Science Focus 科言

Issue 024, 2023

$$\left|\frac{x}{6}\right|^{2.5} + \left|\frac{y}{5}\right|^{2.5} = 1$$

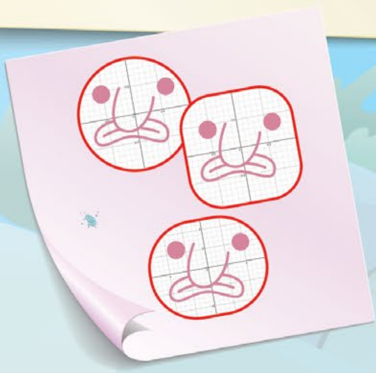
Thinking Out of the Box: Oral Insulin Pill
有何不可：口服胰島素藥丸

The World's "Ugliest" Animals: The Blobfish Files
「醜陋」動物之最：水滴魚檔案

How Do Sticky Notes Work?
便利貼的原理是？

Superellipse: Turning a Circle into a Square
超橢圓：介乎圓形與正方形的詩意

Pheromone Perfumes: Beyond Advertisements
費洛蒙香水：
廣告沒有告訴你的二三事



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

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Message from the Editor-in-Chief 主編的話

Dear Readers,

Have you browsed our Instagram lately? We have re-visited some of our more popular articles in past issues and reproduced them in a short format. Hopefully, these recent posts would intrigue you to dive deeper into the original articles, which can be found on our website.

In this issue, we continue our scientific journey across the ages. Do you know what is in common between the shape of a Swedish traffic roundabout and app icons? Do find out how they can be described mathematically in the article on superellipse. Another shape that has inspired scientists was that of a tortoise shell, which led to the design of an ingestible capsule for the injection of insulin inside the stomach. For those of you who use post-it notes often, have you ever wondered how their not-so-sticky glue was formulated? How did they get the iconic yellow color? We also explored the subject of attraction, based on visual and odor cues, which led us to consider pheromone perfumes and an oddly "cute" deep-sea fish. Finally, as you try to finish reading this issue in one go, with the help of a bowl of spicy ramen, pause before you fetch a glass of water to douse the fiery sensation in your mouth.

By the time this issue reached you, we would have concluded our latest writing competition on Instagram. Please stay tuned for more interactive activities on our social media platforms in the near future!

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

親愛的讀者：

最近有沒有瀏覽《科言》Instagram 專頁？我們把以往一些受歡迎的文章總結成篇幅較短的貼文，希望能勾起你閱讀原文的興趣，而原文就在《科言》網頁，歡迎大家閱讀以了解更多。

這一期我們將繼續穿越年代展開科學旅程。你知道瑞典一個迴旋處跟應用程式圖示在形狀上有甚麼共通點嗎？在介紹超橢圓的文章中你可以找到在數學上描述它們的方法。另一個吸引科學家的形狀也許是陸龜龜殼的形狀，它啟發科學家設計出一種可以把胰島素注射到胃部的口服膠囊。經常使用便利貼的你可曾想過當中不太黏的膠水是怎樣發明的嗎？便利貼又為何會選用它獨特的黃色呢？此外，我們亦會從視覺和嗅覺探討「吸引」這回事，我們會介紹費洛蒙香水和一種樣子古怪得「可愛」的深海魚。最後，如果你想在一口氣讀完《科言》前煮個辛辣麵，小休一會，請緊記我們的忠告：不要嘗試喝水來撲滅口中灼熱的辛辣感！

這期《科言》送到你手之時，我們於 Instagram 舉辦的寫作比賽應該已經步入尾聲。請繼續留意我們在不久將來於社交平台舉辦的更多活動！

主編 麥晧怡教授
敬上

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What's Happening in Hong Kong? 香港科技活動

Fun in Summer Science Activities 夏日科學好節目

Any plans for this summer? Check out these activities!

計劃好這個夏天的好去處了嗎？不妨考慮以下活動！

Material Tales – The Life of Things
天生我「材」— 材料科學與設計

From prehistoric stones and bronzes to the latest nanoproducts, the inventive use of materials have propelled technological advancements throughout the ages. This special exhibition at the Science Museum features a collection from the London Design Museum, alongside innovative locally developed materials and interactive exhibits. You will discover the fascinating connection between materials and human civilization, explore the transformation of materials into everyday products, and be reminded of the potential catastrophic consequences of over-consumption on natural resources.

Period: May 19, 2023 – October 18, 2023

Venue: Special Exhibition Hall, Hong Kong Science Museum

P.S.: This introduction was generated by ChatGPT, and edited by DeepL Write and human editors.

由史前時期的石頭和青銅到今時今日的奈米產品，人類一直都能透過善用材料推動科技發展。這次科學館的專題展覽會同時展出倫敦設計博物館的藏品、本地研發的嶄新材料以及一些互動展品，讓大眾了解材料和人類文明之間的密切關係，探索材料轉化成日用品的過程，亦會提醒我們過度消耗自然資源可能帶來的災難性後果。

展期： 2023年5月19日至 2023年10月18日

地點： 香港科學館特備展覽廳

備註：這篇介紹由 ChatGPT 生成，經 DeepL Write 和人類編者潤飾，再由人類翻譯。

Mars Calling 火星的呼喚

Now being dry and largely uninhabitable, evidence suggests that Mars was once full of water, and perhaps life. To prepare for possible human exploration, NASA has sent five rovers to record the red planet's climate and geology over the decades. Ambitious space travel advocates like Elon Musk and Jeff Bezos are even exploring affordable ways to send travelers to Mars. Do you want to visit the large volcanoes and canyons there one day? Watch the show at the Space Museum to plan your (grandchildren's) grad trip!

Time: 3:00 PM and 4:00 PM on May 14, 2023 (Sun)
4:30 PM and 5:30 PM on June 18, 2023 (Sun)

Venue: Lecture Hall, Hong Kong Space Museum

Admission fee: Free admission on a first-come, first-served basis

雖然現在的火星既乾涸又不宜居住，但證據顯示它曾經水源充足，而且可能是個孕育生命的星球。為著未來人類可能探索火星的一天，美國太空總署在過去數十年曾把五個探測器送上火星，以記錄這個紅色星球的氣候和地質情況。Elon Musk 和 Jeff Bezos 這些雄心勃勃的太空旅遊提倡者更積極尋求方法把旅客送上火星。有天你會想親身觀賞火星上巨大的火山和峽谷嗎？趕快到太空館欣賞這套紀錄片，然後為你（孫兒）的畢業旅行作好準備吧！

時間： 2023年5月14日（日）下午三時至四時
2023年6月18日（日）下午四時半至五時半

地點： 香港太空館演講廳

入場費： 免費入座，座位先到先得

THE MATHEMATICAL AVENGERS: NICOLAS BOURBAKI

數學復仇者聯盟：NICOLAS BOURBAKI

By Sonia Choy 蔡蒨珩

Any Marvel fan – or even most people, really – will know the Avengers – six superheroes who teamed up to save the world. Mathematics, on the other hand, always has the image of being a rather solitary affair. We have written about a modern-day mathematical Polymath Project on the Twin Prime Conjecture in Issue 020, but these collaborations have been happening for a while – almost a whole century ago, in fact.

Meet Nicolas Bourbaki.

Assuming the name of a French general who fought in the Franco-German war (1870-1871), Nicolas Bourbaki, founded 1934-1935, was in fact a collection of mathematicians writing collectively. The name was chosen in jest (founders of the group had a distaste towards hierarchy), and humor is a running theme throughout the group. The group's founders were all French [1] – although later incarnations involved mathematicians of other nationalities; they were admirers of the German mathematician David Hilbert, and the German school's emphasis on precision and rigor of proofs, as opposed to the French school's more handwavy approach based on intuition.

The group's membership would change throughout the ages – there was an agreement that the current members would be kept secret, although former members discuss their involvement with the group openly. This secrecy is to allow the mathematicians to write as a collective without any individual egos involved and no chance to claim copyright of any sort. Most members agreed to gradually drop out after they turn 50, letting the younger generation take over [2]. In their place, new members are recruited through invitation to their annual conference as "guinea pigs", and are accepted into the group once all the mathematicians agree to let them join [3].

Bourbaki's main work was a textbook series on mathematics, known as the *Éléments de mathématique (Elements of Mathematics)*. Originally wanting to write a new textbook for differential calculus [1], the group eventually covered the major areas of mathematics – analysis, algebra and geometry, as well as including more modern areas of active research in later volumes. The group was drawn to abstraction rather than concrete illustration; most of the core six texts (those published before 1954) consist of theorems and proofs written out formally, with little diagrams or examples to illustrate the ideas. The group also wrote articles and hosted a lecture series known as *Séminaire Bourbaki (Bourbaki Seminar)* in Paris since 1948, adding up to over a thousand lectures as of today.

One of Bourbaki's main activities was its periodic conferences, usually held in a rural location, where its members met to draft content on certain topics for the *Elements*. Members would then present those drafts in front of everyone, and the material must be agreed upon unanimously before it can be published under the Bourbaki moniker. As a result, many drafts took years to complete, but they were also guaranteed to be mathematically rigorous after being vetted by all of its members. At these conferences, there were also lively debates and often heated disagreements; Laurent Schwartz reported that André Weil once slapped Henri Cartan on the head with a draft [3]. But almost miraculously, peace was restored within ten minutes, and the group was able to stick together. The group's very strong belief in the culture of collaboration and lively debate held them together; they would stay together despite personal differences on certain issues, which made Bourbaki able to change its views on certain issues such as which topics to write about, sometimes in a completely opposite direction [3, 4]. As Claude Chevalley discusses in an interview [1], "One never feels like he is talking to a wall when talking to Bourbaki."

Bourbaki was most active in the middle of the 20th century, during the 1940s and 50s; only one volume of the *Elements* has been published in the 21st century, on algebraic topology. Nevertheless, the group leaves a sizable legacy on present-day mathematics, especially on symbols used in set theory [5, 6]. The group also had an influence on French structuralism, which prioritizes the study of the relationships between structures before the study of the structures themselves; for example, cultures should be studied in the context of other cultures they exploited in becoming their present day state.

Some also blame Bourbaki for the snobbery towards applied mathematicians in France ever since their foundation, as many see pure mathematics as more superior than applied mathematics. The group's goal of making mathematics more formal and abstract has made French mathematics students and mathematicians prioritize pure mathematics over applied mathematics, as the former is often expressed in symbols and abstract arguments, while the latter is largely guided by more concrete explanations. Benoit Mandelbrot, a former member who was a geometer, even went as far as to emigrate to the United States in part to escape Bourbaki's influence in France [3]; in interviews, he has stated that the group was very much against geometry since the field often relied on pictures and diagrams in explanations; the members also scorned against any other mathematicians who disagreed with them on this issue. There was also an air of superiority within the group, with some of the group's members thinking that they were better than other mathematicians [1, 7].

However, it is undeniable that Bourbaki had a sizable influence on mathematicians, both French and further afield; the *Elements* remains an encyclopedia of sorts for a number of mathematicians, with certain volumes becoming the standard text for that area [3, 4, 8]. Furthermore, despite all the controversy, perhaps their culture of lively debate and collaboration is one we can all learn from – some of the best work can only be produced after an argument.

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[2] Senechal, M. (1998). The Continuing Silence of Bourbaki: An Interview with Pierre Cartier, June 18, 1997. *Mathematical Intelligencer, 20*, 22–28. doi:10.1007/BF03024395

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[4] Borel, A. (1998). Twenty-Five Years with Nicolas Bourbaki, 1949–1973. *Notices of the American Mathematical Society, 45*(3), 373–380.

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[7] Corry, L. (2009). Writing the Ultimate Mathematical Textbook: Nicolas Bourbaki's Éléments de mathématique. In E. Robson, & J. Stedall (Eds.). *The Oxford Handbook of the History of Mathematics* (pp. 565–587). Oxford, UK: Oxford University Press.

