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# SCIENCE FOCUS 科言


Issue 031, 2025




School of 理學院 Science

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

# Contents

Science Focus Issue 031, 2025



## Message from the Editor-in-Chief 主編的話

Dear Readers,

I hope you have enjoyed a great start to the new school year. In addition to keeping up with the regular curriculum, you may also be busy with extracurricular activities that demand originality and teamwork. Perhaps the stories we share will serve as inspiration.

Many of you must have done practice questions on statistics that involve the student's *t*-distribution. Do you know its connection with beer brewing? How about the connection of Euler's number (e) with the calculation of compound interest and radioisotope decay? Although we don't carry an atomic clock with us all the time, it plays an indispensable role in letting Pokémon Go know exactly where we are. Finally, we share a tale that connects itchy sheep, cannibalism, and Nobel Prize. Read on to discover the medical mystery about prions.

Some of you may be thinking about what to study after secondary school. In our ongoing series of articles that feature HKUST alumni, you will learn from four biologists on their paths of success. Hopefully, their stories will give you broader perspectives on university studies and beyond. I wish you the best in choosing your own path to success!

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

親愛的讀者：

希望大家在新學年伊始一切順利。在繼續恆常課程同時，你們可能也忙著各樣需要發揮創意和團隊精神的課外活動，今期故事也許正好能啟發大家。

你們當中很多人應該做過與學生 *t* 分佈相關的統計題目，但你知道它與釀造啤酒之間的關係嗎？你又知道歐拉數 (*e*) 如何被應用於計算複利息和放射性衰變？儘管我們不會隨身攜帶原子鐘，但它在 Pokémon Go 的定位功能中扮演著不可或缺的角色。最後，我們會分享一個與羊搔癢症、食人習俗和諾貝爾獎相關的醫學故事，請閱讀後文，並與我們一起拆解病原性蛋白顆粒的神秘面紗。

你們也許正在考慮中學畢業後的出路，在我們與科大校友的對談系列中，你將會聽到四位主修生物學的舊生踏上成功之路的心路歷程，希望他們的故事能擴闊你對大學及其後生涯發展的認知。衷心希望大家能找到屬於自己的成功道路！

*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 Fall Science Activities 秋日科學好節目

**Any plans for this fall? Check out the following events!**
**計劃好這個秋天的課餘節目了嗎？不妨考慮以下活動！**

## STARMAP to the Unseen Universe 星圖旅航

This Sky Show invites audiences to embark on a captivating journey through the cosmos. This immersive experience spans 13.8 billion years of cosmic history, exploring the origins of the universe and venturing beyond our solar system. Audiences will witness the breathtaking beauty of the Milky Way, the formation of stars in the Orion Nebula, and the dramatic life cycles of stars, including supernova explosions and the mysterious nature of black holes. With stunning visuals and profound insights, STARMAP reveals the hidden complexities of the universe, inviting all to gaze at the stars with newfound wonder.

**Show Period:** Now – November 14, 2025
**Time:** 3:30 PM and 8:00 PM (Mon, Wed to Fri)
2:00 PM and 6:30 PM (Sat, Sun and public holiday)
**Venue:** Space Theatre, Hong Kong Space Museum
**Admission fee:** Standard admission: $40 (stalls), $30 (front stalls)
Concession admission: $20 (stalls), $15 (front stalls)

天象節目《星圖旅航》邀請觀眾踏上引人入勝的宇宙之旅。這次沉浸式體驗將帶大家跨越 138 億年的宇宙歷史，探索宇宙起源，並走出太陽系探險。觀眾將見證銀河系的壯麗、獵戶座星雲中恆星的形成，以及恆星戲劇性的生命週期，包括超新星爆炸和神秘的黑洞等。透過壯觀的視覺效果和深刻的講解，《星圖旅航》將揭示宇宙隱秘的複雜性，從而邀請大家以全新角度凝視星空。

**放映日期：** 現在至 2025 年 11 月 14 日
**時間：** 下午三時半及八時正 (一、三至五)
下午二時正及六時半 (六、日及公眾假期)
**地點：** 香港太空館天象廳
**入場費：** 標準票：40 元 (後座)；30 元 (前座)
優惠票：20 元 (後座)；15 元 (前座)

## Geminid Meteor Shower

**December 14–15, 2025**

This year, the Geminids are expected to peak on December 14 (Sun). The Hong Kong Space Museum has rated the local observation condition as "excellent." You may observe the meteor shower during the entire night of December 14.

Places with wide view of the sky and low light pollution are suitable for the observation, such as the East Dam of the High Island Reservoir, Tai Tau Chau in Shek O, and Tai Au Mun near HKUST. Please observe the "stargazing etiquette"— use a red light torch and don't point it to others. To take photos of the starry sky, don't forget to bring a tripod and a camera with a wide-angle lens!

## 雙子座流星雨

**2025年12月14至15日**

今年雙子座流星雨的高峰期預計是 12 月 14 日(日)。本地觀測條件被香港太空館評為「極佳」，你可以在 14 日的整個晚上觀賞。

天空視野廣闊和光害較少的地方均適宜觀測是次流星雨，本港的觀星熱點包括萬宜水庫東壩、石澳大頭洲以及離科大不遠的大坳門等。觀星時記得遵守「觀星禮儀」：使用紅光手電筒，及不要把光照向其他觀星者。想嘗試天文攝影的朋友記得攜帶三腳架和廣角鏡頭。

# Beer, Student, and t-Distribution

# 啤酒、學生與 t 分佈

By Helen Wong 王思齊

Does project-based learning improve students' academic performance? Which candidate is more likely to win in an election? Is a new drug effective in treating a certain disease?

While these scenarios may seem unrelated, they all share a common thread: We need to collect information from samples or to make an inference about a population, whether it's all students, all voters, or all patients. This process is formally known as statistical inference. Assuming the sampling process is random and unbiased, the quantities calculated from these samples, such as sample mean or sample variance, will vary from one sample to another.

Thus, sample means obtained from different rounds of sampling follow a specific distribution. Without going into the rigorous mathematical proof, the central limit theorem tells us that the sampling distribution of the sample mean will be approximately normally distributed when the sample size is sufficiently large, even if the underlying population is not normally distributed.

But what happens when our sample size is small and we have no idea about the population standard deviation? Today, we take for granted that in such cases, given that the underlying population is a normal distribution, the sampling distribution of sample mean follows the Student's *t*-distribution, thanks to a brewer named William Sealy Gosset (1876–1937) [1–3].

Born in Canterbury, England, Gosset was educated at the University of Oxford, where he earned a first-class degree in chemistry in 1899. Around this time, the Guinness brewery in Dublin recognized the need for rigorous quality control in beer production and began recruiting graduates from Oxford and Cambridge for this purpose. Gosset was among those selected.

As an apprentice brewer, Gosset needed to evaluate how the quality of barley and hops might affect that of the beer. The quality of agricultural products is known to vary throughout a year, depending on factors such as climate and soil conditions. Therefore, Gosset's goal was to maintain a consistently high quality of beer while also ensuring cost-effectiveness. This necessitated relying on small samples to draw conclusions that could inform the large-scale brewing process.

By the early 20th century, the central limit theorem had been established, and many were familiar with using the normal distribution for statistical inference with large sample sizes. Gosset conducted experiments by sampling acidity values from beers produced under various conditions, such as using different batches of malted barley, to determine whether there were significant differences in mean acidity between these groups.

Through his calculations, Gosset discovered that when the sample size was small, the sampling distribution of the sample mean deviated noticeably from the normal distribution. This finding prompted his quest for a new distribution that would resemble the normal distribution but suitable for small sample observations.

Despite achieving a first in the mathematical moderations examination during his time at Oxford, Gosset was clearly not a professional mathematician. The creation of the Student's *t*-distribution was closely tied to his extensive correspondence with many of the leading statisticians of his time.

Karl Pearson (footnote 1) was one of the key influences on Gosset's career. Pearson introduced Gosset to nearly all the statistical methods known at the time and invited Gosset to visit his department at University College London from 1906 to 1907. During this period, Gosset worked on his small-sample problem and published the landmark paper "*The Probable Error of a Mean*" in the journal *Biometrika* [4], where Pearson served as editor, in 1908.

Some curious readers may have noticed that the author of the paper is credited as "Student" rather than William Sealy Gosset. This was due to a policy at the Guinness brewery that prohibited staff from publishing under their own names or using any company data. To comply with this policy, Gosset adopted the pen name "Student," which is believed to have been inspired by the cover of a notebook he was using at the time – *The Student's Science Notebook* [5].

