
The Shaw Prize
邵逸夫獎
2022

2022 年度「邵逸夫獎」
The Shaw Prize 2022

「邵逸夫獎」為國際性獎項，得獎者應仍從事於有關的學術領域，在學術研究、科學研究及應用上有傑出貢獻，或在近期獲得突破性的成果，或在其他領域有卓越之成就。評選的原則主要考慮候選人之專業貢獻能推動社會進步，提高人類生活質素，豐富人類精神文明。

「邵逸夫獎」設有三個獎項，分別為天文學獎、生命科學與醫學獎和數學科學獎，每項獎金一百二十萬美元。除獎金外，各得獎者還獲頒獎章及證書一份。提名及評審程序於每年九月開始，翌年夏季宣布得獎人名單，並於同年秋季舉行頒獎典禮。

「邵逸夫獎」是按邵逸夫先生的意願而設，於 2002 年 11 月宣告成立，以表彰在學術及科學研究或應用上獲得突破成果，和該成果對人類生活產生意義深遠影響的科學家，原則是不論得獎者的種族、國籍、性別和宗教信仰。

「邵逸夫獎」由邵逸夫獎基金會管理及執行。各獎項的評審委員會由國際知名科學家組成，負責評審工作。

The Shaw Prize is an international award to honour individuals who are currently active in their respective fields and who have recently achieved distinguished and significant advances, who have made outstanding contributions in academic and scientific research or applications, or who in other domains have achieved excellence. The award is dedicated to furthering societal progress, enhancing quality of life, and enriching humanity s spiritual civilisation.

The Shaw Prize consists o three annual awards: the Prize in Astronomy, the Prize in Life Science and Medicine, and the Prize in Mathematical Sciences. Each prize carries a monetary award of one million two hundred housand US dollars and each winner receives a medal and a certificate. The nomination process begins in September. The winners are announced in the following summer and the prizes are presented in autumn.

Established under the auspices of Mr Run Run Shaw in November 2002, the Prize honours individuals, regardless of race, nationality, gender and religious belief, who have achieved significant breakthroughs in academic and scientific research or applications and whose works have resulted in a positive and profound impact on mankind.

The Shaw Prize is managed and administered by The Shaw Prize Foundation based in Hong Kong. The important role of adjudication of candidates for the prizes is undertaken by an international team of reputable scientists who serve on the Selection Committees.

邵逸夫獎獎章
The Shaw Prize Medal

獎章的正面顯示獎項創立人邵逸夫先生的肖像。背面則刻上獎項類別、獲獎年份和得獎者姓名，並在右上角刻上中國戰國時代思想家荀子 公元前313至公元前238 的一句說話:「制天命而用之」意思是"掌握自然規律，並加以利用」。

The front of the medal displays a portrait of Mr Run Run Shaw, the founder of this award. On the reverse, the medal shows the award category and year, the name of the laureate, and in the upper right corner, an imprint of a saying due to Xun Zi 313–238 BCE , a thinker in the Warring States period of Chinese history, meaning "Grasp the law of nature and make use of it

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THE SHAW PRIZE 邵逸夫獎

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香港科學館 Hong Kong Science Museum

香港太空館 Hong Kong Space Museum

教育局 Education Bureau

香港教育城 HKEdCity

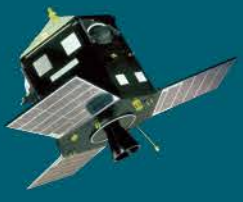
協辦 In association with

澳門科學館 Macao Science Center

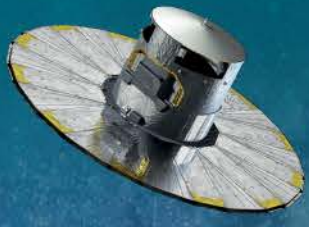
2022 邵逸夫天文學獎
The Shaw Prize in Astronomy 2022

2022 年度邵逸夫天文學獎平均頒予瑞典隆德大學天文學及理論物理系隆德天文台榮休教授**萊納特・林德格倫** Lennart Lindegren 和愛爾蘭都柏林大學學院物理學院客座教授**邁克爾・佩里曼** Michael Perryman ，以表彰他們一生對天體測量學的貢獻，尤其是在歐洲太空總署依巴谷號及蓋亞號以下簡稱依巴谷及蓋亞 的構想和設計中扮演的角色。

The Shaw Prize in Astronomy 2022 is awarded in equal shares to **Lennart Lindegren**, Professor Emeritus, Department of Astronomy and Theoretical Physics, Lund Observatory, Lund University, Sweden and **Michael Perryman**, Adjunct Pro essor, School of Physics, University College Dublin, Ireland for their lifetime contributions to space astrometry, and in particular for their role in the conception and design of the European Space Agency s Hipparcos and Gaia missions.



天文學 Astronomy



得獎人簡介
Biographical Notes of Laureates

萊納特・林德格倫 Lennart Lindegren

萊納特·林德格倫在1950年於瑞典出生，現為瑞典隆德大學天文學及理論物理系隆德天文台榮休教授。1980年於隆德大學取得博士學位，其後留校任教，2000年升任天文學教授，2017年退休。在隆德天文台工作的其中六年，他曾出任台長。他是歐洲太空總署依巴谷號科學團隊 1976 1997 及蓋亞號科學諮詢小組的成員 1997 2000 。他帶領蓋亞號數據處理及分析聯盟的天體測量全球性方案之科學實施，亦是蓋亞號科學團隊的成員 2001–)。他曾擔任瑪麗居禮研究培訓聯網 ELSA 的項目統籌人 2006–2010 。萊納特・林德格倫是瑞典皇家科學院院士。

Lennart Lindegren was born in 1950 in Sweden and is currently Professor Emeritus of Lund Observatory, Department of Astronomy and Theoretical Physics at Lund University, Sweden. He received his PhD in 1980 from Lund University. He joined as a member of the teaching staff at Lund University and became Full Professor of Astronomy in 2000, serving until his retirement in 2017. During his time at Lund Observatory, he had served as the Director for six years. He was a member of the European Space Agency s Hipparcos Science Team 1976 1997 and Gaia Science Advisory Group 1997 2000 . He leads the scientific implementation of the Astrometric Global Iterative Solution in the Gaia Data Processing and Analysis Consortium and is also a membe o he Ga a Sc ence Team 2001 He a so served as Pro ec Coord nator o he Mar e Cur e Research Train ng Ne wo k ELSA 2006 2010 . He is a member of the Royal Swedish Academy of Sciences.