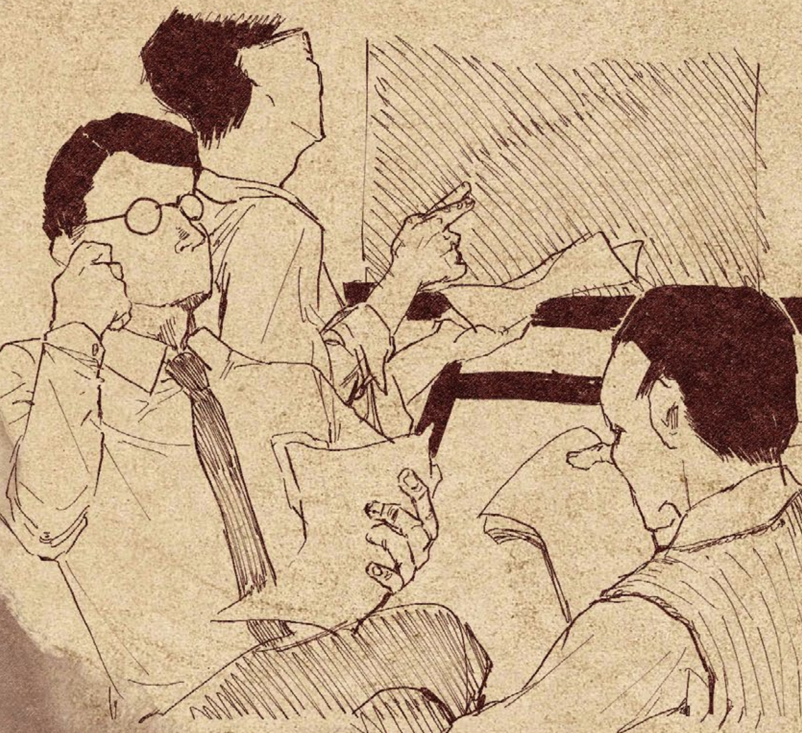
[8] Aczel, A. D. (2006). *The Artist and the Mathematician: The Story of Nicolas Bourbaki, the Genius Mathematician Who Never Existed*. New York, NY: Thunder's Mouth Press.

即使你不是 Marvel 粉絲，也會認識由六個超級英雄組成，拯救世界的復仇者聯盟。數學和復仇者聯盟看似風馬牛不相及，畢竟數學向來給人的印象都是閉門然後獨自奮鬥的一回事，但我們在第二十期曾經寫過關於孿生質數猜想的現代數學合作計劃 — 博學者計劃（Polymath Project），然而這些合作其實並不是甚麼新鮮事，因為將近一個世紀前就已經有類似的協作，那叫 Nicolas Bourbaki。

Nicolas Bourbaki 在 1934 至 1935 年成立，真實身分為幾位一同寫作的數學家，筆名取自普法戰爭（1870-1871）中的一位法國將領。選擇這個名字當然也是一個玩笑（當中成員並不崇尚階級主義），這多少與組織裡總是充斥著幽默空氣有關。組織最初的成員全都是法國人 [1]，儘管後來的成員包括來自其他國家的數學家，但無論甚麼國籍也好，他們都是德國數學家 David Hilbert 的仰慕者，相對於當年法國派數學家喜歡隨直覺寫出不太嚴謹的證明，他們更欣賞德國派務求寫出精確和嚴格證明的作風。

Bourbaki 的班底會隨時間改變，成員們同意把現役成員名單保密，但前成員還是可以公開討論以前在組織參與過的事情。把成員名單保密是為了讓成員能以單一身份共同寫作，避免因個別成員自尊心作祟而影響寫作，也能避免成員因版權問題而作出無謂的爭執。大多數成員都同意在 50 歲時淡出組織，讓年青一代繼承他們的工作 [2]。新成員會以「天竺鼠」（guinea pigs）的身分被邀請到周年大會，在所有成員同意下才能加入組織 [3]。

Bourbaki 的主要著作是名為《數學原本》（*Éléments de mathématique*）的教科書系列。成員起初希望寫一本全新的微分教科書 [1]，但最後除了涵蓋數學的三大範疇：分析、代數和幾何外，在後來的卷數還包含了較現代的活躍研究範圍。Bourbaki 崇尚抽象的表達多於實在的表述，在 1954 年前出版的六卷核心文獻中，大多都採取了只將定理和證明列出的寫法，甚少以圖像或例子去說明定理的內容。除了編撰教科書外，Bourbaki 也寫過不少論文，還在 1948 年起於巴黎舉辦一系列名為「Bourbaki 研討會」（*Séminaire Bourbaki*）的講座，至今已舉辦講座數目超過 1000 場。

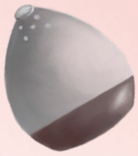


Bourbaki 其中一個主要活動是周年會議，成員通常會約定於郊區某處草擬《數學原本》某主題的內容。眾人會在其他成員面前報告自己撰寫的草稿，內容須經全體成員一致同意才能以 Bourbaki 的名義發表。基於這個嚴格的審核過程，很多草稿需要許多年才能完成，但內容的嚴謹程度卻毋容置疑。周年會議中發生過不少激烈的辯論，也多次出現因意見不合而鬧得面紅耳赤的場面，Laurent Schwartz 指 André Weil 曾用草稿當頭怒打 Henri Cartan [3]，但最終這次混亂奇蹟地在十分鐘內得以平息，成員間終究能和好如初。成員們都堅信合作和辯論的價值，縱然他們在某些事情上的看法可能有分歧，但他們仍然會堅守在組織裡，這使 Bourbaki 能從善如流，對諸如寫作方向等問題上的立場可以靈活轉變，有時甚至能完全改變 [3, 4]。正如成員 Claude Chevalley 在一次訪問中提到 [1]：「跟 Bourbaki 對話的時候，你從來不會有對牛彈琴的感覺。」

Bourbaki 最活躍的時期為二十世紀中期，尤其是 1940 和 50 年代。到了 21 世紀，Bourbaki 只出版過一卷主題是代數拓撲的《數學原本》。儘管如此，Bourbaki 對現代數學的影響不容忽視，尤其是集合論中所採用的符號 [5, 6]。Bourbaki 也影響了主張研究事物前，應先研究事物之間關係的法國結構主義（譬如研究文化時，應先從綜觀它們如何受其他文化影響而演變成今天的形態）。

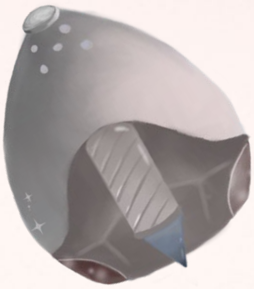
然而並非所有人都同意 Bourbaki 的觀點：有人指責他們認為純數比應用數學高尚，因而從一開始就對法國應用數學家諸多挑剔的態度。組織決意令數學變得更嚴謹和抽象的宗旨實際上亦使法國的數學學生投向多數以符號和抽象概念表示的純數，多於以實在論述表示的應用數學。由於 Bourbaki 在法國極具影響力，作為幾何學家的前成員 Benoit Mandelbrot 在某程度上亦為了避開 Bourbaki 而移民到美國 [3]。他在訪問中曾經透露組織成員極之針對幾何學，因為這個範疇往往要利用圖像來說明定理，組織更會鄙視一切對這個立場有異議的數學家。另外組織成員亦心存一種優越感，有些成員甚至認為自己勝過其他數學家 [1, 7]。

儘管如此，Bourbaki 對法國，甚至全世界數學家的影響毋容置疑，《數學原本》仍然是一些數學家的百科全書，其中數卷甚至成為了某些範疇的標準參考書籍 [3, 4, 8]。此外，即使組織引來不少爭議，他們鼓勵討論和合作的文化也許是我們應該學習的精神，畢竟一些最好的作品只能在爭辯下誕生。



Thinking Out of the Box 有何不可：

Oral Insulin Pill 口服胰島素藥丸



By Helen Wong 王思齊

Imagine the following scenario: You are required to stab your abdomen with a needle up to four times a day and seven days a week. Wouldn't this be a nightmare for you? This is exactly what happens to people with type I diabetes [1]. These patients need regular insulin injections as their bodies cannot produce enough insulin to effectively lower blood glucose levels.

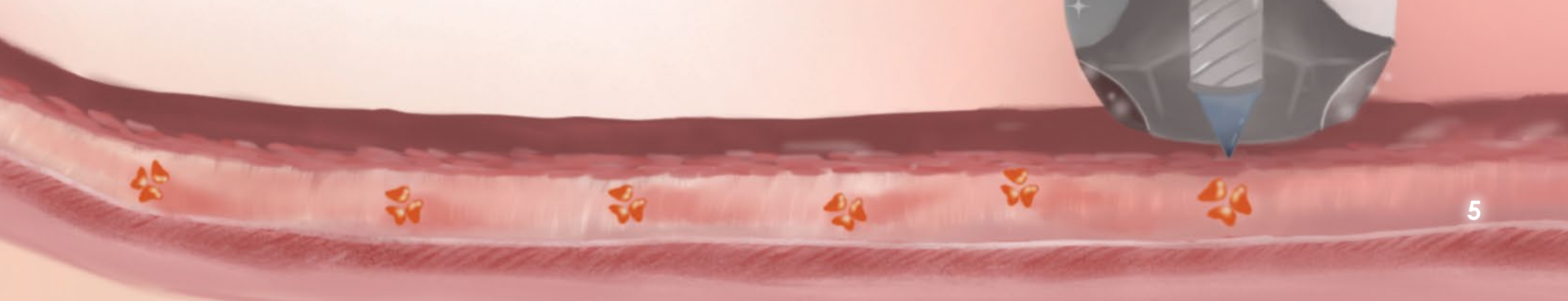
To liberate type I diabetes patients from the nightmare, scientists and doctors have been searching for reliable oral insulin delivery systems for decades. However, extreme pH, the presence of proteases and thick mucus layers along the gastrointestinal (GI) tract posed great challenges to such a quest.

In 2019, researchers at the Massachusetts Institute of Technology reported a breakthrough study in which they designed a novel ingestible device called self-orienting millimeter-scale applicator (SOMA) only at the size of a blueberry [2, 3]. While the concept of SOMA is simple – a capsule that contains a hidden needle, which would inject insulin once the device is in contact with the stomach wall, it has a well-thought-out design. Let's take a closer look at the challenging but successful journey of SOMA along the GI tract!

After being swallowed, a SOMA would pass through the esophagus and enter the stomach. As the first step, the capsule would localize and self-orient its injection mechanism toward the stomach lining. This ingenious self-orientation system was inspired by the seemingly unrelated leopard tortoise (*Stigmochelys paradalis*). This tortoise species has a shifted center of mass and a steep-dome-shaped shell that allow it to always self-orient to a preferred upright position. Researchers applied computer models to optimize SOMA's dome shape, and used a combination of low-density polycaprolactone and high-density stainless steel to lower its center of mass. Experiments showed that SOMA self-orientation only took one second.

The second step is insulin injection. The needle inside the capsule has two components: a tip made of compressed insulin and a biodegradable shaft. Only the dissolvable insulin tip would pierce the stomach wall. To provide enough force for needle insertion into the stomach wall, the team further attached a compressed spring, which was initially fixed in sucrose and isomalt, to the needle. During actuation, water in the stomach would enter SOMA through its vents to dissolve the sugar barrier. This would release the spring and insulin would be injected into the stomach wall. The whole process required one minute and subsequent dissolution of the solid insulin drug lasted for about an hour under experimental conditions. After successful insulin delivery, the capsule would pass through the remainder of the GI tract and eventually be excreted in feces.