Yet Gosset himself did not coin the term "*t*-distribution." In his 1908 paper, he still used the symbol *z* in his derivation of the sampling distribution

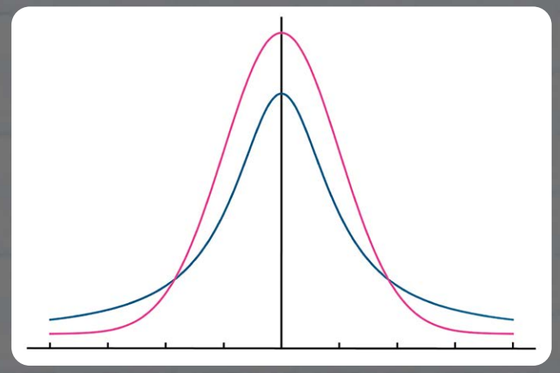


**Figure 1** Normal distribution (pink) and *t*-distribution when the degree of freedom is 1 (blue). The *t*-distribution is flatter at the peak and has "thicker" tails compared to the normal distribution.

of the sample mean for sample sizes ranging from 4 to 10. The symbol *t* was later introduced by Ronald Fisher (footnote 2), a legendary statistician and close friend of Gosset, in a 1925 paper [6]. In this work, Fisher fully derived the values of the Student's *t*-distribution and demonstrated that it is a transformed normal distribution. The shape of the *t*-distribution changes depending on the sample size *n*, which is represented

by the degrees of freedom (calculated as $n - 1$). With a smaller number of observations, the *t*-distribution is flatter at the peak and has "thicker" tails compared to the normal distribution (figure 1). As the sample size increases, especially when $n$ exceeds 30, the *t*-distribution starts to resemble the normal distribution.

Perhaps contrary to Gosset's expectations, as reflected in his letter to Fisher, "you're the only man that's ever likely to use them!" the *t*-distribution has become one of the most famous statistical distributions. It is widely applied in both everyday life and academic research, and of course, a staple in statistics courses. So, the next time you encounter the Student's *t*-distribution (or find yourself grappling with it in class), take a moment to appreciate the "Student" behind it, William Sealy Gosset, and the fascinating story of its creation.

1. Karl Pearson (1857–1936) was a British statistician and a key figure in the development of modern statistics [7]. His work laid the foundation for many statistical methods and concepts still in use today, including the Pearson correlation coefficient and the chi-squared distribution. Notably, Pearson founded the first university statistics department in the world at University College London in 1911.
2. Ronald Aylmer Fisher (1890–1962) was a British statistician and geneticist [8]. Hailed as "a genius who almost single-handedly created the foundations of modern statistical science," Fisher's contributions to statistics include the significance test, analysis of variance (ANOVA), and maximum likelihood estimation, among many others. In genetics, he is regarded as one of the three founding fathers of population genetics, a key component of the modern synthesis that combines Mendelian genetics with Darwin's theory of evolution.

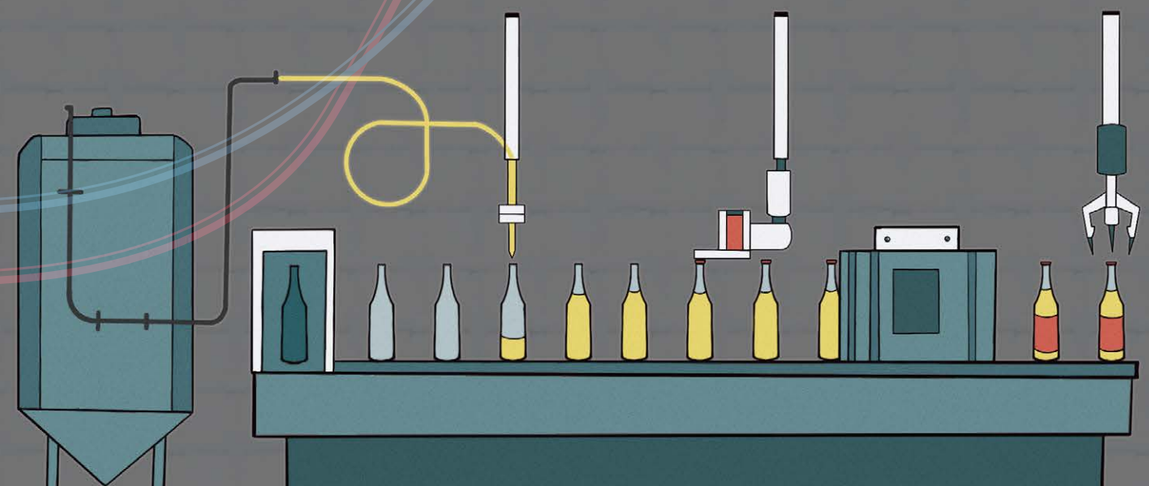
專題研習是否能提升學生的學業表現？哪位候選人更有可能在選舉中勝出？某種新藥對治療特定疾病是否有效？

雖然這些情境看似毫無關聯，但它們都指向一個核心概念：我們需要從樣本收集資訊，然後針對某個總體（population）作出推論，總體可以是全體學生、全體選民，也可以是全體病人。這過程被稱為「統計推論」（statistical inference）。假設抽樣過程是隨機且無偏的，從樣本中計算出的統計數值，如樣本平均值和樣本方差等，在每次取樣皆會有所不同。

因此，從多次抽樣中得到的樣本平均值會遵循一個特定的分佈。撇開嚴謹的數學證明不說，根據中心極限定理（central limit theorem），當樣本量足夠大時，即使總體並非正態分佈（normally distributed），樣本平均值的抽樣分佈（sampling distribution of the sample mean）仍會近似正態分佈。

但如果樣本量很小，且我們對總體的標準差沒有頭緒時，又該怎麼辦呢？今天我們早已習以為常：在這種情況下，只要總體為正態分佈，樣本平均值的抽樣分佈就會遵循學生 *t* 分佈（註一）。這一重要發現要歸功於一位名叫 William Sealy Gosset（1876–1937）的釀酒師 [1–3]。

Gosset 出生於英格蘭的坎特伯雷，1899 年於牛津大學取得化學一級榮譽學位。當時，位於都柏林的健力士（Guinness）啤酒廠意識到在釀酒過程中進行嚴格品質控制的重要性，因而開始從牛津和劍橋大學招募畢業生，Gosset 便是其中之一。



作為見習釀酒師，Gosset 的工作是評估大麥和啤酒花的品質如何影響啤酒品質。農產品的品質會隨氣候和土壤條件等因素而有所波動，因此 Gosset 的目標是在確保成本效益的同時，將啤酒品質維持在高水平，這就需要從小量樣本推論出大規模的釀造過程是否合乎標準。

20 世紀初已經存在中心極限定理，許多人已經熟悉在樣本數量足夠大時使用正態分佈進行統計推論。Gosset 透過量度在不同條件下（例如使用不同批次的發芽大麥）釀造出來啤酒的酸度值，以判斷不同批次啤酒是否在平均酸度上存在顯著差異。

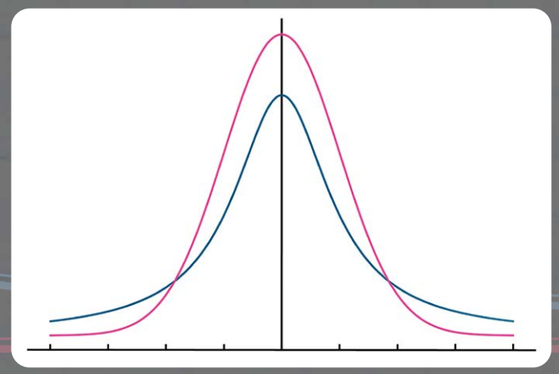
透過計算，Gosset 發現當樣本量較小時，樣本平均值的抽樣分佈會明顯偏離正態分佈。這個發現促使他開始尋找類似正態分佈，但適合小樣本量的新型分佈。

雖然 Gosset 曾在牛津大學的數學考試中取得優秀成績，但他顯然並非專業數學家，因此學生 *t* 分佈的誕生其實有賴他與當時多位頂尖統計學家的緊密聯繫。

其中，Karl Pearson（註二）對 Gosset 的職業生涯影響深遠。Pearson 向 Gosset 介紹了幾乎所有當時已知的統計方法，並邀請他於 1906 至 1907 年訪問 Pearson 於倫敦大學學院所在的學系。在此期間，Gosset 專注研究小樣本問題，並於 1908 年在 Pearson 主編的《*Biometrika*》期刊上發表了一篇劃時代的論文〈平均值的可能誤差〉（*The Probable Error of a Mean*）[4]。

細心的讀者或許會注意到，這篇論文的作者署名是「Student」（學生），而非 Gosset 的本名。這是因為健力士啤酒廠有一項規定，禁止員工以本名或使用任何公司數據發表論文。為了遵守這項政策，Gosset 選擇使用筆名「Student」發表論文，據說靈感來自他當時使用的筆記本封面標題《學生的科學筆記本》（*The Student's Science Notebook*）[5]。

