any of the two narrow slits before arriving at the wall. On the wall, there is a screen to accumulatively record the locations where the electrons hit it. If we let the electron gun operate for a while, what pattern will form on the screen?

According to our common sense, we should expect the pattern shown in ***Figure 1***:

The electrons that pass through the slits form two straight bands on the wall – perhaps this is what we have expected. This prediction is still correct if we shoot objects with the size of a tennis ball or a bullet. However, this is not what actually happens if we shoot tiny particles like electrons and photons.

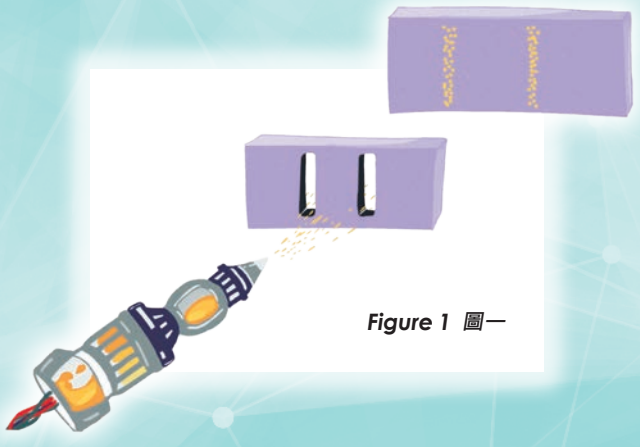


Figure 1 圖一

The pattern that actually forms (***Figure 2***):

The electrons seemed to have curved around the two slits and arrived at the positions that we didn't expect. An orderly stripes pattern formed. This pattern is super familiar to scientists – it is created when waves (e.g. water waves) pass through two narrow slits due to its property of interference, like in ***Figure 3***.

This implies that the gunshots that passed through the double slit were waves instead of particles. However, we clearly know that electron is a particle – when one electron was shot, we could only see one signal on the wall. But when the signals accumulated, an interference pattern was shown – did the electrons suddenly turn into wave when passing through the double slit but become particles again before they hit the wall?

Scientists at that time were confused by this ambiguous phenomenon because it could not be explained by classical mechanics. Later, they realized that electrons can simultaneously possess the properties of wave and particle. In other words, they show wave-particle duality[1]. Electrons may display the characteristics of wave and/or particle depending on the experimental setting, but both kinds of characteristics can't be fully shown in a single experiment, e.g. the patterns in ***Figure 1*** and ***2*** can't be shown simultaneously.

To further add mystery, observation itself can affect the experiment. The pattern shown in ***Figure 2*** only appears when we are not "observing". If we monitor the path of each electron and know exactly which slit they pass through, the pattern in ***Figure 1*** forms. On the other hand, if we are not "monitoring" and don't know which slit will the electrons pass through, all the possibilities will superpose to form the resulting pattern in ***Figure 2***. This is like a classroom – when the teacher is absent, the students can either be

量子力學 —— 你的雙眼能殺死薛丁格的貓

By Nicole Wu 胡欣蕾

前言

如果我們不幸中了縮小魔法，變成原子一樣的大小，我們將會看到與我們原本所處世界截然不同的、顛覆一切常識的量子世界。這個世界會有多奇怪？讓我們拋棄所有常識，試試了解它。

雙縫實驗與波粒二象性 —— 是波還是粒子？

每談量子力學必提著名的雙縫實驗，它簡單直接地體現了量子力學的詭異之處。

假設我們用槍以隨機角度每次發射一顆電子，這些電子只能穿過兩條狹窄的縫隙才能到達另一邊的牆；另一方面，牆上有一塊屏幕，能把電子每次到達牆上的位置累積地記錄，當我們持續地發射電子，牆上會映照出怎樣的圖案？

根據我們的直覺，理應如***圖一***：

射進縫內的電子在牆上形成兩道直條 — 也許我們都這樣預測，如果我們射的是網球或子彈等大小的物件，這樣的推測還算是正確；可是在渺小如電子或光子的情況下，現實卻並非如此。