"The design of SOMA sounds cool, but what's the point of injecting insulin into the stomach wall instead of the abdomen? Needle injection is always painful!" You may have the same question in mind as you are reading through this



Thinking Out of the Box

Oral Insulin Pill

article. Please rest assured that patients would not feel any pain as the stomach wall has no pain receptors. The effectiveness of stomach wall injection by SOMA was also proved to be comparable to conventional subcutaneous injection in pig studies.

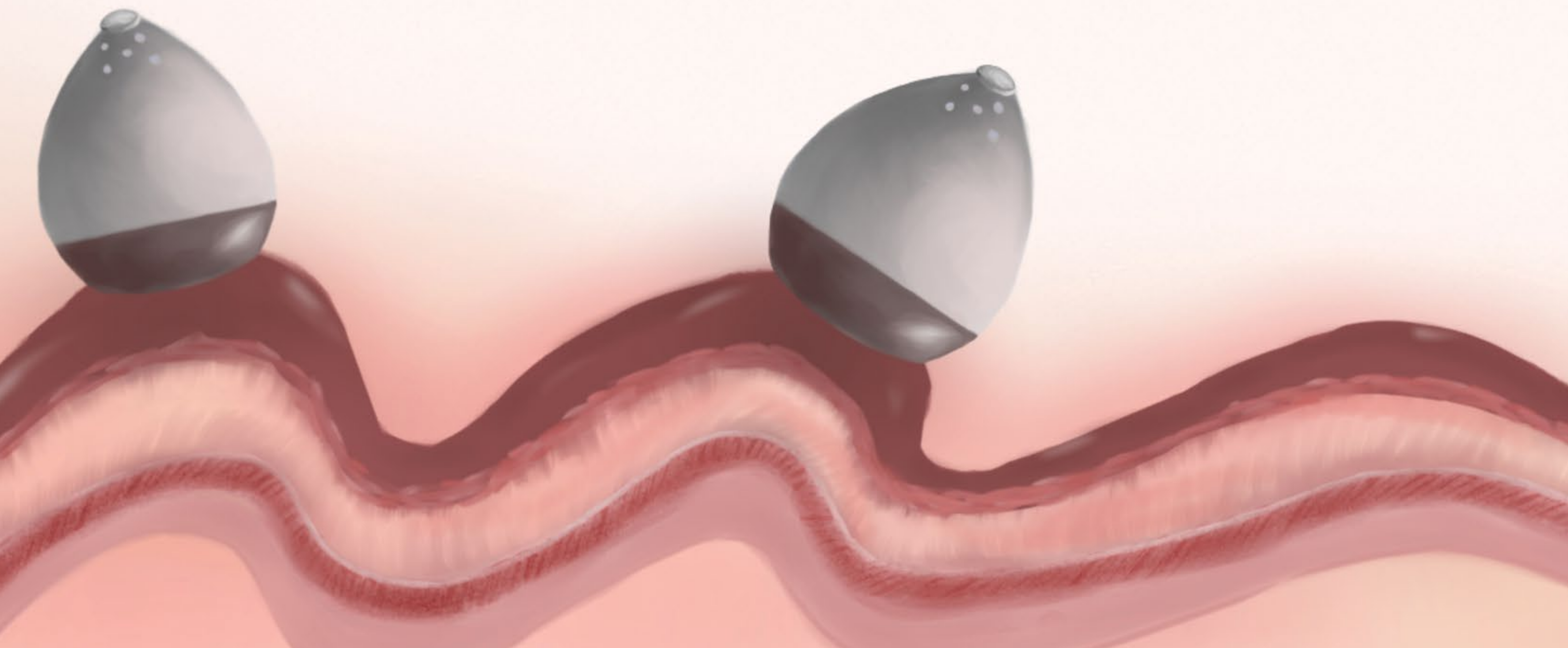
In fact, insulin is just one of the many drugs that could potentially be delivered by SOMA. To improve the applicability of SOMA, the team reported a new version of SOMA in 2021, the liquid-injecting SOMA (L-SOMA). It could deliver monoclonal antibodies in liquid form and at larger dosing volumes [4], implying that it could potentially target cancers and autoimmune diseases (e.g. rheumatoid arthritis) besides diabetes. The scope of applicable biomacromolecules further expanded to RNA in early 2022 [5, 6]. As single-stranded RNA is susceptible to degradation, researchers made use of protective polymeric nanoparticles to produce RNA-nanoparticle complexes. Results showed that SOMA was able to deliver these complexes into stomach cells at an amount comparable to that in COVID-19 vaccines. We are a step closer to oral mRNA vaccines now!

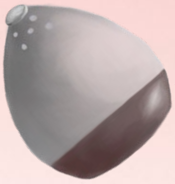
試想像如果你需要每週七天，每天四次在腹部進行注射，你會感到害怕嗎？這正是第一型糖尿病患者所面對的困境 [1]。由於身體無法產生足夠胰島素，這些患者需要通過定期注射來降低血糖水平。

為了幫助第一型糖尿病患者，科學家和醫生幾十年來都在尋找可靠的口服胰島素系統，可是極端 pH 值、蛋白酶以及消化道的厚黏液層都為相關研究帶來巨大挑戰。

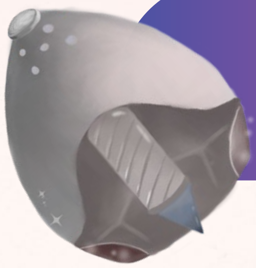
在 2019 年，麻省理工學院的研究人員發表了一項突破性研究，他們設計了一種只有一顆藍莓大小，名為自我定向毫米級投藥器（self-orienting millimeter-scale applicator，簡稱 SOMA）的可服用裝置 [2, 3]。SOMA 麻雀雖小，但設計卻非常精巧 — 它是一顆包含隱藏針頭，一與胃壁接觸就會注射胰島素的膠囊。讓我們仔細看看 SOMA 沿著消化道充滿挑戰但又成功的旅程吧！

患者吞服 SOMA 後，膠囊會沿食道進入胃部。SOMA 第一步會自動將其注射裝置指向胃壁。這個巧妙的自動導向系統靈感來自看似風馬牛不相及的豹紋陸龜（*Stigmochelys paradali*），這種陸龜的低重心和陡峭的圓拱形外殼使它始終能夠回到直立的狀態。研究人員以電腦模型優化 SOMA 的拱形，並用低密度聚己內酯和高密度不銹鋼兩者的組合來降低重心。實驗結果顯示 SOMA 只需一秒鐘就能自動導向。





有何不可：



口服胰島素藥丸

第二步是注射胰島素。膠囊內的注射針由兩個部分組成：壓縮胰島素製成的針頭及可被生物降解的針桿，但只有可溶解的針頭會刺入胃壁。為了提供足夠的力讓針頭刺入胃壁，研究團隊將注射針和壓縮彈簧連接，彈簧起初被蔗糖和異麥芽酮糖醇固定，在注射一刻胃部水份會通過 SOMA 的開口進入內部以溶解糖屏障，從而釋放彈簧將胰島素注入胃壁，整個過程需時一分鐘，隨後固體胰島素藥物在實驗條件下持續溶解大約一小時。成功輸送胰島素後，膠囊會穿過餘下的消化道，最終隨糞便排出體外。

「SOMA 的設計聽起來很酷，但為甚麼要將胰島素注射到胃壁而不是腹部呢？打針總是很痛的！」閱讀本文時，您可能會想到同樣的問題。但請放心，由於胃壁沒有痛覺感受器，患者並不會感到痛楚。在豬隻進行的研究也證明 SOMA 胃壁注射和傳統皮下注射成效相當。

事實上，胰島素也只是 SOMA 可運載的眾多藥物之一。為了擴大 SOMA 的應用範圍，研究團隊在 2021 年發表了新版本的 SOMA — 液體注射 SOMA (liquid-injecting SOMA，簡稱 L-SOMA)。它能運送大劑量的液態單克隆抗體 [4]，意味著有望能針對除糖尿病外的疾病，例如癌症和自體免疫疾病 (類風濕關節炎等)。而在 2022 年初，RNA 成為了 SOMA 能運送的生物巨分子之一 [5, 6]。由於單鏈 RNA 容易被降解，研究人員利用以聚合物製成的保護性奈米顆粒來造出 RNA- 奈米顆粒複合物。實驗結果表明 SOMA 能將與 2019 冠狀病毒病疫苗相當劑量的複合物注入到胃細胞，意味著我們離口服 mRNA 疫苗又邁進一步了！

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The World's "Ugliest" Animals: The Blobfish Files

「醜陋」動物之最：水滴魚檔案

By Sonia Choy 蔡蒨珩

Among the world's ugliest animals, the blobfish will always be ranked near the top – one only needs to look at a single picture of them to understand. With their squashed flat bodies and bulging eyes, any measurement of beauty would put them into a disadvantaged position. Here are some facts about the blobfish, besides ugliness, that may surprise you.

Blobfish and Where to Find Them

Blobfish, fish in the family Psychrolutidae [1], lives at the bottom of the Atlantic, Pacific and Indian oceans [1-3]. They live at depths of approximately 600–1200 m under water, where the pressure is about 60–120 times that of atmospheric pressure [2, 4]. At this pressure, humans will surely be crushed to death, as our lungs will be unable to expand to breathe [2]. Little to no light reaches these depths; typically, beyond 200 meters, there is not enough light for photosynthesis to occur, and no light reaches beyond 1000 meters [5]. A research expedition at these depths would be too expensive, so very little is known about the blobfish and its habitat [3, 6].

About Mr. Blobby

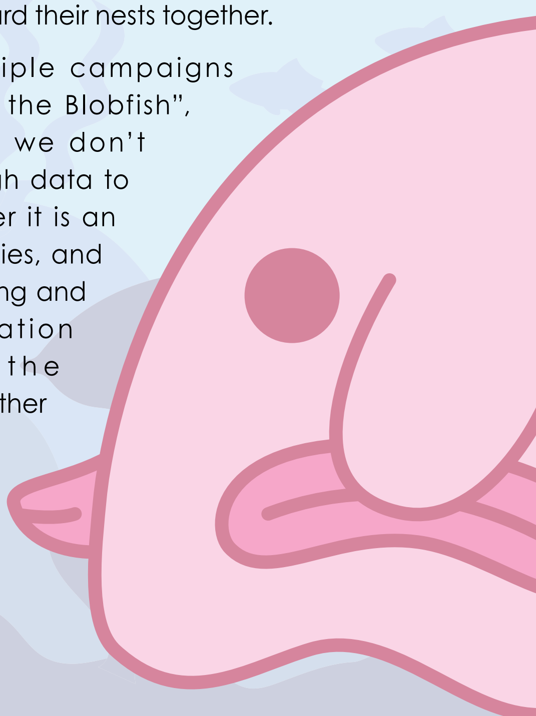
The current picture that we have of the blobfish (*Psychrolutes microporos*) is from a deep-sea trawl during a research expedition in 2003 [1]. The researchers affectionately named the fish Mr. Blobby [1], due to the (rather obvious) fact that it looks like, well, a blob.

Despite Mr. Blobby's fame (or infamy), we don't even know whether Mr. Blobby is male or female, since no one is going to perform an autopsy on arguably the Internet's most famous preserved fish specimen now [6]. Little is known about the blobfish's biology. For example, how old can they get in general? Although another deep-sea fish, rougheye rockfish, which lives at depths of 150–450 m, can live for over 200 years! One thing we know, however, is that they are mostly a

Photo credit: Kerryn Parkinson, Australian Museum © NORFANZ Founding Parties

jelly-like mass with very little muscle. While most other fish have a swim bladder to maintain buoyancy, the blobfish doesn't have one because gas-filled cavities would collapse under such an extreme pressure. The blobfish is instead a mass of mostly water and fat which offers a density slightly less than that of water, allowing it to float above the sea floor without much effort. The blobfish can be an ambush predators when it comes to hunting for snails, brittle stars, anemone and other bottom dwellers. As for reproduction, they lay eggs on rocks, thousands at a time, and expectant mothers would guard their nests together.