然而，「*t* 分佈」這個名稱並非出自 Gosset 本人。在 1908 年的論文中，Gosset 仍然使用符號 *z* 來推導樣本量為 4 到 10 時樣本平均值的抽樣分佈。符號 *t* 稍後由傳奇統計學家兼 Gosset 好友 Ronald Fisher（註三）於 1925 年的論文引入 [6]。Fisher 在這篇著作中完整推導出學生 *t* 分佈的值，並證明了它是一種經轉換後的正態分佈。*t* 分佈的形狀會隨樣本量 *n* 改變，而技術上樣本量會以自由度（degree of freedom，即 $n - 1$）表示。在樣本量較小的情況下，相比起正態分佈，*t* 分佈的峰部會較矮，尾部也較「粗」（圖一）。隨著樣本量增加，尤其當 *n* 大於 30 時，*t* 分佈會開始變得接近正態分佈。



**圖一** 正態分佈（粉紅）和自由度為 1 時的 *t* 分佈（藍）。與正態分佈相比，*t* 分佈的峰部較矮，尾部較「粗」。

Gosset 自己曾在寫給 Fisher 的信中評論道：「你很可能是唯一一個會用這些東西的人！」然而，讓 Gosset 始料不及的是 *t* 分佈如今已成為最著名的統計分佈之一。它被廣泛應用於日常生活和學術研究中，更不必說在統計學課程中可以經常找到它的蹤影。因此，下次當你在遇到學生 *t* 分佈，或在課堂中被它搞得頭昏腦脹時，別忘了那位真正的「學生」— William Sealy Gosset，以及背後的精彩故事。

1. 編按：學生 *t* 分佈（Student' s *t*-distribution）有時會根據讀音被翻譯成「司徒頓 *t* 分佈」。
2. Karl Pearson（1857–1936）是英國統計學家，也是推動現代統計學發展的關鍵人物 [7]。他的工作為許多至今仍被廣泛使用的統計方法和概念奠定了基礎，包括 Pearson 相關係數和卡方分佈。值得一提的是，Pearson 於 1911 年在倫敦大學學院成立了全世界第一個統計學系。
3. Ronald Aylmer Fisher（1890–1962）是英國統計學和遺傳學家 [8]。Fisher 被譽為「幾乎以一己之力奠定現代統計科學基礎的天才」，他對統計學的貢獻包括顯著性檢驗、變異數分析（ANOVA）和最大似然估計等。在遺傳學方面，他被視為群體遺傳學的三位奠基人之一。群體遺傳學是結合孟德爾遺傳學和達爾文演化論的現代演化綜論（modern synthesis）的重要組成部分。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# Prions: A Mysterious Infectious Agent

# 病原性蛋白顆粒：神秘的致病元兇

By Daria Zaitseva

What could possibly link a sheep illness called scrapie, a disease associated with cannibalism called Kuru, and a neurodegenerative disease called Creutzfeldt-Jakob disease? These fatal diseases occur in different species, and yet share a chilling commonality. More mysteriously, scientists could not identify the pathogen – neither virus nor bacteria were the culprit. Human's knowledge at that time simply could not break the mystical curse. Let's explore the mystery and see how one of the most obscure killers was discovered.

## Scrapie: Affected Sheep Uncontrollably Scratching Their Backs

We begin in 18th-century England, where sheep farming was a cornerstone of the economy. But farmers soon faced a disturbing problem: Some sheep began scratching their backs against posts uncontrollably, then stopped feeding and became lame, and eventually turned emaciated and died [1]. The only way to prevent the spread of the disease was to isolate the sick animals from the flock. Nevertheless, without the ability to investigate further, this eerie disease was soon forgotten [1].

By the middle 20th century, scientists took a closer look [1]. They tried to identify the underlying pathogen. As the first step, they succeeded in experimentally transmitting the disease by inoculating the brain or spinal cord tissue from a diseased animal to a healthy one. The onset of disease can take as long as one to two years, so it left the scientists confused about the results of the experiment at first. Then, scientists attempted to identify the pathogen by treating tissue samples with different standard inactivation methods at the time, such as using a bacterial exclusion filter to remove, if any, bacteria. They also applied a dose of ionizing radiation that could disrupt, if any, nucleic acid (including DNA and RNA) in a separate experiment. However, the tissues remained infectious, so they realized the pathogen could be unusual this time. The only clues from brain dissections are the signature vacuoles – described as "soap bubbles" – in the cytoplasm of nerve cells, and the strange holes – called spongiform – in the sheep's brains, giving the brain a sponge-like appearance.

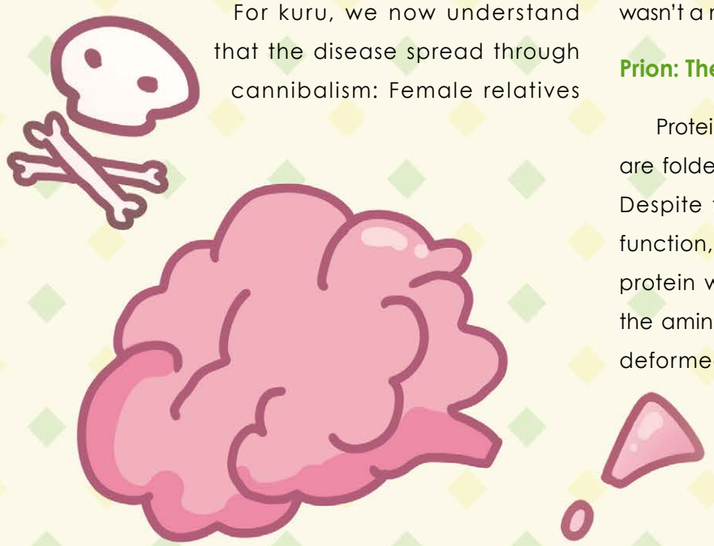
## Kuru: A Mystical Curse Associated with Cannibalism

As scrapie returned to the limelight, two medical doctors, Daniel Gajdusek and Vincent Zigas, reported firsthand in 1957 from Papua New Guinea a mysterious disease that

some believed was associated with cannibalism [1, 2]. Kuru was first discovered in the Fore tribe, with victims trembling, losing muscle control, laughing uncontrollably, and dying within months. The disease primarily affected women, with a female-male ratio of 14:1 in adults.

In 1959, William Hadlow, an American veterinarian working on scrapie, happened to visit an exhibition on kuru in a medical museum in London [3]. He was shocked to find striking similarities between the two progressive degenerative diseases, from the signature "soap-bubbles" in the nerve cells, the extensive incubation period, to the failure in isolating a microbial agent [4].

After that, Hadlow wrote a letter to the editor of *The Lancet*, and also reached out to Gajdusek, drawing scientists' attention to the high resemblance of the two diseases [5]. Later, Igor Klatzo, a neuropathologist who studied the brains of 12 kuru patients received from Gajdusek, also drew parallels between kuru and another human spongiform brain disease, Creutzfeldt-Jakob disease (CJD) [6]. In the next decade, scientists were able to experimentally transmit kuru and CJD to chimpanzee by inoculating infected human brain tissue, and later to laboratory rodents [1].



For kuru, we now understand that the disease spread through cannibalism: Female relatives would consume their relatives' bodies as a mortuary practice "to free the spirit of the dead [7, 8]," during which they ingested the infected human brain concentrated with the infectious agent.

## Creutzfeldt-Jakob Disease: Lessons to Scientists

So, what was the infectious agent? Stanley Prusiner, an American neurologist and biochemist, recalled the bizarre observation in his CJD patients: There was no immune response elicited – no fever, no increase in white blood cell count, and no humoral immune response – meaning that whatever caused the disease might not be a foreign agent [9].

With his biochemistry background, Prusiner decided to approach the problem differently by attempting to purify the infectious agent from affected mice inoculated with scrapie agent [9]. After harvesting and blending the spleens and brains of the mice, the homogenate was centrifuged for different times and speeds to separate constituents with different densities. After testing the infectivity of each sample, a highly infectious fraction was recovered despite the removal of over 98% of proteins and polynucleotides. With this cleaner sample, scientists demonstrated that infectivity could be reduced by procedures that hydrolyze or modify proteins, eventually leading to the discovery that the culprit wasn't a microbe at all, but a misfolded protein.

## Prion: The Misfolded Protein

Proteins are essentially amino acid chains, which are folded into precise shapes to function properly. Despite the lack of knowledge about its precise function, prion (*PRNP*) gene encodes normal prion protein which is active in the brain [10]. However, the amino acid chain somehow misfolds, and these deformed proteins, usually referred to as "prions" (derived from "proteinaceous infectious particles"), can damage nerve cells [11]. Even worse, they can convert the normal prion protein into more prions, enabling them to multiply exponentially within the body and transmit among individuals through ingestion of affected tissue or direct contact of body fluid. Some prion diseases, such as fatal familial insomnia, are heritable; mutations in *PRNP* gene which can induce the formation of the abnormal protein were identified in those cases [12].