實際形成的圖案（***圖二***）：

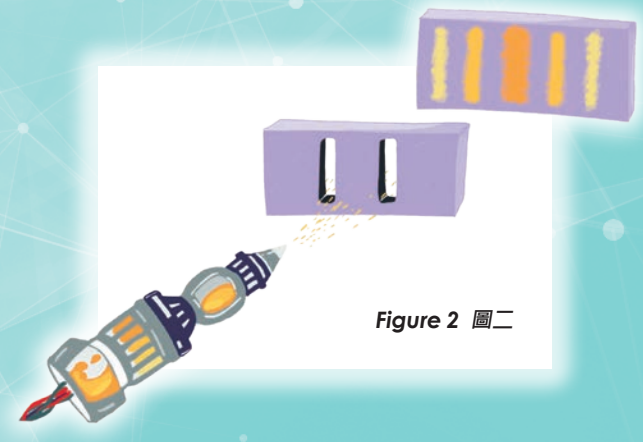


Figure 2 圖二

電子彷彿會拐彎，跑到我們始料未及的位置上，並有規律地排列出條紋形狀 — 這個圖案對於科學家來說再熟悉不過，因為這是當波（例如水波）通過雙縫時，根據波會互相干涉（interference）的特性才會產生的圖案，比如***圖三***：

也就是說，這個圖案告訴我們，從槍射出及通過雙縫的是波而非粒子。但確切地我們知道電子是一種粒子：我們每次只發射一粒電子，在牆上也只看到一粒電子；可是當牆上的光點累積，卻是一個互相干涉的圖案 — 難道電子能夠瞬間變成波，通過雙縫後，再變成粒子映在牆上嗎？

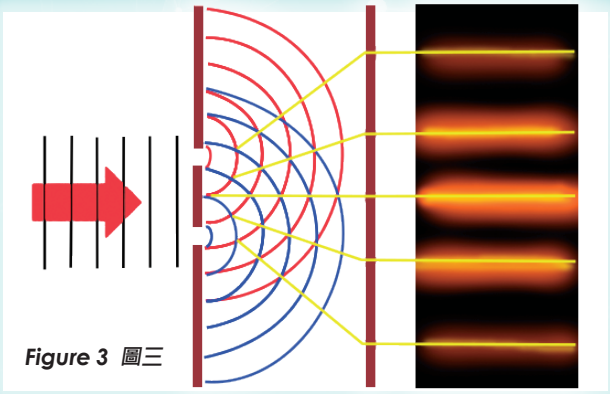


Figure 3 圖三

如此像霧又像花的現象確實令當時的科學家一時間不能利用已知古典力學的原理來解釋。後來我們了解到，這些電子同時有粒子和波的特性，亦即具有波粒二象性（wave-particle duality）[1]。根據實驗設計的不同，電子或會呈現粒子的特性，或會呈現波的特性，更甚的是我們無法在單一實驗中同時完全展示其粒子和波的特性 — 即不能同時出現***圖一***和***圖二***的圖案。

更有趣的是，觀察本身足以影響實驗。***圖二***的現象都是在我們沒有「監視」時才會發生。如果我們全程追蹤著每顆電子的軌跡，並知道電子會穿過哪一條狹縫的話，牆上就只會出現***圖一***的圖案。在我們沒有「監視」時，我們不知道電子會穿過哪條狹縫，結果會把所有可能性以疊加（superpose）的姿態（***圖二***）呈現。這就好比老師不在的教室，學生們也許在認真學習，但更有可能在大吵大鬧，不過一察覺老師在觀察，學生就會安分做個乖孩子。

studying seriously or messing around; but when they realize that the teacher is watching, they will all be good kids.

This is bizarre, isn't it? Not really, some explain this phenomenon with the analogy of the ambiguous image, "My Wife and My Mother-in-Law". In this drawing we can see either a young lady or an old woman depending on our perspective. The drawing itself has both the young lady and the old woman drawn on it, but it is our observation that obliterates the existence of either one of them.