Despite multiple campaigns striving to "Save the Blobfish", the truth is that we don't even have enough data to conclude whether it is an endangered species, and how bottom trawling and ocean acidification could affect the species [2, 7]. Whether

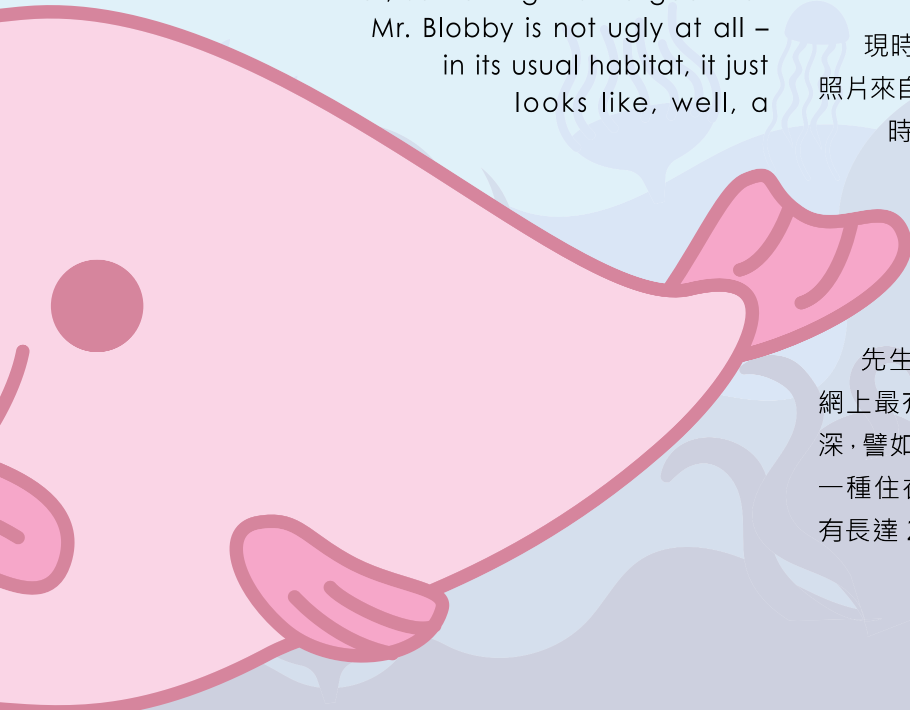


there are millions or hundreds of blobfish in the world, nevertheless, one thing we must hold onto is to care for all animals, no matter their appearance. Just like humans, we can't judge an animal by its cover, after all.

The Psychology of Ugliness ... and a Misunderstanding

You might have seen videos of ugly animals around social media, but have you ever thought about why people even share them? At first thought, it seems like humans are programmed to appreciate beauty and therefore repel ugly things, but there seems to be a sort of "ugly-cute" that humans find endearing. These "ugly-cute" animals are usually characterized by big bulging eyes, large heads, and soft-looking bodies [8]. If these sound slightly familiar, it's because things we consider cute and lovable, such as puppies and infants, also share the above characteristics. Ethologists suggested that humans are naturally built to take care of their offspring, so seeing these features causes a rush of emotion in us which manifests as cuteness [9]. So, it is no wonder that Mr. Blobby was voted the world's ugliest animal by the Ugly Animals Preservation Society in 2013 – it is ugly, yes, but still endearing in a certain way.

Yet, some might sill argue that Mr. Blobby is not ugly at all – in its usual habitat, it just looks like, well, a regular fish. The pressure of the deep sea helps hold the blobfish's body together in a fish-like shape, but when it is dragged out of the water, the sudden drop of pressure causes its body to expand into a balloon, which looks very different from its usual appearance – just as humans would certainly look a bit squashed 1,200 m underwater. It is no surprise that even the photographer, Dr. Kerryn Parkinson, admitted that the famous picture of Mr. Blobby was no decent scientific image [6]. But seeing how loved Mr. Blobby is now across the world, it might not be a bad thing after all!



水滴魚必定高踞世上最醜動物排行榜的頭幾位，任何看過水滴魚照片的人都會清楚明白，牠們扁平的身軀和凸出的眼睛，絕對不會符合任何學派對美學的描述。除了醜陋的外貌外，以下是水滴魚令人驚嘆的二三事。

水滴魚與牠們的產地

水滴魚泛指隱棘杜父魚科（Psychrolutidae）的成員 [1]，牠們住在大西洋、太平洋及印度洋的海底 [1-3]，深度約為 600–1200 米，那裡的水壓是大氣壓力的 60–120 倍 [2, 4]，在這種壓力下人類肯定會被壓成一團而死，肺部會因無法擴張而不能呼吸 [2]。光線亦很難到達這個深度：基本上由 200 米起，熹微的光線已不足以支撐光合作用；由 1000 米開始，海洋就只剩一片漆黑 [5]。由於在這種深度進行考察的費用過於高昂，因此我們對水滴魚及其生境的了解並不多 [3, 6]。

關於水滴先生

現時我們看見的水滴魚（*Psychrolutes microporos*）照片來自 2003 年一次深海考察中的拖網打撈任務 [1]。當時的研究員打趣地把這條魚取名為「水滴先生」（Mr. Blobby）[1]，原因也不用多解釋，因為牠的外型就像水滴一樣。

雖然水滴先生已經遐邇聞名（或是說因醜陋的外表而聲名狼藉），但我們始終未能得知牠是先生還是小姐，畢竟沒有人想解剖這個可能是在互聯網上最有名的魚類標本 [6]。我們對這個物種的認識也不深，譬如我們不知道水滴魚一般可以活多久，我們只知道另一種住在水底 150–450 米，叫阿留申平鮋的深海魚可擁有長達 200 年的壽命！但有一件事我們是知道的，就是水

相片來源： Kerryn Parkinson, Australian Museum
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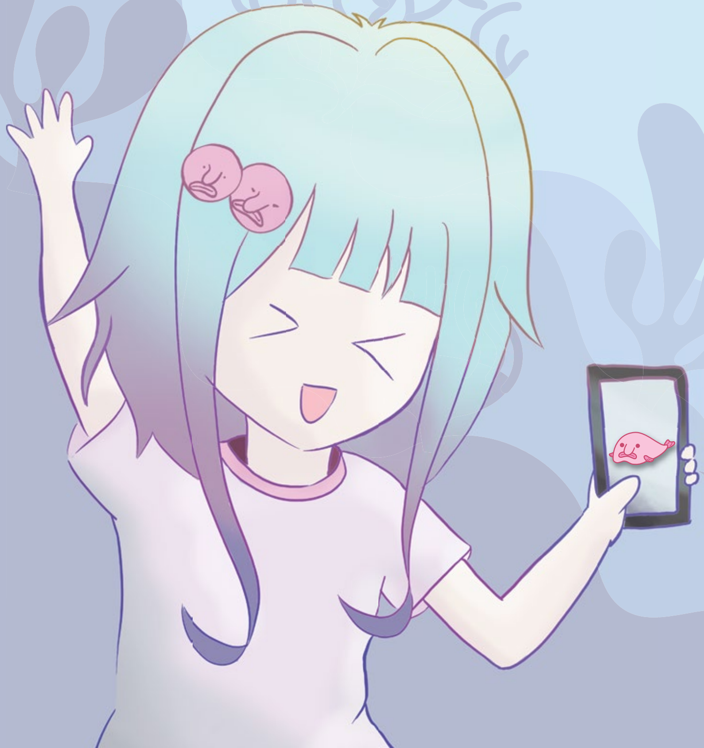
滴魚是擁有非常少肌肉的一團果凍狀物體。大部分魚類靠魚鰾維持浮力，但水滴魚並沒有魚鰾，因為海底極端的水壓會使任何空腔塌陷。反之，牠們身體幾乎就是由水分和脂肪組成的混合物，因此牠們擁有一個稍稍低於海水的密度，能不費吹灰之力就能浮在海床之上。另外，水滴魚是伏擊型捕食者，會狩獵海螺、陽隧足（海蛇尾）、海葵，以及其他居住在海床上的底棲生物。在繁殖方面，水滴魚會在岩石上產卵，每次產上成千上萬顆，即將成為母親的水滴魚們會成群保衛巢穴。



雖然人們舉辦了不同「救救水滴魚」行動，但其實我們並沒有足夠資訊去判斷水滴魚是否瀕危物種，也不知道海底拖網捕魚和海洋酸化將如何影響牠們 [2, 7]。然而，無論地球上有數百萬條水滴魚也好，或只剩數百條也好，外表漂亮或不討喜的動物都一樣值得人類保護；我們不能以貌取人之餘，也不能「以貌取魚」。

醜陋心理學……一切只是一場誤會？

你可能已經在社交媒體看過一些載有醜陋動物的片段，但你可曾想過我們為甚麼還會分享它們呢？乍想之下，人類似乎與生俱來就會擁抱美麗的事物，而排斥醜陋的；可是，醜陋之中又似乎有種惹人憐愛的「醜萌」（ugly-cute）可以歸入可愛之列。這些「醜萌」的動物通常擁有凸出的眼睛、巨大的頭顱和看似軟糯的身體 [8]。如果你覺得這些特徵似曾相識，可是因為我們覺得可愛的東西，譬如嬰兒和小狗，都擁以上特質。動物行為學家認為照顧後代是人類的天性，因此看到這些特徵會觸發我們的情感，進而轉化為覺得對象「可愛」的觀感 [9]。由此觀之，水滴先生在 2013 年被醜陋動物保護協會票選為「全球最醜的動物」也不是甚麼令人意外的事情 — 沒錯，牠是醜陋，但某程度上亦是可愛。

然而還有人為水滴魚抱不平，說這完全只是一場誤會，皆因水滴魚在自己的生境中根本一點也不醜：在深海裡，牠的形狀就是正常的一條魚啊！深海的水壓把水滴魚的身體壓成正常的「魚形」，但當被拉上水面時，周遭急降的壓力卻使其身體像氣球般澎漲，漲得完全「不成魚形」。如果我們反過來想想，人類在 1200 米的深海裡想必也「不似人形」吧。因此，水滴魚照片的拍攝者 Kerryn Parkinson 博士也承認那張爆紅的照片其實不是一張嚴謹的科學照片 [6]，但看見水滴先生如何受全世界網民的愛戴，那張照片也許還不賴吧！

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Understand Spiciness:

A Pain but Not a Taste

辣……其實是一種痛？

By Roshni Printer

You must have experienced the aftermath of a bowl of spicy ramen, a dollop of wasabi, a bite of chili pepper. Your tongue feels like it's on fire; your eyes start watering, and you begin to sweat through your clothes. No other sensation would come close to the overwhelming sensory experience that comes with spiciness. Here is an interesting fact: Spiciness is not a taste, but rather a sensation of pain. Then, why does spiciness intrigue humans so much that we would prepare food "so tasty it hurts"?

Chili peppers contain an alkaloid compound known as capsaicin, which can trigger the burning sensation of spiciness. As we chew, capsaicin molecules are released and spread across our tongue. However, they bypass the taste pores and bind to pain receptors instead [1]. Originally functioning as a detector to alert the brain of high temperatures (>43 °C [2]), these pain receptors, by the name of TRPV1, can also be activated by capsaicin. As a cation channel by nature, TRPV1 receptors will open when activated, so cations can diffuse into the nociceptive (pain-sensing) neurons [3]. The increase in electric potential, known as depolarization, will trigger the neuron to fire and send a signal to the brain. Our brain will then interpret the signal and think that our tongue is in contact with a burning hot substance, giving us the false impression that our mouth is on fire.