Prion accumulation then destroys brain tissue, creating the sponge-like holes seen in scrapie, kuru, and CJD. Unlike most other pathogens, such as bacteria or viruses, prions have no DNA – so perhaps they are not "programmed" to infect the host, but rather a tragic mistake of nature, simply a mistake in the folding process. Yet, they cause incurable, fatal diseases across species.

## Conclusion

The history of prions is a testament to the power of scientific curiosity, perseverance, and collaboration. What began as a radical and controversial idea challenged a fundamental biological dogma and ultimately reshaped the understanding of multiple fields. As scientists continue to confront new mysteries in biology and medicine, this story serves as an inspiration: Truth is not always obvious, but with rigor, collaboration, and intellectual courage, even the most unconventional ideas can shed light on the darkest of nature's secrets.

究竟在羊類發現的「羊搔癢症」、與食人習俗有關的「庫魯病」，以及一種叫「克雅二氏症」的神經退化疾病之間有甚麼關係？雖然這些致命疾病出現在不同物種中，但它們卻有可怕的共通之處。更神秘的是，科學家無法確定病原體，致病元兇既不是病毒，也不是細菌。當時人類的認知無法破解這個神秘詛咒。讓我們探討這個謎團，了解如何找出這個難以捉摸的致命元兇。

## 羊搔癢症：受感染的羊不受控制地抓撓背部

故事開始於 18 世紀的英國，那時牧羊業是經濟的基礎。然而農民不久就面臨一個令人憂慮的問題：一些羊開始不受控制地借柱子抓撓背部，隨後停止進食，變得一瘸一拐，最終消瘦不堪並死亡 [1]。避免疾病傳播的唯一方法是將病羊隔離。由於缺乏進一步調查的能力，這種怪異的疾病很快已被遺忘 [1]。

到了 20 世紀中葉，科學家進行更深入的研究，嘗試找出病原體 [1]。首先，他們成功透過將病羊的腦或脊髓組織接種到健康羊隻身上，從而人工傳播疾病。由於潛伏期可以長達一至兩年，這一點曾讓科學家對實驗是否成功感到困惑。隨後，科學家嘗試透過使用當時多種能使病原體失去活性的標準方法處理樣本組織，例如使用除菌濾膜去除可能存在的細菌等，試圖識別病原體。在另外的實驗中，他們還以能破壞核酸（包括 DNA 和 RNA）的電離輻射劑量處理樣本組織，嘗試破壞當中可能含有的核酸。可是組織依然具傳染性，使他們意識到這次的病原體可能前所未見。腦部解剖獲得的唯一線索是神經元細胞質出現被形容為「肥皂泡」的空泡，以及大腦中的奇怪空洞，使大腦看起來呈海綿狀。

## 庫魯病：與食人習俗有關的神秘詛咒

在羊搔癢症重新成為科學家關注議題的同時，Daniel Gajdusek 和 Vincent Zigas 兩位醫生於 1957 年從巴布亞新幾內亞第一身報告了一種被認為與食人習俗相關的神秘疾病 [1, 2]。庫魯病首次發現於法雷部落，患者不僅會顫抖和喪失控制肌肉的能力，還會失控地大笑，並在幾個月內死亡。這種疾病主要影響女性，成年患者中女性與男性之比為 14:1。

在 1959 年，研究羊搔癢症的美國獸醫 William Hadlow 碰巧在倫敦的醫學博物館參觀一個關於庫魯病的展覽 [3]。他驚訝地意識到這兩種進行性退化疾病之間有著明顯的相似之處，例如神經元中的標誌性「肥皂泡」、長潛伏期，以及無法識別致病微生物等 [4]。

此後，Hadlow 向《刺針》（*The Lancet*）的編輯寫信，又主動聯絡 Gajdusek，希望喚起科學界關注這兩種疾病的高度相似性 [5]。隨後，神經病理學家 Igor Klatzo 從 Gajdusek 取得 12 個庫魯病患者的腦部樣本，在仔細檢視後，發現庫魯病與另一種人類海綿狀腦病 — 克雅二氏症亦有著相似之處 [6]。隨後十年，科學家成功透過接種受感染的人腦組織，將庫魯病和克雅二氏症在實驗中傳給黑猩猩和小鼠 [1]。

至於庫魯病，我們現在知道它是透過食人行為傳播的：女性會在喪葬儀式中進食親屬的遺體以「釋放死者的靈魂」[7, 8]，過程中攝取了含高濃度致病因子的人腦組織。

## 克雅二氏症：給科學家的啟示

那麼，致病因子究竟是甚麼？美國神經學家和生物化學家 Stanley Prusiner 回憶起他在其克雅二氏症病人中觀察到的反常現象：疫病並沒有引發免疫反應。患者沒有發燒，白血球數量沒有增加，也沒有觸發體液免疫反應，意味著引起疾病的可能不是外來的病原體 [9]。

Prusiner 憑藉自己的生物化學背景，決定以一個不同的方式著手。他嘗試從接種了羊搔癢症致病組織的小鼠中提取致病因子 [9]。在收集並攪勻小鼠的脾臟和腦部後，用離心機以不同時間和轉速處理所得的勻漿，把成分按密度分離。在測試每個樣本的傳染性後，他發現一個保留了具高度傳染性的樣本，當中超過 98% 的蛋白質和多核苷酸已被去除。有了這個更乾淨的樣本，科學家證明致病樣本的傳染性可以透過水解或修飾蛋白質減少，最終發現罪魁禍首根本不是微生物，而是錯誤折疊的蛋白質。

## 病原性蛋白顆粒：錯誤折疊的蛋白質

蛋白質本質上是氨基酸鏈，它們需要被折疊成正確的形狀才能運作。普里昂蛋白基因編碼著正常的普里昂蛋白，儘管我們對其功能尚未清楚了解，但已知普里昂蛋白活躍於大腦 [10]。然而，其氨基酸鏈在相關疾病中不知為何被錯誤折疊，產生的畸形蛋白稱為「病原性蛋白顆粒」，能損害神經細胞 [11]。更糟的是，它們能將正常的普里昂蛋白轉換為病原性蛋白顆粒，使它們在體內的數量呈指數級增長，並能透過攝取受影響組織或體液接觸在個體間傳播。也有些病原性蛋白顆粒疾病具遺傳性，例如致死性家族失眠症等；在這些病症中，已知一些普里昂蛋白基因上的突變能引發異常蛋白形成 [12]。

病原性蛋白顆粒的積聚能破壞腦部組織，產生出現於羊搔癢症、庫魯病和克雅二氏症的海綿狀空洞。與細菌或病毒等大多數病原體不同，病原性蛋白顆粒並沒有 DNA，所以或許它們感染宿主的背後並不受任何「指令」指使，而僅為折疊過程中的錯誤，導致這場悲劇。儘管如此，它們為多個物種帶來無法治癒的致命疾病。

## 結論

病原性蛋白顆粒的故事見證了科學好奇心、堅持不懈和合作的力量。最初一個具爭議的假設挑戰了生物學的基礎法則，儘管看似違反常理，但最終重塑了多個領域的認知。隨著科學家繼續面對生物學及醫學上的謎團，這個故事提醒我們：真相並非總是顯而易見，但透過嚴謹研究、相互合作和敢於挑戰常理的勇氣，即使是最非比尋常的想法，也能照亮自然中最黑暗的秘密。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# How Atomic Clocks Keep Almost Perfect Time

# 原子鐘如何精確計時？

By Sam Fan 樊潤璋

## Why Do We Need Perfect Time?

Every time you launch Pokémon Go or other games that require the Global Position System (GPS), your phone's GPS determines coordinates and shows your location. What if your avatar is teleporting across town or refusing to register the two kilometers you've walked to hatch an egg – frustrating, right? That's exactly what happens when GPS timing drifts even for a small error.

Radio signals travel at the speed of light, which is approximately $3 \times 10^8$ m/s. To determine the distance between you and a GPS satellite, the travel time of the radio signal emitted by the satellite to you is needed. By the simple velocity formula, we know that an uncertainty of just one nanosecond ($10^{-9}$ seconds) in a clock corresponds to about 30 cm of range error [1], so a timing drift can misplace your avatar enough to miss a rare resource in game. Without atomic-level precision, our smartphones' "blue dot" on the map could drift wildly from reality.

## Nature of Time

Let's start with a fundamental question: What is time? Philosophers have long debated whether time "flows" like a river – an ever-moving present that carries us from past to future – or whether all moments exist equally, with past, present, and future represented as slices in a four-dimensional space, and many other competing perspectives [2]. While no one knows what exactly time is, one pragmatic point of view is that we can define the length of time by counting some repeatable, periodic processes.