Superposition & Wave Function Collapse

Imagine if the students are not intelligent enough to play and study simultaneously, they can only be 100% playing or 100% studying. Then, no matter whether the teacher exists, they are either playing or studying – this is our common sense in everyday life. However, if the students are extremely tiny particles like electrons, you'll have to abandon all your common sense and embrace a totally different reality. Before we observe these "tiny students", we can't say whether they are playing or studying but they are in a state of "superposition" of playing and studying – perhaps they are a piece of dark cloud, an enigma, a pixelated image, or whatever strange things that is difficult to put into words. It is our observation that forces them to display the state of either studying or playing.

In quantum mechanics, this phenomenon is called "wave function collapse". In the microscopic world, since each particle has the characteristics of wave, we cannot specify the locations of them. "Wave" is throwing a dice with many faces: each face of the dice is labelled with a position where the quantum may appear when wave "transforms" into a complete particle. If we add up the possibilities of all the locations where an electron may exist in the next second, the sum is always equal to 1, i.e. 100 percent.

Let me explain it with another analogy. In 2 p.m. (which is within the school hours), at a school in the quantum world, students always appear simultaneously in the classroom, laboratory, playground, medical room, washroom, etc. However, if we keep an eye on a student, the "clones" of that student will disappear and the student will be forced to only appear in one place. As it's within the school hours (and the students are supposed to be having a class), the student is likely to be in the classroom: say, 70%. But they can also be having a laboratory session or PE class, at a lower frequency: say, 20%. Other uncommon places that they may exist are the medical room or the toilet, which may add up to a possibility of only 10%. So, when we start to "observe", the dice stops, and there will only be one possibility – although the original possibility may only be 10%, if the dice stops at "medical room", the fact that the student is receiving medical treatment becomes the 100% truth. And this is the collapse of the wave function.

Schrödinger's Cat

Here, we hope to cast light on the famous thought experiment, "Schrödinger's cat". In this thought experiment, a cat and some radioactive substance are put into a black box such that nothing can be seen from outside. Due to the wave-particle duality of the reactive substance, the substance is actually tossing a coin with the words "decay" and "remain unchanged" on either side. Eventually, if "decay" is shown, the cat dies; if "remain unchanged" is shown, the cat survives. The coin keeps flipping in midair and the cat is staying between the boundary between "alive" and "dead" – a state resulting from the superposition of them. Only when we open the black box to observe does the coin land, and shows either "decay" or "remain unchanged" to decide the fate of the cat. It's our observation that forces the wave function to collapse. "Curiosity killed the cat", isn't it? – we opened to observe the black box curiously, but it forced the cat to be either live or die.

End

If you are still with us, then congratulations, you have entered the world of quantum mechanics. What is fascinating is the abrupt difference between this quantum world and the everyday world we know. This is just the beginning. If you continue to explore, you will discover more surprises and possibilities.

1 About wave-particle duality: Actually all objects possess wave-particle duality, including large objects like tennis balls and soccer balls. However, only the wave-particle duality of objects in atomic sizes (like electrons and photons) is apparent to us.

QUANTUM MECHANICS 量子力學 — 你的雙眼能殺死薛丁格的貓 – YOUR EYES CAN KILL SCHRÖDINGER'S CAT

這很詭異吧，其實也不是。有人會用「少女與老人」的錯視圖來作比喻，畫中的是少女還是老人，其實只是觀察焦點的差異造成，本身圖中的人既是少女也是老人，只是觀察這一個動作把另一方的存在抹殺而已。

量子疊加態與波函數坍縮

假設沒有學生聰明到可以邊玩邊學習，只能 100% 玩或者 100% 學習，那無論老師在不在場，學生要不在玩，要不在學習，這是我們這個世界的常識。但當學生是電子這種極其微型的粒子時，你就要拋棄之前所有的常識，去重新接受現實。這些「電子學生」在我們觀測之前，我們不能說他們在玩或者在學習，而只可以說他們處於玩與學習的疊加態 (superposition) —— 也許他們是一片黑雲，一個謎團，一堆馬賽克……反正是我們無法說清楚的奇怪狀態。是我們的觀測迫使他們呈現在玩或者在學習的姿態。