If spiciness truly is a sensation of pain, why will we have the urge to go back for one last bite? Here's where our body's self-regulatory mechanism comes into play. After perceiving that we are in pain, hormones like endorphins, which are known as the natural painkillers and the "feel-good" hormones of the body, are released [4]. These hormones also increase the level of a neurotransmitter, dopamine, making us feel even more pleasant and euphoric [4]. Therefore, the secret behind our addiction to spiciness is, in fact, the "feel-good" chemicals that give us a light-hearted rush.

If your first instinct when your mouth is "on fire" is to grab a glass of water, think again! Capsaicin is a hydrophobic ("water-hating", or "fat-loving"), non-polar molecule with a long hydrocarbon tail. Drinking water will only spread capsaicin all over the tongue, and heightens the burning sensation. You should instead consume dairy products because it contains casein, a non-polar protein which can bind to capsaicin. Similar to the cleaning action of detergents to remove grease, casein molecules will surround capsaicin molecules to form tiny droplets which can then be washed away easily [5]. Hence a cup of milk, or a cone of ice cream can likely "cool off" spicy food.

Some foods may contain other compounds that can also activate TRPV1, and/or the "wasabi receptor" TRPA1, another pain receptor under the TRP family. Black peppers contain piperine [6], while mustard [7] and wasabi [8] contain compounds belonging to the class of isothiocyanates. Isothiocyanates are volatile small molecules that can be inhaled and stimulate the receptors in the nasal cavity, so mustard and wasabi can burn not only our mouth, but also our nose. Notably, this will eventually lead to the secretion of the "feel-good" chemicals as well.

Alongside its ability to elicit a sensation of pain, surprisingly, capsaicin is also used in pharmaceuticals to provide relief to pain. It is commonly sold over the counter in the form of topical ointments and patches (the pain-relieving "hot" patches) [9]. In addition, capsaisin was approved in Europe to treat neuropathic pain [10], which is often described as shooting or burning pain, resulting from nerve injury [11]. Researchers have hypothesized how capsaicin works in relieving pain, with the desensitization of TRPV1 (i.e. decreased responsiveness after repeated exposure) being one of the possible mechanisms [9].

To conclude, the spicy capsaicin molecule can give us pleasure and pain at the same time. While scientists continue to unravel the working mechanisms of capsaicin and other pungent molecules in our body, we can, at least, take the lesson and keep a glass of milk handy next time when we feast on chili peppers!

如果你嚐過一碗地獄拉麵、一抹山葵或一口辣椒，當時的辛酸你一定不會忘記：舌頭像被火燒一樣，淚水從眼角滲出，汗水穿透衣服襲來；沒有一種官能刺激比辣更具威脅性。告訴你一個有趣事實：與其說辣是一種味道，不如說是一種痛。那到底是甚麼驅使人們烹調辛辣的食物，自投痛楚的羅網呢？

辣椒含有一種叫辣椒素的生物鹼，它能觸發辣的灼熱感。咀嚼會使辣椒素分子從食物中釋放，並擴散到舌頭的每個角落。然而它們會繞過味覺感受器，並與痛覺感受器結合 [1]。這些名為 TRPV1 的痛覺感受器原本的作用是在高溫（>43°C [2]）的情況下對腦部作出警告，但它們亦可以被辣椒素觸發。作為正離子通道，TRPV1 感受器被觸發時會打開，令正離子得以擴散進入痛覺神經元 [3]。這個增加電勢的過程叫去極化，會觸發神經元發出神經脈衝把信號傳遞至腦部，腦部在詮釋信號後便誤以為我們的舌頭正與灼熱的物件接觸，給予我們嘴巴被火燒的錯覺。

如果辣真的是一種痛，為甚麼我們會有多嚐一口的欲望呢？那正是因為我們身體有一個自我調節系統：身體在感到痛楚時會釋放安多酚等激素，安多酚既是天然止痛劑，亦能帶來身心愉悅的感覺 [4]。同時，安多酚亦能提高多巴胺這種神經遞質的水平，使我們更感愉快和興奮 [4]。因此，令我們戀上吃辣的原因正是這些使我們自我感覺良好的化學分子。

假如你在吃辣後的第一個反應是拿起一杯水來「救火」的話，你可要再想想！辣椒素是帶有碳氫長鏈的疏水（亦即親脂）非極性分子，喝水只會使辣椒素散落到舌頭的四周，加劇灼熱感。你應該喝奶類製品，因為它們含有非極性的酪蛋白，能與辣椒素結合。與清潔劑去除油脂的原理相近，酪蛋白分子能包圍辣椒素形成微滴，然後能被輕易沖走

[5]。所以一杯奶，或一杯雪糕更能止辣。

也有一些食物含有其他能激發 TRPV1 的化合物，它們有機會亦能觸發 TRP 家族中的另一種痛覺感受器 — 被稱為「山葵感受器」的 TRPA1。黑椒含有胡椒鹼 [6]，芥末 [7] 和山葵 [8] 則含有屬於異硫氰酸鹽的化合物。因為異硫氰酸鹽是細小的揮發性分子，能被吸進鼻腔並刺激裡面的感受器，所以芥末和山葵不止能使口腔灼熱，而且還會嗆鼻。值得留意的是這個過程最終也會令身體釋放出使我們愉悅的化合物。

辣椒素既能觸發痛楚，亦意想不到地被用於製造鎮痛藥物。這些產品多為非處方的外用軟膏及鎮痛貼（就是常見的熱感鎮痛貼）[9]。此外辣椒素也在歐洲被批准用於治療神經病變性疼痛 [10]，一種源自神經損傷，經常被形容為刺痛或帶灼熱感的疼痛 [11]。研究人員對辣椒素的鎮痛原理提出了一些假設，當中 TRPV1 的去敏感作用（即以重複刺激的方式去降低其反應）被認為是其中一個可能的原理 [9]。

總括而言，辛辣的辣椒素分子既能給予我們愉悅的感覺，亦能為我們帶來痛楚。在科學家繼續揭開辣椒素和其他辛辣分子運作原理的同時，我們也許可以從中汲取知識，最少懂得在下次麻辣大餐前準備好解辣用的牛奶！

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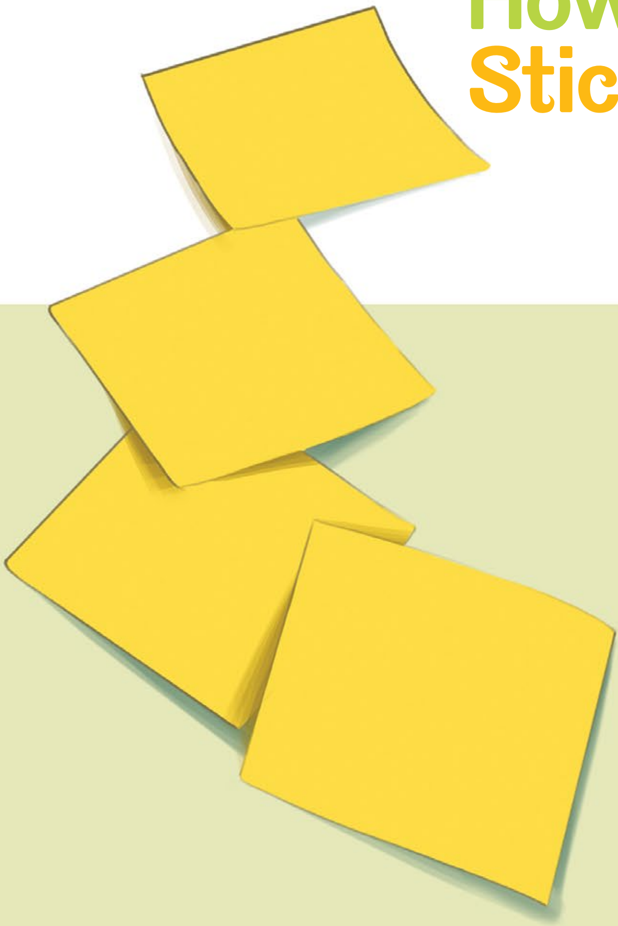
How Do Sticky Notes Work?
便利貼的原理是？

By April Lam 林芷因



Post-it notes are undoubtedly easy and convenient to use. Not only can they be placed anywhere without fasteners (i.e. tacks, paper clips, or staples), they do not easily fall off, nor leave any glue stains. Accepted as part of our many modern day conveniences, one rarely thinks about why this is possible in the first place.

History of Sticky Notes

Spencer Silver was a research chemist developing adhesives strong enough for aircraft construction [1]. In his attempts to invent such an adhesive, Silver instead discovered a weak adhesive that could be peeled on and off without losing its "stickiness [2]." While many may have thought this to be a useless invention, Silver's colleague Art Fry gave him the idea of using the adhesive to create removable paper bookmarks for his choir hymn book. This moment in history led to the invention of Post-it notes.

How to Describe the Strengths of Adhesives?

Adhesives have two kinds of strengths that make up the adhesive bond: shear strength and peel strength. As illustrated in Figure 1, shear strength is measured by the forces pulling in a direction parallel to the two surfaces joined by the adhesive. Peel strength, on the other hand, is measured by the forces perpendicular to the two surfaces.

For a Post-it note to be useful, it should have moderate shear strength to allow firm yet temporary attachment to a surface, while also having low peel strength to allow removal without tearing [3].

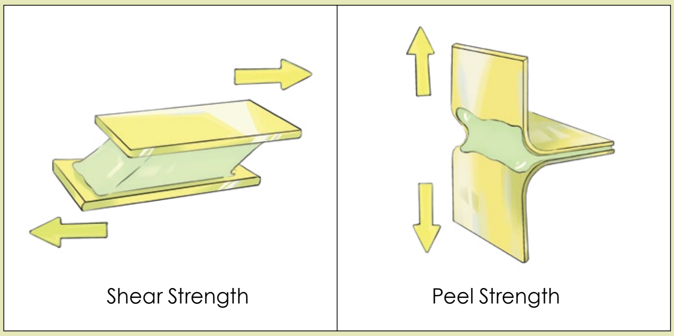


Figure 1 Shear Strength and Peel strength.

Why Are Polymer Adhesives Sticky?

Before looking into the unique properties of sticky notes, let's try to understand why they can stick to surfaces in the first place. Polymers are used as adhesives in the making of Post-it notes. These are large, long-chain molecules formed by repeating monomer units through a process called polymerization. When polymers come into contact with a surface, van der Waal's forces will form between the polymers and the molecular surface of the object, causing them to stick together. Almost all polymer adhesives work using these interactions [4].

When producing polymer adhesives for a specific purpose, scientists typically mix different ratios of monomers to modify the properties of the resulting polymer. This process results in a copolymer, defined as polymers formed from more than one type of monomer. To produce the adhesive mixture to be sprayed on sticky notes, Silver found the ideal ratio to be 95 to 99 percent of acrylate monomer, and 1 to 5 percent of mixtures containing ionic monomers and maleic anhydride [5]. In other words, small amounts of acrylate monomers are substituted with ionic monomers and maleic anhydride to form long, cross-linked chains. Such modifications can improve the elastic properties of the copolymer, and allow the adhesive to be produced as an aerosol spray [5].

How Do Sticky Notes Work?

But why can you stick and unstick a Post-it effortlessly? The copolymer is actually produced in the form of microspheres with diameters as small as 50 to 75 μm [6]. A single layer of sparsely spaced microspheres are sprayed on the paper of the Post-it note, which looks like the bumpy surface of a basketball under a microscope, with little glue bubbles protruding from the flat surface [7]. As illustrated in Figure 2, when force is applied to stick a Post-it note onto a surface, the elastic microspheres are flattened and cling to the surface. The flattening of microspheres temporarily provides an increased surface area for adhesion, and hence greater van der Waal's forces for attachment [8]. But these interactions are still not very strong, so the Post-it can be peeled off just as easily. Conveniently, re-sticking of the Post-it is allowed without adding extra adhesive because no significant levels of adhesive will be lost on the surface after removal [7]. The deformed microspheres are known to regain their spherical shape for another round of sticking [5]. However, Post-it notes do have a limited life span. With every attachment and removal, dust and dirt accumulate onto the sticky microspheres. This diminishes the contact area with the surface, and hence reduces van der Waal's interactions. Therefore the Post-it note will gradually lose its stickiness.