The most common periodic processes are sunrise and sunset, caused by Earth's rotation. We can also use gravity-driven swinging pendulums, which provide a near-constant oscillation period and form the basis of early mechanical clocks. Albeit less notably, even your body counts: You wake up refreshed and feel sleepy at night, which marks one full day (assuming your circadian rhythm stays on track). However, given that the Earth does not rotate at a perfectly uniform speed, and that the duration of one swing is slightly different from pendulum to pendulum due to manufacturing error [3], a new definition of time is needed. In 1927, a Canadian engineer, Warren Marrison, found that quartz crystals vibrate at a remarkably consistent frequency under an electric field [3]. When carefully cut into a proper shape and size, a standard quartz crystal in a clock vibrates at 32,768 Hz [3, 4]. By counting the duration for which 32,768 oscillations take, we can define that one second has passed.

## Core of Cesium-Beam Atomic Clock

However, from 10 seconds per year for a mechanical clock to only one second in three years for a quartz clock [3], there was still room for improvement for the timekeeping accuracy. As a result, scientists developed more advanced timekeeping technologies. Cesium-beam clocks are just one member of the atomic clock family: Others include rubidium-beam standards, hydrogen masers, compact chip-scale clocks, and the newest optical lattice clocks. Cesium-beam designs remain the most widely used standard worldwide. In fact, the Hong Kong Observatory has been relying on cesium-beam atomic clocks to provide official time service since 1980, with an accuracy kept within 0.01 microsecond ($10^{-8}$ seconds) per day [5].

At its core, the clock does not "tick" atoms but counts the cycles of a microwave signal precisely locked to an atomic reference. The cesium atoms act as a built-in tuning fork; cesium only resonate to the frequency at 9,192,631,770 Hz within the microwave band to change between two very slightly different energy states. This happens when cesium atoms pass through a microwave cavity [6]. If the microwave frequency is above or below 9,192,631,770 Hz, fewer atoms undergo a change in energy levels. The irregularity can be detected, and the oscillator will be steered back onto the exact cesium resonance frequency, ensuring the microwave oscillator stays locked to atomic standard. Once the oscillator is held exactly at the resonance frequency, every single cycle becomes one "tick" of the clock. By simply tallying 9,192,631,770 of these ticks, the device measures one second [6, 7].

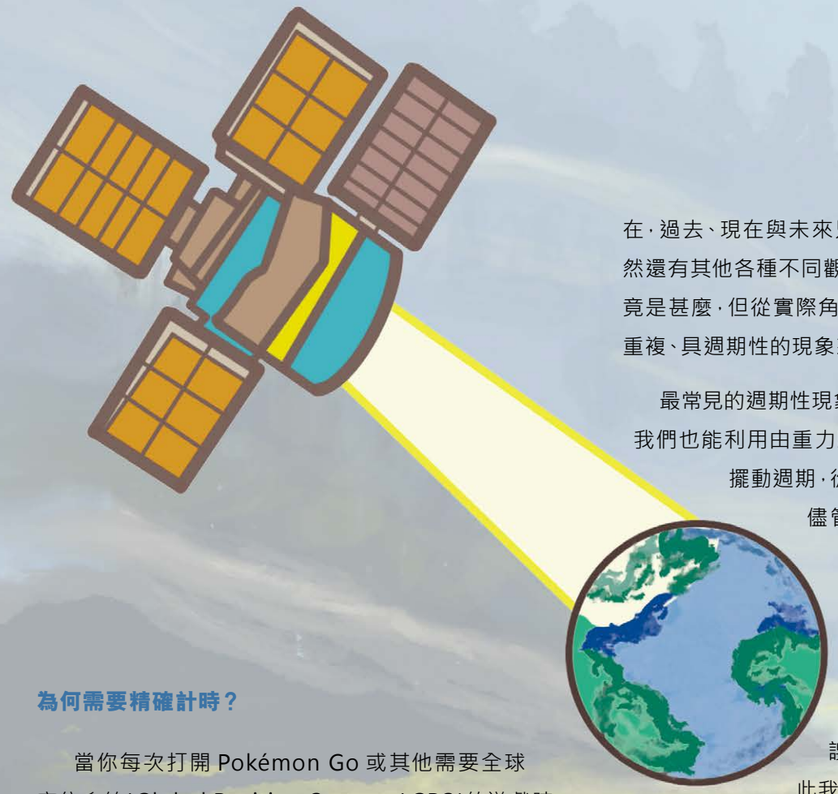
Since this shift in energy levels is a fundamental property of cesium atoms, every clock built anywhere with cesium atoms can reproduce the same resonance frequency of 9,192,631,770 Hz signal, ensuring that time is uniform around the world.

## Importance of Time Synchronization

Every GPS satellite carries multiple atomic clocks and broadcasts signals with an accurate timestamp of when the signal is emitted, so that receivers on the ground can determine their distance to the satellite by multiplying the signal's travel time and the speed of light [8]. Without the cesium or rubidium standards, minute timing drifts would quickly lead to substantial positional errors in just a few minutes due to the cumulative time error of the onboard clock.

## Summary

In just a few decades, we've gone from pendulums and quartz crystals to atomic clocks and optical lattices that keep time to within a quintillionth of a second ($10^{-18}$ seconds), so precise that they can sense minuscule shifts in Earth's gravity or hunt for hints of dark matter in the cosmos [9]. Although the principles behind atomic precision may seem complicated, the technologies they enable are integral to our daily lives. Every time we check our phones, play a game, look up our location, or simply glance at the clock, we tap into nature's steady rhythms.



## 為何需要精確計時？

當你每次打開 Pokémon Go 或其他需要全球定位系統(Global Position System / GPS)的遊戲時，你手機的 GPS 都會確定你所在的座標並顯示你的位置。假如你的角色突然在地圖上「瞬間移動」，或是遊戲不承認你已走完孵蛋所需的兩公里路程時，無力感隨即會在剎那間湧現，GPS 時間出現些微誤差都會導致這些問題發生。

無線電訊號以光速傳播，大約是每秒 $3 \times 10^8$ 米。要得知你與 GPS 衛星之間的距離，系統需要知道衛星發出的無線電訊號到達你所在位置的所需時間。依照最簡單的速度公式，我們知道時鐘只要出現一納秒（$10^{-9}$ 秒）誤差，就會導致大約 30 厘米的範圍誤差 [1]。因此，即使是極小的時間偏差，也可能讓你的角色錯過遊戲中的稀有資源。沒有原子等級的精準度，手機地圖上的「藍點」就可能大幅偏離現實位置。

## 時間的本質

我們可以從一個基本問題作為起點：甚麼是時間？長久以來，哲學家爭論時間是否像河流般「流動」：是不斷前進的現在將我們由過往帶到未來；抑或所有時刻平等地存在，過去、現在與未來只是四維空間中的一幀幀片段。當然還有其他各種不同觀點 [2]。雖然沒有人能確定時間究竟是甚麼，但從實際角度來說，我們可以透過數算一些可重複、具週期性的現象來定義時間的長度。

最常見的週期性現象是因地球自轉而產生的日出日落。我們也能利用由重力驅動的鐘擺，它能提供幾乎恆定的擺動週期，從而成為早期機械鐘的基礎。另外，儘管你可能不自覺，但甚至你的身體也在「計時」：你在早上精神飽滿，晚上感到困倦，以此完成一天的循環（假設你的生理時鐘沒有偏差）。不過地球的自轉速度並不完全恆定，不同鐘擺也會因製造誤差導致擺動週期略有不同 [3]，因此我們需要一個全新的時間定義。1927 年，加拿大工程師 Warren Marrison 發現石英晶體在電場下會以極穩定的頻率振動 [3]。當被切割成適當形狀與大小時，時鐘裡的標準石英晶體會以 32,768 赫茲的頻率振動 [3, 4]。只要計算 32,768 次振動所需的時間，我們就可以定義一秒。

## 銫原子鐘的結構

然而，從機械鐘每年可能出現 10 秒誤差，到石英鐘三年只會出現一秒誤差 [3]，精準度依然有進步空間，於是科學家發展出更先進的計時技術。銫原子鐘是原子鐘家族的一員，其他還包括銣原子鐘、氫原子鐘、晶片級原子鐘，以及最新的光晶格鐘。銫原子鐘仍是全球最常用的設計，而事實上，香港天文台自 1980 年起就以銫原子鐘提供授時服務，精準度可維持在每天 0.01 微秒（$10^{-8}$ 秒）以內 [5]。

銫原子鐘的內部並非藉原子「滴答滴答」擺動計時，而是精確地數算鎖定於銫原子基準的微波訊號週期。銫原子就像內建的音叉，只對 9,192,631,770 赫茲的微波頻率產生共振，而在兩個能量狀態之間轉換。這個過程發生於銫原子通過微波空腔時 [6]，如果空腔中的微波頻率偏離這個值，會令較少銫原子轉換能量狀態。我們可以在偵測到偏離的情況下校正微波共振器，以確保共振器始終鎖定在銫的共振頻率上。只要共振器固定在這個頻率，它發出的每個微波訊號週期就成為一次「滴答」。當數到第 9,192,631,770 次時，原子鐘就會記錄一秒過去 [6, 7]。