在量子力學裡，這個現象稱為「波函數坍縮 (wave function collapse)」。在量子的微觀世界裡，由於量子具有波的特性，我們無法說出它們的特定位置。「波」會擲一顆有很多面的骰子：骰子的面標示著當波「變身」成為完全的粒子之後，量子可能會出現的各個位置。如果我們把下一秒電子出現在特定範圍內所有位置 (即擲出骰子所有的面) 的機率加起來，這些零碎數字的總和會是 1 (即 100%)。

再打個比喻，在下午二時正這個上課時間，在量子世界的學校裡，學生會「同時出現」在課室、實驗室、操場、醫療室、洗手間……我們一旦開始「盯向」這個學生，他會收起自己無數個分身，只出現在上述其中一個地方。在這個時間，因為在上課，學生有較大可能 (比如七成機會) 會出現在課室，但也有可能在上實驗課或者體育課，這些課比較少，二成機會吧。至於在醫療室洗手間等等不太常見的情況，加起來能有個一成機會。但當我們開始「觀測」，骰子停下，便只會存在一種可能性 —— 即使本來只有一成機會，但若果骰子轉到「醫療室」，學生在醫療室養病也會變成百分之一百的事實了 —— 這也就是「波函數坍縮」。

薛丁格的貓

看到這裡希望能幫助你理解一個著名的思想實驗 ——「薛丁格的貓」。將一隻貓放進黑箱裡，使我們無法觀測裡面的情況。我們同時放入放射性物質，由於放射性物質具有波粒二象性，所以這物質在擲硬幣，硬幣上分別寫著「衰變」或者「不變」。假設骰子擲出「不變」，貓存活；擲出「衰變」，貓死亡。

這顆硬幣會一直轉動，貓亦會在死和沒有死的疊加態之間。直到打開箱子那一刻，我們的觀察使「波函數坍縮」，即硬幣停止轉動，擲出「衰變」或者「不變」，決定貓的生死。這不正是「好奇心殺死貓」嗎 —— 我們好奇地對黑箱觀察，造成了貓必須生或者死的局面。

結語

如果覺得有違常理、難以置信，那恭喜你真正進入量子力學的世界了。正因為這個世界與我們認知的世界大相徑庭，才會那麼吸引。這只是開始，更多的探索，將會帶來更多的驚奇，以及更多可能性。

1 關於波粒二象性：其實所有物體都具有波和粒子的雙重性質，包括體積較大的網球和足球，但只有在微觀尺度下物體 (例如電子和光子) 的波粒二象性才能容易被觀測到。

Professor Gyu-Boong JO
(Associate Professor, Department of Physics)
曹圭鵬教授 *(物理系副教授)*

Prof. Gyu-Boong Jo obtained his bachelor's degree from the Seoul National University and PhD degree from the Massachusetts Institute of Technology. He joined HKUST in 2013.