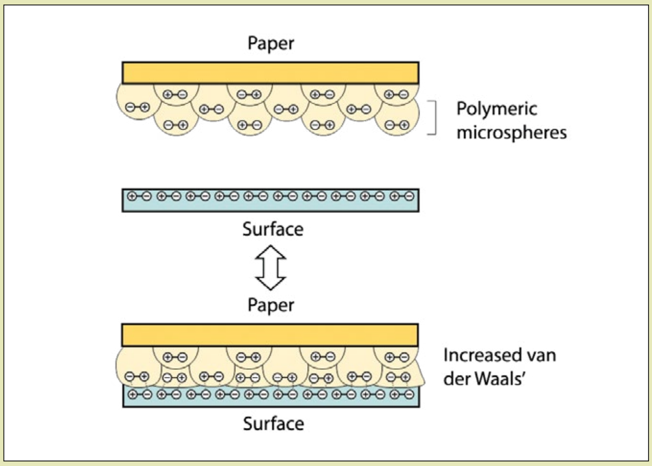


Figure 2 Representation of the forces responsible for polymeric adhesion of Post-it notes.

Believe it or not, Post-it notes have been sticking around for 43 years since its invention! From bookmarks to annotating documents and brainstorming in meetings, Post-it notes have served as an indispensable addition to our daily life, boosting productivity. The next time you grab a Post-it note to mark down a thought, be sure to remember this eureka moment of Silver and Fry's discovery.

Fun Fact:

The iconic canary yellow of Post-it is actually chosen by chance as the lab next to Silver's only had pale yellow scrap paper to use during development [9].

便利貼無疑是既易用又方便的發明，它不需配件(大頭釘、萬字夾或釘書釘)就可以貼在任何地方，既不輕易脫落，也不會留下膠水痕跡。便利貼已成為現代生活中不可或缺的一部分，但相信很多人未必會去想便利貼為何會擁有這樣的特質。

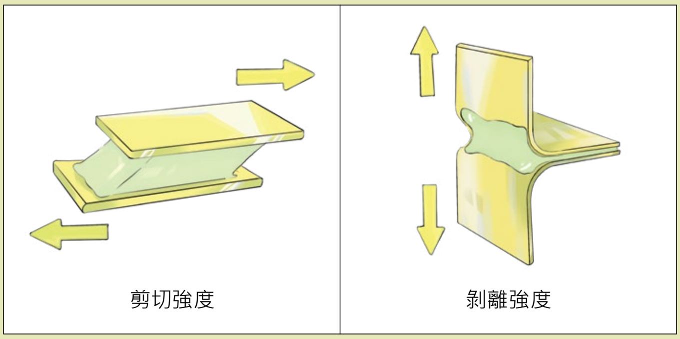
便利貼的歷史

Spencer Silver是一位化學家，當時希望研究出強度足以用於組裝飛機的黏著劑 [1]。在多次嘗試中，Silver意外發現了一種較弱的黏著劑，它可以被反覆貼在表面再撕走而不失其黏性 [2]。那時候許多人認為這是個無用的發明，Silver的同事Art Fry卻建議他用這種黏著劑為自己的合唱團詩集製作可移除的書籤，正是這個提議令便利貼得以面世。

如何描述黏著劑的強度？

黏著劑的黏力強度可以分為兩方面描述：剪切強度和剝離強度。如圖一所示，剪切強度可以透過量度平行於黏合表面的拉力得知，剝離強度則是通過量度垂直於兩個表面的力來測定。

便利貼要擁有理想的黏貼特質，它應該擁有中等剪切強度，使它可以牢固地暫時附著在表面上；然後應該具低剝離強度，使它能在不把物件撕破的情況下從物件表面移除[3]。

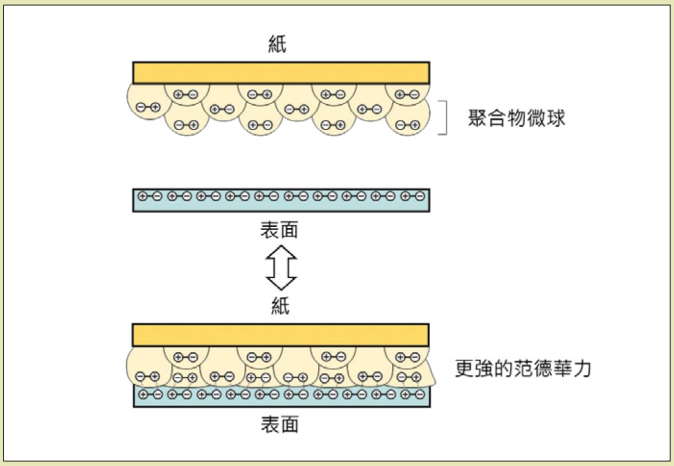


圖一 剪切強度和剝離強度

為甚麼聚合物黏著劑會黏？

在解釋便利貼特性之前，讓我們先了解為甚麼它能黏附在表面上。製作便利貼所用的黏著劑是聚合物，那是重複單體通過聚合作用組成的巨型長鏈分子。當聚合物與表面接觸時，聚合物和物件的分子表面之間會形成范德華力使它們黏在一起，幾乎所有聚合物黏著劑都依靠這種原理運作 [4]。

在生產用於特定用途的聚合物黏著劑時，科學家通常會混合不同比例的單體以改變所得聚合物的特性，這個過程產生的聚合物叫共聚物(copolymer)，定義為由多於一種單



圖二 便利貼聚合物黏合時相互作用的示意圖

體組成的聚合物。對於製造噴在便利貼上的黏著劑混合物，Silver 發現理想比例為 95% 至 99% 丙烯酸單體（亞加力單體），加上 1% 至 5% 離子性單體和順丁烯二酐的混合物 [5]。換句話說，交聯的（cross-linked）聚合物長鏈中小部分的丙烯酸單體被換成離子性單體和順丁烯二酐，這些改動可以改善共聚物的彈性，並使黏著劑能被製成氣溶膠噴霧 [5]。

便利貼的原理是？

但為甚麼我們可以毫不費力地黏貼和撕走便利貼呢？便利貼黏著劑共聚物實際上是直徑僅為 50 至 75 µm 的微球 [6]，單層而間隔稀疏的微球會被噴於便利貼的紙上，在顯微鏡下就像籃球凹凸不平的表面，在平面上布滿突出的膠水泡泡 [7]。如圖二所示，當我們施力將便利貼黏在表面時，具彈性的微球會變得扁平並黏附在表面上。微球變得扁平能暫時增加黏附的表面積和范德華力 [8]。可是這些分子間引力也不太強，所以便利貼能輕易地被撕走。此外，便利貼的便利之處在於重新黏合時無需添加額外的黏著劑，因為黏著劑幾乎不會在撕走的過程中流失 [7]，變得扁平的微球也能恢復原來的球狀供新一輪黏貼之用 [5]。然而，便利貼的壽命確實有限，因為每次黏貼和撕走都會使灰塵和污垢積聚在黏性微球上，減少其與表面接觸的面積和范德華力，使便利貼逐漸失去黏力。

不知不覺便利貼已經誕生 43 年了！從作為書籤到標註文件，以及在會議中記下大家靈光一閃的構思，便利貼已經成為大家日常生活不可或缺的工具，提高了人們的生產力。下次當你取下便利貼記下突如其來的念頭時，相信你一定會想起 Silver 和 Fry 在故事中靈機一動的時刻。

知多一點點：

便利貼採用標誌性的金絲雀黃其實只是個巧合，因為Silver實驗室旁的實驗室在開發過程中只有淡黃色的廢紙可供使用 [9]。

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Superellipse: Turning a Circle into

超橢圓：介乎圓形與正方形的詩意

By Peace Foo 胡適之

"In the whole pattern of civilisation there have been two tendencies, one toward straight lines and rectangular patterns and one toward circular lines. There are reasons, mechanical and psychological, for both tendencies. Things made with straight lines fit well together and save space. And we can move easily — physically or mentally — around things made with round lines. But we are in a straitjacket, having to accept one or the other, when often some intermediate form would be better." — Piet Hein [1]

Draw a line, any line, and it will have to be either straight or curved. Extend a curved line far enough and it closes to become a circle. Cross two straight lines and you get a corner; straighten the corner and you get a right angle. "Straight vs. curved" is a very natural paradigm that shows up all around us, and from its beginning mathematics has been built on the study of their differences. Euclid's *Elements*, the most famous geometry textbook of all time, begins with the assumption that straight lines, right angles, and circles can always be drawn. The idea of translating these geometric shapes and problems into algebra, which was first described by Descartes only about a century after the beginning of algebra in its modern form, unified those two main areas of mathematics. It is the reason we still learn about Cartesian graphs (graphs drawn with the coordinate system that we are all familiar with) in school.

On the usual x-y plane, the equation for a straight line is familiar: $y = mx + c$. Linear equations, where the highest-order term is x or y, always produce straight lines. Quadratic equations, with x^2 or y^2, will produce one of the curved conic sections – circles, ellipses, parabolas, or hyperbolas [1]. Consider $x^2/a^2 + y^2/b^2 = 1$, the general equation for the ellipse, which becomes the equation for a circle when $a = b$: the equation $x^2 + y^2 = 1$ should look familiar. By 1818, all this was well known to mathematicians. In a geometry book published that year, Gabriel Lamé decided to take things further by thinking about what happens with exponents n other than 2 [2].

The generalized curve $x^n + y^n = 1$ comes in many varieties depending on n [3], but the most interesting one for us is what happens when n is a fraction p/q, with p even, and q odd and greater than 1. These fractions for n include all the even integers 2, 4, 6, 8, …

From the circle at $n = 2$, you can see the shape become progressively closer to a square as n increases through the even integers (Figure 1). By adding absolute values, we allow n to be any number; now the Lamé curve $|x|^n + |y|^n = 1$ varies continuously for all $n > 2$ from a circle at $n = 2$ to a square in the limit as n goes to infinity. So does the general Lamé curve $|x/a|^n + |y/b|^n = 1$, which turns into a rectangle instead when the same limit is taken. If you never knew the equation for a square or rectangle, congratulations! Now you do.

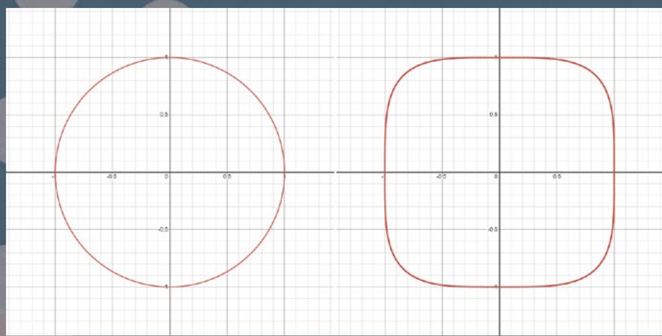


Figure 1 Transition of Lamé curves as n increases ($n = 2$ and $n = 4$ from left to right).

Thanks to the visual tool and shorthand provided by algebra, we have an intermediate shape between square and circle that can be described in a simple form. This simplicity is the reason for the sudden revival of this obscure curve in some unusual applications. Here are a few of them.