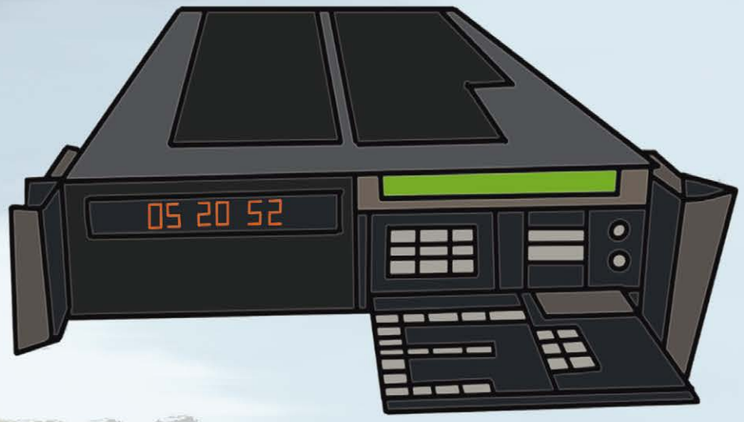
由於這種能量狀態的轉換是銫原子的基本性質，所以無論銫原子鐘在哪裡製造，都能有著相同的 9,192,631,770 赫茲共振頻率，因而確保計時標準全球通用。

## 時間同步的重要性

每顆 GPS 衛星都搭載多台原子鐘，並廣播帶有精準時間戳記的訊號，讓地面接收器能透過「訊號傳播時間 × 光速」計算出其與衛星的距離 [8]。如果沒有銫或銣的時間標準，衛星時鐘在幾分鐘內累積的微小時間誤差，就已經能導致巨大的定位偏差。

## 總結

短短幾十年間，我們已經從鐘擺與石英晶體，發展到原子鐘，以及能將誤差控制在百京分之一秒（$10^{-18}$ 秒）的光晶格鐘，精準到足以感應地球引力的微小變化，甚至用來搜尋宇宙中的暗物質 [9]。雖然原子鐘背後的原理看似複雜，但當中所使用的技術卻已融入日常生活。每當我們查看手機、玩遊戲、定位，或只是看時鐘時，其實我們都在借助大自然的律動。





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# The Magic of EULER'S NUMBER e

# 歐拉數e的魔力

By Jane Yang 楊靜悠

## What Is Euler's Number?

Have you ever come across a number that seems to connect math, science, and the world around us? One of the most fascinating is Euler's number, written as *e*, a special constant approximately equal to 2.718, central to countless natural and scientific phenomena. It's the foundation of the natural logarithm, a tool that helps us understand how things grow or shrink over time. From bacteria multiplying in a lab to stars fading in the sky, *e* appears in countless natural processes [1]. Surprisingly, this number was first uncovered not in a science lab but in a puzzle about money. Let's explore how *e* came to be and why it's so extraordinary.

## A Mathematical Gem Discovered in Finance

The story of *e* begins in the 1600s with Jacob Bernoulli, a mathematician curious about how small changes add up [2, 3]. Imagine you have $1.00, and you're offered an unrealistic 100% annual growth rate. If this growth is added once at the year's end, your $1.00 doubles to $2.00. But what if the growth is calculated more often?

Suppose it's added twice a year. Every six months, you gain 50%, so your $1.00 grows to $1.00 × 1.5 × 1.5 = $2.25 by year's end. If it's calculated four times a year, each period adds 25%, turning your $1.00 into $1.00 × 1.25 × 1.25 × 1.25 × 1.25 = $2.44. Monthly calculations yield $1.00 × (1 + 1/12)^12, about $2.61. The pattern is clear: More frequent additions mean a larger result.

Here's the exciting part. What if the growth is calculated every day, every minute, or even every second? The formula becomes $1.00 × (1 + 1/*n*)^*n*, where *n* is the number of times the growth is added. As *n* grows larger — approaching infinitely frequent additions — the result doesn't climb endlessly but settles around 2.718281828459045... . This number is *e*! Bernoulli discovered this constant, revealing a mathematical gem that would resonate far beyond his original question.

## The Power of *e* in Our World

Why is *e* so important? Named after Leonhard Euler, who further explored its properties in the 1700s, this number became a universal key to understanding exponential change, appearing in fields like biology, physics, medicine, and engineering. Its unique properties make it ideal for describing processes that speed up or slow down, like a snowball growing larger or a whisper fading away. It also simplifies complex problems, making it a go-to tool for scientists and engineers.

In biology, *e* models population growth. Picture a colony of bacteria doubling every hour. The smooth, accelerating curve of their growth uses *e* to predict how many bacteria there will be after a day or a week [4]. In ecology, *e* helps track how animal populations expand or how resources, like fish stocks, shrink when overharvested. For example, conservationists use *e* to estimate how quickly a threatened species might recover if protected [4]. In physics and chemistry, *e* describes decay, such as how radioactive elements like uranium lose energy over time. Scientists rely on *e* to calculate a substance's half-life, the time it takes for half of it to break down, which is crucial for safe handling in medical treatments or power plants.

In daily life, *e* shines in engineering and technology that makes our life easier. It models how a capacitor stores charge in a circuit, essential for designing devices like your phone or computer. In medicine, *e* helps track how drugs are absorbed or cleared from the body, helping doctors determine safe dosages. In technology, *e* underpins algorithms for signal processing, ensuring clear audio in your earbuds or smooth video streaming.

## Enormous Impact of the Seemingly Small Number

What makes *e* truly special is that it connects these diverse phenomena. Its value, about 2.718, may seem small, but its impact is enormous. Next time you hear about a virus spreading, a species recovering, or a cup of tea cooling, think of *e* — a quiet number with a massive role in unlocking the secrets of our world.

## A Practical Archeological Question: Carbon-14 Dating

Carbon-14 dating is a method used to determine the age of organic archeological specimens from the age of 500 to 50,000 years [5]. Carbon-14 is an unstable radioisotope, which undergoes decay into nitrogen-14. Living plants incorporate naturally occurring atmospheric carbon-14 into their tissues through carbon fixation, and pass it on to animals through the food chain. The ratio of carbon-14 in living tissues is relatively stable because living organisms constantly take in air and food despite the constant decay of carbon-14, but once the organism dies, there will be a net reduction in carbon-14 content.

The decay process can be expressed by the exponential decay function: $N = N_0 e^{-kt}$, where $N$ is the number of undecayed nuclei, $N_0$ is the initial number of undecayed nuclei, $k$ is the decay constant, and $t$ is the time lapsed [6, 7]. The half-life $t_{1/2}$ of carbon-14, or the time needed for half of the radioisotope to decay, is roughly 5,730 years. If we have a piece of ancient wood whose carbon-14 content has four tenths of that in living trees, find:

1) the decay constant $k$ (to four decimal places).
2) the age of that piece of wood (to the nearest year).

**Solution:**

## 甚麼是歐拉數？

你是否遇過能連結數學、科學與我們周遭世界的數字？歐拉數是其中非常有趣的一個，經常被寫作 *e*。這是一個特殊的常數，約等於 2.718，亦是無數自然與科學現象的核心。作為自然對數的基礎，它能幫助我們理解事物隨時間增長或衰減的過程。從實驗室繁殖的細菌到天空逐漸黯淡的星星，*e* 出現在無數自然現象中 [1]。令人驚訝的是，這個數字最初並非在科學實驗室中被發現，而是源自一個關於金融的謎題。讓我們一起探索 *e* 如何變得不平凡。

## 發現於金融的數學瑰寶

*e* 的故事始於 17 世紀，當時數學家 Jacob Bernoulli 對微小變化的累積方式感到興趣 [2, 3]。假設你有 1.00 元，並獲得一個不切實際的 100% 年增長率。如果這筆增長在年底一次性計算，你的 1.00 元會翻倍成 2.00 元。但如果增長結算得更頻繁呢？

假設每年計算兩次，每六個月增長 50%，那麼你的 1.00 元在年底會變成 1.00 × 1.5 × 1.5 = 2.25 元。如果每年計算四次，每次增長 25%，你的 1.00 元會變成 1.00 × 1.25 × 1.25 × 1.25 × 1.25 = 2.44 元。每月計算則為 1.00 × (1 + 1/12)^12，約為 2.61 元。規律很明顯：計算越頻繁，結果越大。

然後最興奮的部分來了。如果增長每天、每分鐘，甚至每秒計算一次呢？公式將變為 1.00 × (1 + 1/*n*)^*n*，其中 *n* 是計算增長的次數。當 *n* 趨近無限大時，結果並不會無限增長，而是趨近於 2.718281828459045...。這個數字就是 *e*！Bernoulli 發現了這個常數，揭示了這個意義遠超過他最初問題的數學瑰寶。