曹圭鵬教授在首爾大學取得其學士學位，並於麻省理工學院取得博士學位。他於2013年加入科大。

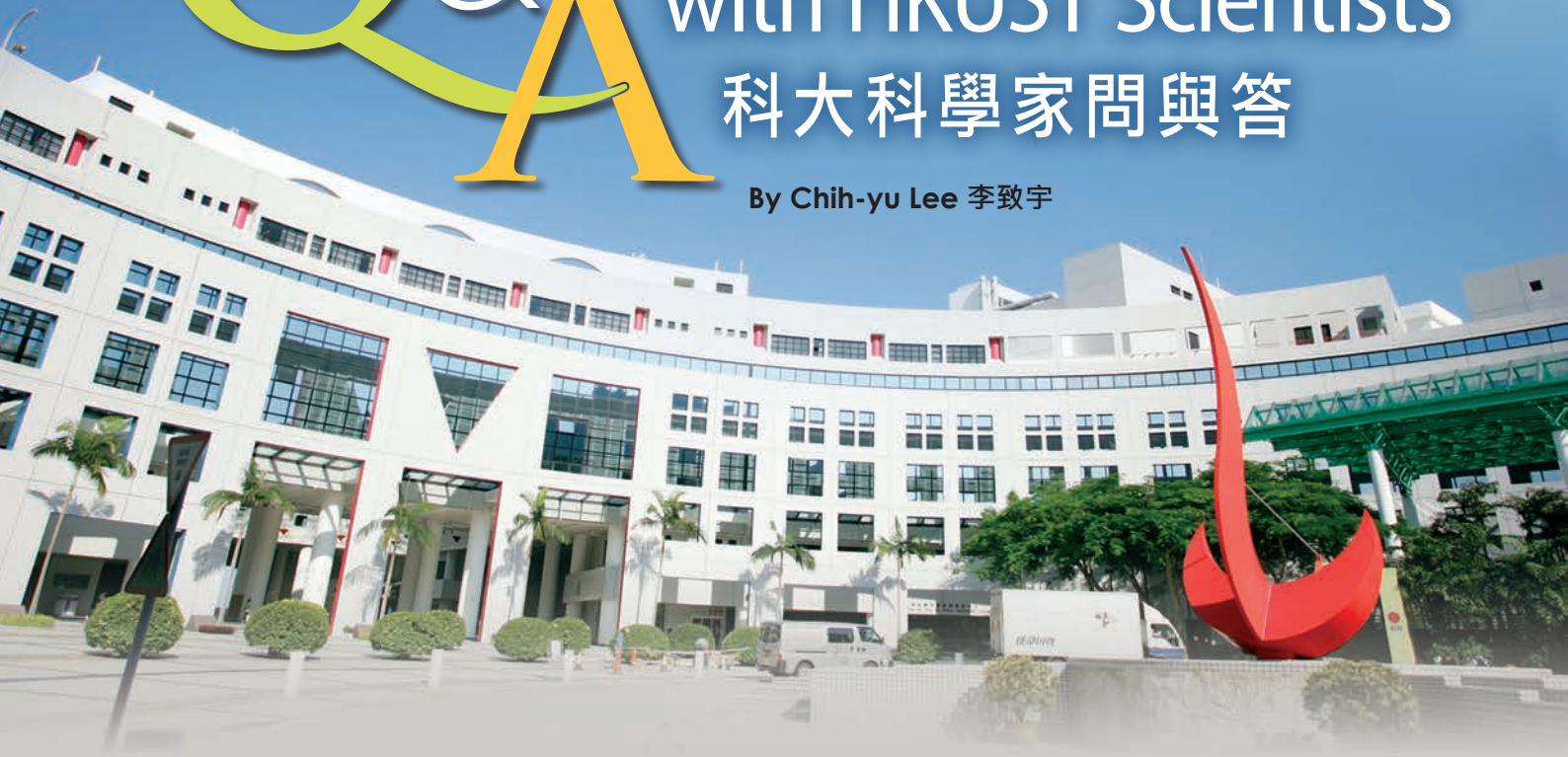
Professor Stanley Chun Kwan LAU
(Associate Professor, Department of Ocean Science)
劉振鈞教授 *(海洋科學系副教授)*

Prof. Stanley Lau earned his bachelor's and PhD degrees from the HKUST. He is now an associate professor at the Department of Ocean Science.

劉振鈞教授於科大取得其學士及博士學位，現在為海洋科學系副教授。

Q&A with HKUST Scientists
科大科學家問與答

By Chih-yu Lee 李致宇



In October 2017, Stephen Hawking allowed his PhD thesis *Properties of Expanding Universes* to be available online to the public, hoping to inspire others to think, learn and "look up at the stars and not down on their feet". It was accessed more than 2 million times within just a few days. We chatted with two scientists from different fields of science at HKUST to learn more about their favorite scientific work, inspiration and advice for students.