In 1959, Swedish architects wanted to build a roundabout that could fit into a rectangular space between the buildings of downtown Stockholm [4]. Roundabouts tend to be circles, of course, but a circle would leave part of the space unused. An ellipse has pointed ends that would be harder for traffic to navigate. The city planners also tried a combination of eight arcs, but that would create too many points where the curvature would suddenly change. A Danish designer and scientist, Piet Hein, came across this problem when it was announced as a design challenge, and leaned on his mathematical background to find a compromise shape between ellipse and rectangle. He came across the Lamé curve and experimented with the value of n for an ellipse of width 6 and height 5 (i.e. $a = 6$, $b = 5$), eventually deciding on $n = 5/2$ or 2.5 (Figure 2) [5], which he called a "superellipse":

a Square

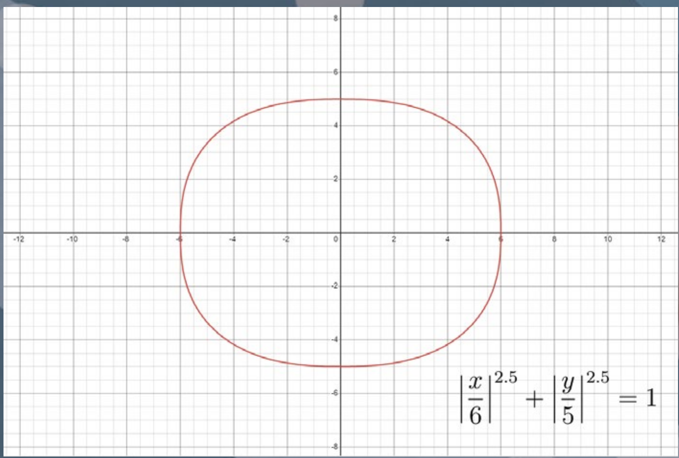


Figure 2 Piet Hein's solution to the roundabout at Stockholm.

Piet Hein decided that this was the most beautiful shape possible for the roundabout. In an article he wrote afterward, he remarked that [1]:

"To draw something freehand — such as the patchwork traffic circle they [other architects] tried in Stockholm — will not do. It isn't fixed, isn't definite like a circle or square. You don't know what it is. It isn't aesthetically satisfying. The super-ellipse solved the problem. It is neither round nor rectangular, but in between. Yet it is fixed, it is definite — it has a unity."

Between iOS 6 and iOS 7, the design team at Apple also decided to make use of this satisfying aesthetic. Up until then the shapes of the app icons in iOS had been squares with rounded corners (Figure 3) [6]. This is a problem for the same reason as the Stockholm roundabout: The transition from straight line to tightly curved circle is visually jarring even if we don't notice it consciously.

So, Apple's designers based their new app icons on the Lamé curve. They adopted the curve where n = 26/5 or 5.2 with slight modifications [7], which results in a shape that has a smooth flow that is meant to feel more natural. (Note that the four sides of a superellipse are not straight lines, but curves, even if n equals to a relatively large number like 5.2.)

Figure 3 App icons in iOS 6 (square with rounded corners) and iOS 7+ (modified superellipse).

Xiaomi may have thought along the same lines. In 2021, the electronics company also changed its logo from a rounded square to an obvious Lamé curve (Figure 4).

Figure 4 Shapes of the previous (left) and new (right) logos of Xiaomi.

Kenya Hara, the leading Japanese designer who oversaw the initiative, went through the same process as Piet Hein did and decided that n = 3 would look the most aesthetic [8]. But Piet Hein did something that Xiaomi didn't. Piet Hein had a definite purpose in mind when he chose the superellipse. On the other hand, Xiaomi reportedly paid Hara two million yuan to change the shape of the logo and almost nothing else; the consensus on the Internet was that there was no real purpose to the redesign [9]. Xiaomi already had an iconic logo. Did the redesign really have a purpose? The answer was affirmative according to Hara; the new logo was said to be "an encapsulation of Xiaomi's inner spirit" and "essentially a reflection of the concept 'Alive [8].'"

The Lamé curve strikes a balance between straight and curved, useful tool and purposeless curiosity. So does much of mathematics – it may be hiding out of sight; it may take 200 years to find an application; it may occasionally be mocked on the Internet, but somehow it is there, if you know where to look.

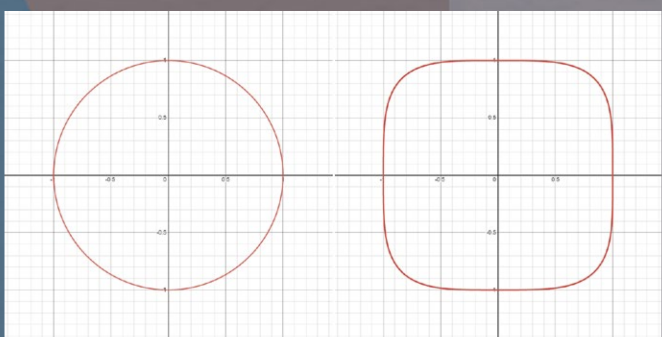
Piet Hein：「在文明社會的圖樣中有著兩種傾向，一種是直線和矩形，另一種是曲線。無論在機械或心理上，我們都有原因解釋這兩種傾向：直線構成的物件能被整齊地放在一起，節省空間；我們亦可以 — 物理或心理上 — 輕鬆地移動由曲線構成的東西。然而我們彷彿被束縛著一樣被迫二擇其一，但有時採取兩者之間的形態卻會更好 [1]。」

畫一條線，隨意畫，你會發現那條線只能是直線或曲線。把一條曲線延長，到某個位置它會閉合成圓。使兩條直線相交，你會得到一隻角；把角度調得工整一點，你就會得一隻直角。曲與直就像無處不在的兩股勢力，而在它們崛起的同時數學家就已經著手研究兩者的差異。世上最著名、歷久不衰的幾何教科書 — 歐幾里得的《幾何原本》在起首正是假設我們無論如何都能畫出直線、直角和圓形。笛卡兒在代數以現代形式出現後僅僅約一世紀，就提出了把幾何圖形和問題轉化為代數的概念，統整了數學上這兩個主要範疇。這亦是今天學校仍會教授笛卡兒坐標圖（就是以我們大家都熟識的坐標系統所畫的圖）的原因。

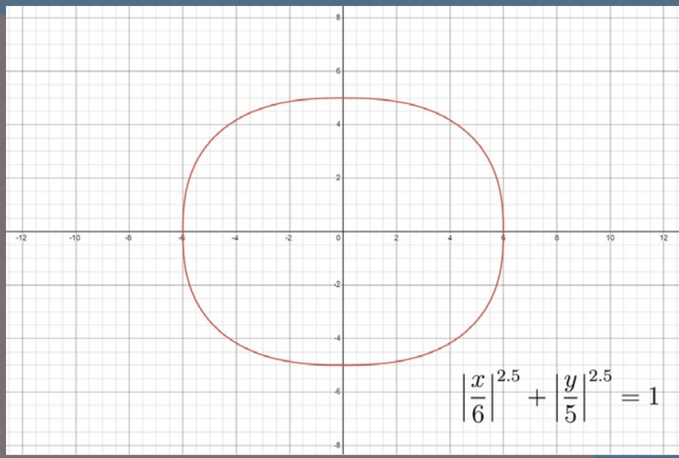
在慣常的 x-y 平面上，直線的方程就是我們熟識的 $y = mx + c$。線性方程，即是最高次項為 x 或 y 的方程永遠會得出一條直線；二次方程，即是最高次項為 x^2 或 y^2 的方程則會得出其中一種圓錐曲線 — 圓形、橢圓、拋物線或雙曲線 [1]。如果我們考慮橢圓的方程 $x^2/a^2 + y^2/b^2 = 1$，當 $a = b$ 時就會變成大家都熟知的圓方程 $x^2 + y^2 = 1$。在 1818 年，這全都是數學家已知的事實。在一本於當年出版的幾何書籍裡，Gabriel Lamé 決定再進一步看看如果指數 n 變成 2 以外的值時會發生甚麼事 [2]。

方程 $x^n + y^n = 1$ 的曲線可以根據 n 被分成不同種類 [3]，但當中最有趣的是當 n 為分數 p/q，且 p 為偶數，q 為奇數而且大於 1 時的曲線，這些分數包含了 2、4、6、8 在內的所有偶整數。

隨 n 增加成更大的偶整數，你可以看到圖形由 $n = 2$ 時的圓形變得越來越接近一個正方形（圖一）。透過取絕對值，我們允許 n 為任何數；現在的 Lamé 曲線 $|x|^n + |y|^n = 1$ 在 $n > 2$ 的情況下，由 $n = 2$ 時的圓形連續地變成 n 趨向無限大極限時的正方形。Lamé 曲線的一般方程 $|x/a|^n + |y/b|^n = 1$ 也是如此，取相同極限時會變成矩形。如果你從未聽過正方形或長方形方程的話，恭喜你，你現在知道了！



圖一 n 增加時 Lamé 曲線的轉變（左至右分別為 n = 2 和 n = 4）



圖二 Piet Hein 提出的斯德哥爾摩迴旋處方案

感謝繪圖工具和代數提供的簡潔表達，我們現在擁有可以被簡單描述，一個介乎正方形和圓形之間的圖形。簡潔正是令這條形狀曖昧的曲線突然被再次提起，並被採用於多個意想不到的情境中的原因。以下是幾個例子。

在 1959 年，瑞典建築師想在斯德哥爾摩市中心被建築物包圍的長方形用地興建一座迴旋處 [4]。迴旋處當然多數都以圓形設計，但圓形會浪費大部分用地；使用橢圓形的話，兩端的急彎會造成駕駛上的不便。城市規劃師也提出過以八條弧組成環形的方案，不過這會使車輛轉過多不必要的彎。後來這道難題成為了設計比賽的題目，引起了丹麥設計師及科學家 Piet Hein 的注意。大會藉著他的數學背景找到了這個橢圓形與矩形之間的折衷辦法。Piet Hein 無意中發現 Lamé 曲線，他嘗試把不同數值代入 n 去改造一個寬度為 6 和高度為 5（即 $a = 6$、$b = 5$）的橢圓形，最後決定採用 $n = 5/2$ 或 2.5（圖二）[5]，並稱這個圖形為「超橢圓」。

Piet Hein 認為這個形狀是最美麗而又可行的解決

圖三 iOS 6（正方形加上圓角）及 iOS 7+（作過改動的超橢圓）上的應用程式圖示

方案。在隨後一篇文章，他這樣寫道 [1]：

「徒手畫些東西的話 — 像是他們［其他建築師］為斯德哥爾摩迴旋處所畫，由不同形狀拼湊而成的圖形 — 並行不通。那樣的圖形並不規則，也不像圓形或方形般有明確的定義；你既不知道那是甚麼，那亦毫不美觀。超橢圓就能解決這個問題，它不圓也不方，介乎兩者之間，但它既是個規則的圖形，也有明確的定義 — 它有種統一性。」

在 iOS 6 升級 iOS 7 的時候，蘋果的設計部門也決定採用這個美觀的圖形。在那之前 iOS 應用程式的圖示都是在正方形加上圓角（圖三）[6]，這與斯德哥爾摩迴旋處問題同出一轍：直線至圓形之間過於兀突的過渡會在不經意間為我們帶來視覺上的不快。

因此蘋果的設計師基於 Lamé 曲線設計出新的應用程式圖示。他們採用了 $n = 26/5$ 或 5.2 的曲線再加上少許改動 [7]，使圖形有著流暢而更自然的外型。（要注意即使 n 是如 5.2 般較大的數字，超橢圓的四邊都不是直線，而是曲線。）

小米也許有著相同的想法。在 2021 年，小米把公司標誌由帶圓角的正方形改為明顯是 Lamé 曲線的圖形（圖四）。

首屈一指的日本設計師原研哉監督了整個計劃，他的做法跟 Piet Hein 一樣，但認為 $n = 3$

圖四 小米新舊標誌的形狀（左邊為舊標誌，右邊為新標誌）

才最為美觀 [8]。然而 Piet Hein 跟小米的故事又有著不同之處：Piet Hein 選用超橢圓是有他明確的原因，但小米據報支付了原研哉二百萬元人民幣，對方就只對公司標誌的形狀作出了這項小改動，而沒有別的大改變。網民一致認為這次重新設計標誌並沒有任何意義 [9]，皆因小米早已有具標誌性的公司標誌。那重新設計真的有其意義嗎？根據原研哉的說法，答案是有意義的，因為新標誌是「小米內在精神的象徵」，以及是「對『Alive』（生命感）這個設計概念的呼應 [8]」。

Lamé 曲線是曲和直之間的折衷點，也是在漫無目的的好奇下誕生的有用工具。大部分的數學也是如此：它可能隱沒在人們的視線外，可能用上 200 年才找到它的用途，偶爾也可能成為網民訕笑的對象；但如果你懂得怎去發掘，它就在那裡。

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Pheromone Perfumes: Beyond Advertisements
費洛蒙香水：廣告沒有告訴你的二三事

By Charlton Sullivan 蘇柏安

The cosmetics industry has long been promoting pheromone perfumes for their power to attract the opposite sex. They claimed that such products can enhance a person's charm and sexual attractiveness. Therefore, some believe that pheromone perfumes can make the one you love fall for you more easily. Is this myth true or not?