## *e* 在我們世界中的力量

為甚麼 *e* 如此重要？這個數字以在 18 世紀深入研究其性質的 Leonhard Euler 命名，及後成為了理解出現在生物學、物理學、醫學和工程學等領域中指數變化的鑰匙。其獨特性質使它成為一個理想工具去描述正在加快或減慢的過程，例如越滾越大的雪球或逐漸消逝的耳語。它還能簡化複雜問題，成為科學家和工程師的首選工具。

在生物學中，*e* 用於為種群增長建立模型。想像一個每小時數量翻倍的細菌群落，其平滑且越發陡峭的增長曲線以 *e* 來預測一天或一週後的細菌數量 [4]。在生態學中，*e* 協助追蹤動物種群的擴張或資源（如魚類）在過度開發下的衰減。保育人士用 *e* 估算瀕危物種在受保護情況下的恢復進度 [4]。在物理學和化學中，*e* 描述衰變過程，例如鈾等放射性元素如何隨時間流失能量。科學家依賴 *e* 計算物質的半衰期，即一半物質分解的所需時間，這對於醫院及核電廠安全處理放射性物質至關重要。

在日常生活中，*e* 在工程和科技上大放異彩，使我們生活變得便利。它為電路中電容器如何儲存電荷提供量化描述，是設計手機和電腦等設備的關鍵。在醫學中，*e* 幫助追蹤藥物在人體中吸收或清除的速度，協助醫生判斷安全劑量。在技術領域，*e* 是訊號處理算法的基礎，確保耳機能播放清晰的音頻和網站能播放流暢的串流短片。

## 看似微小數字的巨大影響

*e* 的特別之處在於它連結了上述各式各樣的現象。它約為 2.718 的值看似微小，但影響力巨大。下次當你聽到病毒散播、物種保育或簡單如一杯茶冷卻時，想想 *e* —這個默默無聞卻在解開世界奧秘中扮演重要角色的數字。

## 現實的考古問題：碳-14 定年法

碳-14 定年法是考古學上用於測定有機樣本年齡的方法，測定範圍從 500 年到 50,000 年 [5]。碳-14 是不穩定的放射性同位素，會衰變成氮-14。活植物透過固碳作用將大氣中的碳-14 納入其組織，經食物鏈傳遞至動物。活體組織中的碳-14 比例相對穩定，因為生物不斷攝入空氣和食物，抵消了碳-14 的持續衰減；但生物一旦死亡，碳-14 含量就會出現淨減少。

衰變過程可以用指數衰減函數表示：$N = N_0e^{-kt}$，其中 $N$ 是未衰減核的數量，$N_0$ 是初始未衰減核的數量，$k$ 是衰變常數，$t$ 是經過的時間 [6, 7]。碳-14 的半衰期 $t_{1/2}$，即放射性同位素衰減一半所需的時間，約為 5,730 年。如果我們有一塊古代木材，其碳-14 含量是活樹的四成，試計算：

1) 衰變常數 $k$（準確至四位小數）。

2) 木材的年齡（準確至最接近的年）。

**答案：**


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# Q&A with HKUST Life Science Majors
# 讀生命科學的人：與科大學子對談

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*Photo credit: Heather Ainsworth / AP Images for HHMI*

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**What is your plan at this stage of your career? How different would your career path be if you did not study life science?**
**在職業生涯這個階段你的計劃是甚麼？如果沒有修讀生命科學，你的職業路徑會怎樣不同？**

### Coby

I already had a passion for teaching since my time in primary school, but what truly sparked me is a course here in HKUST. It was about promoting science in the community. I really liked that course because I think nurturing youngsters is especially important. In the coming year, I will study for a postgraduate diploma in education and hopefully become a biology teacher soon. I believe that teaching allows me to have a more immediate and meaningful impact by nurturing and inspiring young minds.

我從小學時期就已經對教育充滿熱情，但真正啟發我的是科大這裡一門關於在社區推廣科學的課程。我非常喜歡這門課，因為我認為培育年輕人特別重要。在接下來一年，我會攻讀學位教師教育文憑課程，並希望在不久將來成為生物老師。我相信教學能讓我透過培育和啟發年輕人，對社會作出直接而有意義的影響。

### Charles

Looking back, I feel like I never had to choose the program. Yet I remember when I declare my major at the end of the first year, I was debating between mathematics and economics, and biology. The former would make money; people around me thought it was popular and hot. Biology, on the other hand, was more my true interest. You know, in Hong Kong, there's a very strong business culture. Under that environment, it makes sense for someone to wonder whether you should pursue a career path that feeds into that big field. But at the time, I was lucky to have good mentors, like Professors King Chow and Tom Cheung. They encouraged me to pursue research, so I ended up in the first cohort of the international research enrichment track. Then everything just fell into place – I went for PhD, did a postdoc, and hopefully, one day I'll be a professor somewhere.

回顧過去，我覺得自己從不需要為選擇課程而煩惱。然而，記得在第一年末選擇主修時，我曾在數學與經濟學課程和生物學之間掙扎：前者會賺錢，身邊的人認為它是熱門之選；另一方面，生物學更符合我的真實興趣。你也知道香港是個商業社會，在這種環境下，考慮是否應該順應潮流投身到主流職業路徑當中也非常合理。當時我有幸遇到一些好導師，譬如周敬流教授和張曉東教授，他們鼓勵我追求科學研究，因此我成為了國際科研課程的第一屆畢業生。然後一切都非常順利 — 我攻讀了博士學位，完成博士後研究，希望有一天能成為教授。

### Nathan

My major at HKUST was biology. After graduation, I enrolled into another undergraduate program, which is a medical degree at CUHK. I'm now working in the hospital authority as a resident doctor. My specialty is oncology. Back then my first choice was not biology, but the Bachelor of Arts program offered by HKU because I wanted to study Chinese. I cannot imagine what I would be doing now if I enrolled in that program.

我在科大的主修是生物學，畢業後報讀了另一個本科課程，那是中大的醫學學位。我現在於醫院管理局擔任駐院醫生，專業是腫瘤學。其實我最初的第一選擇並不是生物學，而是港大的文學士課程，因為我想讀中文系。我無法想像如果我當時入讀了那個課程，現在會踏上一條怎樣的道路。

## Brian

During my undergraduate studies, I explored neuroscience; in my master's program, I delved into developmental biology; and in my PhD, I shifted my focus to mechanobiology. After graduation, I was fortunate to join the Department of Health to assist in the fight against COVID-19. Now, I am back on campus pursuing medical studies, while actively participating in psychiatric research. My dream is to become a clinician-scientist one day, bringing clinical questions into the research laboratory. At this moment, my solid foundation in biology from HKUST life science program provided me with a strong base to realize this dream. If I had not studied biology, I believe I would have chosen philosophy. A life dedicated to exploring questions and seeking answers is truly wonderful and inspiring.

在本科時我探索了神經科學，在碩士時研究了發育生物學，而在博士階段，我將研究方向轉為力生物學（mechanobiology）。畢業後，我有幸加入衛生署協助對抗新冠肺炎。現在我回到校園，一邊修讀醫科課程，一邊參與精神病學研究，夢想一天能成為臨床科學家，將臨床問題帶到實驗室進行研究。科大的生命科學課程為我追尋夢想提供了紮實基礎。如果沒有修讀生物學，我想我會選擇哲學吧。一直發掘問題然後追尋答案的人生也很棒，而且令人振奮。

**How has your perspective on life science evolved during your time at HKUST and beyond?**

**在科大讀書和畢業後，你對生命科學的看法有著怎樣的改變？**

## Nathan

I wanted to study medicine and Chinese. My public exam results certainly wouldn't allow me to study medicine, so my first choice was the Bachelor of Arts program. I didn't end up in that program but the biology program at HKUST. I studied quite well in the first one or two years, so I thought maybe I could try to apply for the medicine program. Therefore, I looked into the non-JUPAS path for a medical degree. In HKUST, I had a chance to study the cancer biology course taught by Dr. Eugene Hung, which eventually led me to work as an oncologist.

One reason for choosing oncology is that there is a constant advancement in treatment, so it is a very exciting field to be in. On the other hand, it is a very humane field; you have to be sympathetic because after all, you are seeing patients and their family, helping them face the disease but not just using new technology or giving them drugs.

我最初想修讀醫科或中文，但我的公開考試成績顯然不允許我讀醫，因此我的第一選擇是文學士課程。我最後在未能入讀該課程的情況下，進入了科大修讀生物學。我頭一兩年的成績不俗，因此我想或許可以嘗試申請醫科課程。於是，我尋求以非聯招方式取得醫學學位的途徑。在科大，我有幸修讀了由洪少俊博士主講的癌症生物學課，最終使我踏上成為腫瘤科醫生之路。

選擇腫瘤科的其中一個原因是癌症治療方法不斷出現突破，因此這是一個好消息相對豐富的界別。另一方面，它是一個非常以人為本的專科：你必須具有同理心，因為你的工作就是會見病人和家屬，與他們站在同一陣線對抗頑疾，因此並非純粹施用一下新技術或單純給他們藥物。

## Brian

During my time in secondary school, I was only interested in "microscopic" cell biology. Only after entering HKUST did I realize ecology is also fascinating. The concepts I learned about competition theory in ecology left a deep impression on me, and I also discovered that many conflicts among humans seem to reflect similar principles. Additionally, the time when I entered HKUST coincided with the dawn of the gene-editing era. Being able to immerse myself in such a vibrant and groundbreaking scientific world has truly been a wonderful experience.