在二零一七年十月，Stephen Hawking（斯蒂芬霍金）在網上公開了他的博士論文 —— 宇宙膨脹的屬性，希望能夠啟發他人思考和學習。在短短幾天之內，論文已被讀超過200萬次。我們與科大兩位來自不同科學領域的科學家作專訪，了解他們最喜愛的科學研究、獲得的啟發及予學生的建議。

Q1 ***Whose thesis/scientific work would you like to read? Could you please tell us more about the scientist and his/her work?***

Prof. Gyu-Boong Jo:

Because I am a physicist, of course, I read papers and theses related to my field. However, before I started my academic career, I really loved to find some very old papers or those written by very famous people. I cannot point out only a single person, but, for example, I tried to read some articles written by Einstein, and Paul Dirac, a famous guy who developed the quantum theory in the old days. At that time, I couldn't fully understand those papers and especially because some were written in German. Although there were English versions, I couldn't fully understand the work. Nevertheless, it was still fascinating to find out how the quantum theory was conceived a hundred years ago. I really enjoy knowing how those people developed "new" concepts in the old days. If you just read the latest textbooks, they sometimes don't explain that well what happened a hundred years ago about the same topic.

Prof. Stanley Lau:

I am an environmental microbiologist, and I am interested in water pollution issues. When the water is polluted by sewage, it will become a carrier of pathogens. People who are in contact with the water, either by drinking, swimming, or other recreational activities will have the chance of getting waterborne diseases.

The work that I really like to read about is John Snow's because he was the first one who investigated the epidemiology of waterborne diseases. His research was conducted in the 19th century even before the germ theory of diseases was proposed in 1850 by Louis Pasteur. The germ theory of diseases states that we got diseases by the infection of microorganisms such as bacteria and virus. John Snow came up with the hypothesis that the main culprit of a massive cholera outbreak in London was the sewage contamination of groundwater. At that time, people thought that diseases are caused by breathing "bad air", but they didn't even know what were actually in the air. They thought it was something transmitted in the wind, but, obviously, it was something transmitted in the water. They didn't have the knowledge of disease transmission and bacterial contamination of food or water, so this kind of ideas were really common, until John Snow's investigation. Therefore, for a person working on water pollution and the microbiology of pollution, I really like to read about his work.

您希望閱讀哪位科學家的論文或著作？能否介紹一下這位科學家及其研究？

曹圭鵬教授：

因為我是一個物理學家，我通常閱讀與我領域相關的論文。但是在我開始我的學術生涯前，我十分喜愛找一些非常舊，或是由知名的物理學家們所寫的論文。我很難只指出一個人，但舉例說我會試著閱讀 Einstein（愛因斯坦）與另一名研究量子理論的物理學家 Paul Dirac 的文章。當時，我無法完全地理解那些文章，因為有些論文是以德文書寫的。就算是有英文版本，我還是無法能夠完全了解透徹，但能得知物理學家們如何在一百年前構想出量子理論還是非常吸引的。我真的享受了解前人如何在當時發展出「新」概念。畢竟如果你只閱讀現時的教科書，它們很多時都不會深入地闡釋一百年前在那個課題上發生過的事情。

劉振鈞教授：

我是一個環境微生物學家，而我對水污染的議題感興趣。當水被污水污染時，它便成為了病原體的載體。那些因為飲用、游泳或進行其他休閒活動而接觸到污水的人便有機會得到一些由水傳播的疾病。

我喜歡閱讀 John Snow 的作品，因為它是研究水媒病（經水傳播的疾病）流行病學的第一人。它的研究在十九世紀進行，甚至比在 1850 年由 Louis Pasteur 提出的「病菌說」還要來得早。「病菌說」指出得到疾病的原因是因為受到微生物（細菌或病毒等）感染。而 John Snow 提出的假說是指當時在倫敦爆發霍亂原因是地下水受污水污染。在當時，人們認為得到疾病的原因是因為呼吸到「壞的」空氣，然而他們卻甚至不知道那空氣中實際上含有什麼。他們認為那是由風傳遞的，但事實上它是藉由水來傳播的。他們沒有足夠關於疾病傳播及細菌污染食物和水的知識，因此那種說法在當時十分普遍。因此，身為一個研究水污染和與污染相關微生物學的科學家，我真的喜歡閱讀他的作品。

Q&A with HKUST Scientists

Q2 Is there any particular experience in your childhood or other reasons that make you love science?