What Are Pheromones?

With that being said, you may wonder what exactly is a "pheromone"? First discovered in insects, pheromones were defined in 1930s as hormones that are secreted outside the organism's body (ectohormones) with effects on the conspecifics [1]. Although consensus cannot be reached on how to define pheromone beyond insects, most definitions agree that pheromones should be species-specific chemicals that have well-defined effects on the behavior or endocrine system of another individual [1]. Pheromones should also consist of one or just a few chemicals, with the effects minimally affected by learning (that is, one cannot easily learn to resist those inherent reactions) [1].

How Do "Pheromones" Work in Animals?

Insects are well known to possess pheromones. Female silkworm moth (*Bombyx mori*) produces a pheromone called bombykol to attract males [2], initiating and guiding the flight of the male moth to the female [1]. Pheromones also play a crucial role in regulating the honey bee society. The queen releases "queen pheromones" as signals to stimulate various behaviors of the worker bees, including cleaning, building, guarding, foraging, and brood feeding, and inhibit ovary development in workers to ensure that the queen is the only fertile female in the hive [3].

Since 1960s, scientists began to investigate whether mammals also possess pheromones. They observed that vaginal secretions of rhesus monkeys seemed to elicit copulatory behaviors in males, and agents in the tarsal scent glands of male deer appeared to elicit licking by females [1]. These observations led to the discussion of whether mammalian pheromones exist. The androgen derivatives found in boar saliva are considered a typical example of mammalian pheromone by some scientists [1, 4]. Boars are known to salivate profusely and foam around the mouth when sexually aroused. It is suggested that the volatile pheromones will diffuse in the air and elicit lordosis, a posture in which the spine of a sow bents inward to prepare for mating. Some scientists doubted that these agents are pheromones. They argued that sows do exhibit mating preferences, i.e. they do not lordose for all salivating males; the chemicals isolated from saliva cannot elicit the same response in all sows [1]. Taken together, the results are inconclusive because other stimuli, such as visual, tactile and auditory cues may also contribute to the sow's response. Given the much higher complexity of mammalian nervous system, our social behavior cannot be explained in the same way as insects' [1].

Do Humans Possess Pheromones?

Androgen derivatives, namely androstenone, androstenol and androstadienone, are externally secreted hormones which were purported to be the putative human pheromones by some experts. Particularly, they found that androstenone and androstadienone in sweat may contain a musk-like scent to the ones who can smell them, reminding us of the folklore that musk is a social attractant to humans [1, 5]. Androgen derivatives were hypothesized to be human pheromones also because of their effects on the reproductive behaviors in other mammals, such as lordosis in sows. Moreover, the facts that men have high levels of these steroids than women, and that women are more sensitive to these agents, imply the sexual dimorphism in their production and perception [1], and lend support to these agents as potential sexual attractants.

Conversely, some scientists believe none of these steroids are human pheromones, and think that even if they are found in body fluids, it does not necessarily mean that they serve as means of communication, and have the ability to alter reproductive responses [1]. Androstenone and androstenol are quite ubiquitous: They can be found in many animals and plants [1], including the roots of parsnip and celery [6]. In addition, while some people find the odor of these potential pheromones pleasant, others find it repulsive or cannot smell them at all. Therefore, it may not be logical to define all odorants as pheromones. In fact, researchers found evidence showing that humans have shifted the heavy reliance on olfactory senses to sight and vision during evolution that we depend less on smell for survival and reproduction [5].

As you can tell by now, the definition of human pheromones is still a subject of active debate.

Do Pheromone Perfumes Actually Work?

So the ultimate question is whether or not such perfumes work? The answer is: They neither have a clear pharmacological basis, nor work magically like "Cupid's arrow". To recap, many experts question the existence of mammalian pheromones, although the industry has already claimed and made the assumption that related products can reproduce the sexual response that occurs in other mammals. An interesting fact is that many products do not even contain the putative human pheromones, and use animal "pheromones" from dogs and pigs or plant extracts as the active ingredient. These ingredients are unlikely to elicit similar effects on humans, as pheromones should be species-specific by definition [7]. Unfortunately, pheromonal products are not regulated by the FDA because they are not therapeutic drugs [8], so the industry can advertise the products with their own claims.

Another point to ponder is whether pheromone perfumes can exert a placebo effect. Just like other perfumes in general, they will make you smell better, which may be sufficient to boost your confidence. As a result, one may act in a manner that the opposite sex finds more attractive. So, the beneficial effects can stem from a change in self-perception, and not from the chemicals of the spray. After all, confidence is only a small part in the pursuit of true love. Empathy, hard work, dedication and patience are qualities that we cannot obtain from such products if you really want to find the love of your life!

美容業界長久以來都以能吸引異性作招徠宣傳費洛蒙香水，他們聲稱產品能增加一個人的魅力和性吸引力，這令不少人相信費洛蒙香水能更易使心儀對象對自己心動。這個傳言是真的嗎？

甚麼是費洛蒙？

你的第一個疑問可能是甚麼是「費洛蒙」。費洛蒙於 1930 年代在昆蟲上被首次發現，當時定義為生物分泌出體外（外激素）而能對同類起作用的激素 [1]。儘管科學家對如何定義昆蟲以外的費洛蒙不能達成共識，但大部分定義均同意費洛蒙是指可以對同種個體起作用的化學物質，能對另一個體的行為或內分泌系統施以明確的作用 [1]。費洛蒙亦應只含一種或僅數種物質，作用應幾乎不受學習影響（即個體不能輕易地學會抵抗那些天生固有的作用）[1]。

「費洛蒙」在動物上怎樣運作？

眾所周知昆蟲擁有費洛蒙。雌性蠶蛾（*Bombyx mori*）會產生一種叫蠶蛾醇的物質吸引雄性 [2]，觸發並引導雄性飛向雌性 [1]。費洛蒙對維持蜜蜂群體的社會性也起著至關重要的作用，蜂后會釋放「蜂后費洛蒙」作為信號，使工蜂從事清潔、建築、保衛、覓食、餵哺幼兒等多種工作，亦能抑制工蜂卵巢的發育，確保蜂后才是巢裡唯一具生育能力的雌性 [3]。

從 1960 年起，科學家著手研究哺乳類動物是否亦擁有費洛蒙。他們觀察到恆河猴的陰道分泌物似乎能促進雄性進行交配行為，雄鹿跗骨氣味腺的物質亦看似能令雌性走近舔舐 [1]，這些觀察都令科學家議論紛紛，討論費洛蒙是否存在於哺乳類。雄豬唾液中的雄性激素衍生物就被部分科學家認為是典型的哺乳類費洛蒙 [1, 4]。我們知道雄豬性慾被挑起時會分泌大量唾液，使嘴巴周圍佈滿白沫，有科學家提出具揮發性的費洛蒙會藉此擴散到空氣中，繼而引發雌豬作出脊柱向內彎，名為脊柱腹凸（lordosis）的姿勢以準備交配；但亦有科學家質疑那些物質並不能算是費洛蒙，皆因雌豬也有自己的擇偶條件，牠們不會無差別地對所有口吐白沫的雄豬作出脊柱腹凸的交配姿勢，而且從唾液提取的化學物質也不能在所有雌豬身上起作用 [1]。總的來說，雄性激素衍生物作為費洛蒙的論據仍是比較薄弱，諸如視覺、觸覺和聽覺等其他感官上的刺激也可能是激發雌豬反應的原因之一。哺乳類的神經系統如此複雜，我們社會行為的運作方式大概不會像昆蟲那樣簡單 [1]。

人類擁有費洛蒙嗎？

雄烯酮、雄烯醇和雄二烯酮這三種雄性激素衍生物是人類分泌出體外的激素，有專家假定它們就是人類費洛蒙。當中，汗水中的雄烯酮和雄二烯酮對部分人來說帶有麝香的香氣，使我們聯想到麝香能吸引人們的民間傳說 [1, 5]。雄性激素衍生物被假定為人類費洛蒙的原因亦是因為這類物質能對其他哺乳類動物的生殖行為作出影響，例如雌豬的脊柱腹凸。此外，這些類固醇在男性體內的水平比女性高，以及女性對這些物質有較高的敏感度，都暗示它們在製造和感知方面都有著明顯的兩性差異 [1]，這可能提供了它們作為性吸引激素的基礎。

相反，另一派科學家認為這些類固醇都不是人類費洛蒙，並認為即使它們存在於體液中，也不代表它們一定是作為同類個體之間溝通的方式，亦未必有改變生殖行為的能力 [1]。雄烯酮和雄烯醇在動物和植物間可謂無處不在 [1]，在不少動植物中也能找到它們，包括

歐洲蘿蔔和西芹的根部 [6]。另外，有人認為這些物質氣味愉悅的同時，也有人厭惡這種氣味又或是完全嗅不到，但無論它們嗅起來像麝香也好，像尿也好，把所有帶有氣味的分子都歸類為費洛蒙並不符合邏輯。事實上，已有證據顯示人類在進化過程中已經由重度依賴嗅覺變為偏重視覺，使我們減少依靠氣味生存和繁殖 [5]。

現在你已經可以理解到，人類費洛蒙的定義至今仍是人們爭論的議題。

費洛蒙香水真的有用嗎？

那麼最後的問題是，費洛蒙香水到底有沒有用？答案是：它們沒有明確的藥理根據，也不會像「邱比特的箭」一樣起魔法般的奇效。重申一下，儘管業界聲稱相關產品可以在人類產生在其他哺乳類動物觀察到的性反應，不少專家仍在質疑哺乳類費洛蒙是否存在的事實。另一個有趣的地方在於很多產品甚至不含假定的人類費洛蒙，而採用從貓、狗提取的動物「費洛蒙」或植物提取物作為活性成分，這些成分事實上並不太可能會在人類身上產生類似效果，因為費洛蒙在定義上應該只對同種生物有效 [7]。然而，費洛蒙產品並不受美國食品及藥物管理局（FDA）監管，因為它們並不是作治療用途的藥物 [8]，因此業界可以在廣告中隨意聲稱產品的效用。

另一樣要思考的是費洛蒙香水是否能產生安慰劑效應。就像普通香水一樣，香水的作用是使身體帶有香氣，這可能就足以使一個人變得更有自信，在異性面前變得神態自若，舉手投足都使對方著迷。這樣的話，效果可能只是由自我感覺上的改變所帶來，而不是由於香水中的化學物質。話雖如此，自信心都只是尋找真愛之中微不足道的一環；同理心、努力、無私奉獻的心和恆久忍耐這些對於長久發展重要的特質都是催情產品給不了你的。

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