中學時我只對微觀的細胞生物學感興趣，進入科大後才發現生態學也很吸引。當年讀到生態學的競爭學說，相關概念到今天依然印象深刻，我亦發現人類世界的大小紛爭也幾乎能以當中原理解釋。此外，在我入讀科大時恰逢基因編輯時代的開始，能浸沉於生機勃勃而且充滿突破的科學世界實在是一段美好經歷。

**Do you have any advice for high school students thinking of studying life science?**

**你有甚麼建議給予考慮修讀生命科學的高中生？**

## Coby

The only way to find out whether you like something is to get your feet wet. HKUST is quite nice in this respect because, for example, they offer summer programs to high school students. As a teenager, I would have loved to hear professors talking and have a taste of what classes would be like if I studied life science. HKUST iGEM team also organizes workshops for high school students. If you are interested, please follow our social media for more information!

了解自己是否喜歡某事物的唯一方法是親身體驗。科大在這方面相當不錯，例如他們會為高中生開辦夏季課程。如果我是青少年，我會想聽聽教授講課，了解一下如果我讀生命科學的話日常上課會是怎樣的。科大 iGEM 團隊也為高中生舉辦工作坊。如果你有興趣，請追蹤我們的社交媒體以獲取更多資訊！

## Charles

When I was graduating from high school or studying at HKUST, I asked for wise words from senior people, but didn't really listen to them. So, I don't know if young people will listen to me either, but I want to encourage students to follow what they like. If you love engineering, go for it. Maybe other people don't see the joy in biology, but if you see it go for biology. Growing up or around college years, there are a lot of voices around you, from your parents, from people around, from the news, from the media, and all have different opinions. However, you have to carve out your own path. After all, it is your own life that you live, right? No one else lives your life.

There are just too many things to worry about. You worry about your grades, about whether you can get a job, about what's the next step in your life. When you have so many things to worry about, it's really hard to enjoy and do what you like. There's a motto I heard somewhere like secondhand wisdom: If there's something you won't worry about in three years, then don't worry about it for more than three seconds. You might dread about your exam today, but in three years, it wouldn't matter, right? So don't worry about it. In the grand scheme of things, small worries don't matter. So just enjoy, have fun, and relax.

從高中畢業或在科大讀書時，我也試過從前輩那裡獲取一些建議，但並沒有真正聽進去。因此，我也不確定年輕人會否聽我的建議，但我想鼓勵同學追隨自己喜愛的方向。如果你熱愛工程，那就去吧。也許其他人看不到生物學的樂趣，但如果你找到了，那就去讀生物。在成長路上或上大學前後，周圍會有很多聲音，它們來自你父母、周圍的人、新聞、媒體，它們都有不同意見。然而，你必須開拓自己的道路，畢竟這是你的人生，對吧？沒有人能代替你過生活。

世上有太多事情需要擔心：你擔心成績，擔心是否找到工作，擔心人生的下一步。當要擔心的事情太多，你真的很難去享受並做你喜歡的事情。我聽過一句頗有智慧的說話：如果一件事在未來三年都不需要你操心，那不要花超過三秒鐘去擔心它。你今天可能為一場考試而憂慮，但以未來三年計，那場考試可能無礙大局，對嗎？所以不要擔心，在大格局下沒有必要為小事情擔憂，因此儘管放鬆享受人生，努力為其添上樂趣。

## Nathan

Be open-minded. What I meant by "open-minded" is that if you are committed to something, you have to finish it. If you are unlucky like me that you fell into your second or third or fourth choice, those are still your choices. You put them into your second, third, or fourth choice, not without a reason, not only for a safety net. You still have to be determined, and during the period of study, again, revisit your reason about why you wanted to study this, and why you wanted your first choice. Then you can think about: Do I have a chance to get my path back to my first choice? If the answer is no, then see things differently and take a different path. Biology was not my first choice [but medicine and Chinese], but I treasure my undergraduate experience as it certainly helped my career and my life. Even if things don't go as planned, you can still find your true calling serendipitously.

要保持開放的心態。我所說的「開放心態」是指如果你承諾做某件事情，那就必須完成它。如果你像我一樣不幸，落入了你的第二、第三或第四選擇，那些仍是你的選擇，你親手將它們放進你的第二、第三或第四選擇，不是沒有原因的，因此它們不僅僅是你的「水泡」。你必須保持堅定，在入學之後，再次回想為甚麼你選擇修讀這一科，以及為甚麼你想進入你的第一選擇。然後你可以思考：我是否有機會回到我的第一選擇？如果答案是否定的，那就換個角度看待事物，接納這條不同的道路。修讀生物並不是我的第一選擇〔而是醫學和中文〕，但我仍珍惜我的本科經歷，因為那無疑在現時職業和生活上幫助了我。即使事情不如預期發展，你仍可以不期而遇地找到適合自己的道路。

## Nathan

Most people think that knowing biology is kind of knowing everything. Usually, my friends would ask me random facts about a beautiful flower, or the meaning of their strange dreams, even after I entered medical school. They asked me the name of a tree because I had studied biology as my first degree. I would reply, "No, no, no. I don't know all the trees and flowers." This is a tricky misconception – all of us are thought to be good at taxonomy or biodiversity – but I don't think memorization matters that much in biology. It is more analytical.

很多人認為懂得生物學就多多少少等於懂得一切。通常朋友會問我他們看見的花朵，或是他們奇怪的夢，在我進入醫學院後也是如此。他們問我樹的名稱，只因我最初在大學是讀生物的。我一律回答：「不，我並不知道所有樹和花的名稱。」這是一個棘手的誤解，外人總覺得我們所有人都擅長分類學和生態學，但我並不認為背誦是生物學中重要的一環，反而更多是分析事情。

## What are some stereotypes surrounding life science that you would like to dispel?

## 想為一些關於生命科學系的刻板印象澄清嗎？

## Coby

There's one major stereotype from my family, relatives, and friends. They were probably influenced by movies in which scientists mistakenly released a deadly virus and that sort of things, so they always think that I do dangerous experiments in full protective gear, but it's not the case. Still, when I tell my friends I'm handling *Escherichia coli*, they tend to think about gut and stomach infection. Actually, there are different strains of *E. coli*, and the strain we handle is harmless. Some strains may even be probiotics and are good for you. Anyway, that kind of dangerous experiments on the screen probably exists, but they are carried out under strict regulations.

我家人、親戚和朋友都對我的主修有嚴重誤解。他們大概受到電影中科學家意外釋出致命病毒等情節影響，總覺得我會在穿著全套防護裝備下進行亡命實驗，但事實並非如此。然而，當我告訴朋友我在處理大腸桿菌時，他們往往會聯想到腸胃感染。其實大腸桿菌也有不同菌株，而我們處理的菌株是無害的。有些菌株甚至是益生菌，對人體有益。無論如何，螢幕上那種危險實驗也許存在，但它們都在嚴格規管下進行。

## Charles

A common one is that many people think biology or life science is all about memorization. I have many friends in mathematics, business or engineering who hate biology because they don't want to memorize all the "random" facts. But once you get into biology or life sciences, you start realizing things make sense, and the only difficulty is to go through the initial "activation energy" to get familiar with the terminology.

一個常見的刻板印象是許多人認為生物學或生命科學是死記硬背的科目。我有許多讀數學、商科或工程的朋友討厭學習生物，因為他們不想背誦那些看似毫無關聯的事實。然而你一踏入生物學或生命科學的世界，就會意識到一切皆有理可循。唯一的挑戰只在於記住術語，衝破了「反應」初期的「能量障礙」就好。

## Brian

Many people might have the stereotypical idea that studying life sciences means you can only pursue related careers. Looking back at my journey, I feel fortunate to have met classmates who have taken very diverse paths: some continue in research, academia, or biomedical engineering, while others have advanced into medical fields. There are also classmates who have gone into finance, consulting firms, or even switched careers to become barristers and pilot. I believe that the greatest benefit of studying science is the development of logical thinking and problem-solving skills. Those who can effectively apply these abilities can shine and make a difference in any profession they choose.

不知道大家會否有「讀生命科學就只能從事相關工作」的既定概念，回看從前有幸遇見最終進入各行各業的同學。他們有些繼續從事研究，留在學術界或生物醫學工程相關範疇，也有些透過進修加入醫療行業。此外亦有同學進入金融或顧問公司，甚至轉行成為大律師和飛機師。個人認為學習科學最大的得著是培養邏輯思維與解難能力，能好好運用這些能力的人，在任何崗位也能發光發熱。

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