Prof. Gyu-Boong Jo:

There is no particular reason why I like science, especially physics. But I know that, at a certain point, I thought about the possibilities of studying different subjects, such as physics, mathematics, life science and chemistry. However, I knew that I don't like that much about life science. It doesn't explain why I like physics, but, generally, I really enjoyed the scientific process – defining some problems, trying to solve them and explain them in principles, rules and laws. I like the problem-solving process in physics and mathematics.

I don't have a particular experience in childhood, but I remember I really liked to try to explain how things work in the world – that is probably why I like physics. Nevertheless, my motivation was quite simple – I just wanted to understand what's going on in the world, and I tried to find the subjects that seems the best to answer my questions. It turned out that either math or physics fits well for my curiosity. In my case, I just keep pushing and doing in the field.

Prof. Stanley Lau:

There was not a particular experience. But I was always interested in breaking things at home. I was not breaking them for the sake of breaking but just curious about the inside and how it works. Sometimes I broke some relatively expensive things and got blamed by my father, but that never stopped me from being curious. When you were a kid, you were unable to ask fundamental scientific questions. What you could do was to observe and find something that make you curious. The simplest question that you would have is how it works, which was always something coming to my mind, so I just broke things open to find the answer. The curiosity was the main reason why I studied in science.

是否因為在童年時有特別的經歷，或其他原因令您愛上科學？

曹圭鵬教授：

對我來說沒有特別的原因使我喜歡科學，尤其是物理。但我知道我曾經在某個時候想過修習一些科目的可能性，像是物理、數學、生命科學或化學。可是我發現我並不是那麼喜歡生命科學。雖然這也沒有解釋為什麼我喜歡物理，但是一般來說，我很喜歡整個科學過程：定義一些問題、試著解答並以定理、規則及定律來解釋它們。我喜歡在物理和數學中解決問題的過程。

雖然我童年時沒有什麼特別的經歷，但我記得我很喜歡嘗試去解釋這世界是如何運轉的，這或許就是為什麼我喜歡物理吧。儘管如此，我的動機還是挺簡單的：我只是想要明白這世界發生著什麼，所以試著找一個最能解答我心裡問題的科目，最終我發現只有物理和數學能夠滿足我的好奇心。在我來說，我只是持續努力地推動及研究這些科目而已。

劉振鈞教授：

沒有一個特別的原因呢！可是我小時候一直以來都對於拆解物件很有興趣。我不是為了破壞而拆解，而是好奇物體裡面的構造以及它是如何運作的。有時，我會因為拆解了相對較貴重的物品而受到父親責備，但這並沒有阻礙我對事物的好奇。當你只是一個小孩的時候，你無法真的去問一些基礎的科學問題，唯一你能做的只有觀察和找一些讓你好奇的事物。其中最簡單你會想到的問題便是它是如何運作的，而這也是一個總是在我腦中出現的問題，因此我會透過拆解物體來找出答案。那份好奇心便是為什麼我會學習科學的主要原因呢！

科大科學家問與答

Q3 ***Could you offer some advice to secondary school students who are interested in pursuing education in science?***

Prof. Gyu-Boong Jo:

I know in Hong Kong, there are many students who are interested in science. But at the same time, I realized there are many other possibilities that they can take for their life. My advice is that choosing the subject(s) in a particular stage (e.g. college) is important but that may not be your final destination. Eventually, it doesn't matter what you studied in your secondary school or college, but it's all about how you are educated and how you solve the problems you face in your field. Studying science is one of the good and efficient ways to train and educate yourselves that improves your problem-solving skills.

My advice is very simple: please do whatever you want, and if you find science interesting, please pursue your interest and push the limits of your skills. At the end, even if you find that you are more interested in other fields, you can easily move on.

Prof. Stanley Lau:

Don't be afraid! It takes a lot of efforts because there are so many distractions around you. Don't be afraid to sacrifice; to study science, you have to sacrifice a lot of your time from other things. You need to be prepared for that and strike a good balance between different aspects of your life. Don't be afraid of making mistakes too, which is a part of the journey. If you are able to "make use" of the mistakes in a correct way, you would actually learn something so that the mistakes are the stepping stones to your success. That is all of my advice.

您能對有志於修讀科學的中學生給予一些意見嗎？

曹圭鵬教授：

我知道在香港，很多學生對於學習科學都是有興趣的。但同時，我也意識到他們可以對未來作出很多不同的選擇。我的建議是在選擇某個學習階段（例如大學）修讀的科目是重要的，但這未必是決定你一輩子的事。最終，你會發現無論你當初在中學或大學選擇的是什麼科目也好，一切都只與你曾接受怎樣的教育（編按：意指在修讀不同的科目時，我們會接受到不同方式和風格的訓練，這可能最終影響一個人思考的角度和方法）和你如何解決在你範疇中遇到的問題有關。學習科學是其中一個非常好而且有效的訓練方法去提升你解決問題的能力。

我的建議非常簡單：請做任何你想做的事情，而如果你覺得科學是有趣的話，請追隨你的興趣並把你的能力提升到極致。最後，你如果發現你其實對於其他領域更感興趣時，你也能夠輕易地轉到其他領域。

劉振鈞教授：

別害怕會是我想要講的重點。這會需要很多努力因為你身邊會有很多分散你注意力你的事物。別害怕去犧牲：為了學習科學，你需要放棄很多花在其他事物上的時間。你勢必得為此做好準備，然後對人生中的每一部份進行取捨。另外，也別害怕去犯錯，因為犯錯是科學之旅必經的一部分。如果你能夠好好「運用」這些錯誤，你一定會學到一些什麼，並發現這會使你通往成功。上述便是我的建議。

Visit our website at *sciencefocus.ust.hk* to read the complete interview with the two scientists!
請瀏覽《科言》網站 *sciencefocus.ust.hk*，閱讀兩位科學家的完整專訪！

Cryptology in Biology: The Genetic Code 生物解碼：遺傳密碼

By Henry Lau 劉以軒

Instruction manuals tell people what to do. Similarly, DNA (deoxyribonucleic acid) directs the various actions of a cell. To perform this function properly, DNA stores information which can be decoded into instruction on how to use amino acids to produce proteins.

The decoding process is simpler than you might imagine! You see, DNA is made of four nucleotides: A, T, C and G, and a series of three nucleotides form a unit of information called codons. In turn, each codon codes for one amino acid, which can be represented by a single letter. For example, "gat aac gcg" can be translated into "D N A".

Can you apply this principle to solve the puzzle below? (Assume that tag = B, tga = O, taa = U)

說明書告訴人們操作的方法。同樣地，脫氧核糖核酸（DNA）指示細胞如何執行各類型的工作。正是如此，DNA 儲存了一些訊息，它們可以被解碼成一些指令，告訴細胞如何利用氨基酸製造蛋白質。

解碼的過程比您想像的簡單！DNA 由四種核苷酸組成：A、T、C 和 G，一組三個的核苷酸組成一個資訊的單位，稱為密碼子。連續地，每個密碼子編碼著一個氨基酸，而每個氨基酸可以用一個英文字母代表，例如：「gat aac gcg」可以解碼成「D N A」。

你能用這個原則來為下面的段落「解碼」嗎？（假設 tag = B、tga = O、taa = U）

(1) gataacgcg is the **(2) tagttgtaagaaccccgcatcaacaca** of life. Simply put, DNA stores information that directs the synthesis of **(3) ccgcgctgaaccgaaattaacagc**. The entire process can be divided into two actions: **(4) acccgcgcgaacagctgccgcattccgaccatttgaaac** and translation. In the former action, information in DNA is copied into an intermediate called messenger **(5) cgcaacgcg**. The intermediate is then translated into a chain of **(6) gcgatgattaactga** acids.

QR code: DNA codon chart and answer key
QR 碼：DNA 密碼子表及答案
http://sciencefocus.ust.hk/dna-codon-chart-issue-016

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