邁克爾・佩里曼 Michael Perryman

邁克爾·佩里曼在1954年於英國盧頓出生，現為愛爾蘭都柏林大學學院物理學院客座教授。分別在1976年及1980年於英國劍橋大學取得數學及理論物理學學士學位和博士學位。他於1980年加入歐洲太空總署，出任依巴谷號的項目科學家 1981–1997 ，隨後出任蓋亞號的研究科學家 1995–2000 及項目科學家 1995–2008 。他在歐洲太空總署服務期間，同時擔任荷蘭萊頓大學天文學教授 1993–2009)。2010年他於德國海德堡大學及馬克斯普朗克天文研究所聯合執教。一年後他於英國布里斯托大學出任物理學客座教授 2011–2012 ，2012年開始在都柏林大學學院擔任客座教授。

Michael Perryman was born in 1954 in Luton, UK and is currently Adjunct Professor, School of Physics at University College Dublin, Ireland. He received his Bachelor s deg ee in Mathematics and Theo etical Physics in 1976 and obtained a PhD in 1980 rom the Univers ty o Cambridge, UK. He oined the European Space Agency ESA in 1980 and was nom nated as Project Scientis 1981 1997 for the Hipparcos mission and subsequently Study Scientis 1995 2000 and Project Scientist 1995 2008 for the Gaia mission. During his service in ESA, he had been Professor of Astronomy 1993 2009 at Leiden University, The Netherlands. He held a joint position at the University of Heidelberg and the Max Planck Institute for Astronomy, Germany in 2010. A year later, he joined the University of Bristol, UK as visiting Professor of Physics 2011–2012 . He has been Adjunct Professor at University College Dublin since 2012.

林德格倫和佩里曼的貢獻
Contributions of Lindegren and Perryman

依巴谷和蓋亞的成功有賴許多人在過去半個世紀的共同努力。邵逸夫獎表彰其中二人，他們均為這兩項任務作出持續且關鍵的科學貢獻。萊納特．林德格倫在依巴谷的設計上提出許多構想。他是負責分析依巴谷數據的兩個獨立團隊中其中一隊的主管，亦是依巴谷科學團隊和蓋亞科學團隊的成員，先後在任時間各達二十多年。邁克爾．佩里曼在1981至1997年期間擔任依巴谷的項目科學家，同時期出任依巴谷科學團隊的主席，並且是1997年一份描述依巴谷星表的論文的主要作者。佩里曼亦在1995至2008年間擔任蓋亞的項目科學家，1995至2000年間擔任蓋亞科學諮詢小組主席，並在2001至2008年間擔任蓋亞科學團隊的主席。林德格倫和佩里曼在九十年代提出蓋亞的構想，在其科學及技術上的設計扮演著重要角色。

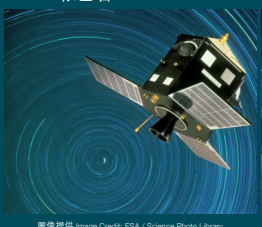
Hipparcos and Gaia succeeded because of the collective effort of many people lasting over half a century. The Shaw Prize ecognises wo of hese ndividuals who have made susta ned key scientif c contribut ons to the two missions. Lennar Lindegren originated many of the concepts of the Hipparcos mission design and was leader of one of the two independent teams that carried out the data analysis for Hipparcos. He was a member of the Hipparcos science team for two decades and the Gaia science team or two decades after that. Michael Perryman was Project Scientist for Hipparcos from1981 o1997, Chair of the H pparcos Science Team for the same period, and lead author on the 1997 paper describing the Hipparcos catalogue. Perryman was also Project Scientist for the Gaia mission from 1995 to 2008, Chair of the Gaia Science Advisory Group from1995 to 2000, and Chair of the Gaia Science Team from 2001 to 2008. Lindegren and Perryman proposed the concept for Gaia in the 1990s and were instrumental in its scientific and technical design.

依巴谷及蓋亞任務
Hipparcos and Gaia Mission

精確的天體測量學十分重要，因為它提供了天體的位置、速度及距離等基本數據，為現代天文學及天體物理學裏幾乎所有的分支奠下基石。恆星與地球精確的距離，讓我們能夠測量它們的絕對光度，繼而為恆星的內部物理過程提供高敏感度的測量。透過測量恆星的速度，我們能推斷出它們的銀心軌道，繼而獲得銀河系的形成歷史和神秘暗物質在銀河系裏分布的線索。

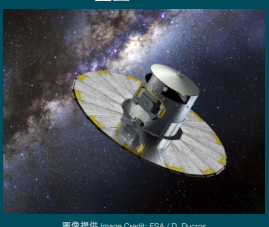
Accurate astrometry is so important because it provides fundamental data—positions, velocities, and distances—that underpin almost every aspect of modern astronomy and astrophysics. Accurate distances to stars allow determination of their intrinsic luminosities, and these in turn are a sensitive measure of their internal physical processes. Measurements of the velocities o stars a low us to n er their Galactic orb s, which in urn prov de c ues to the format on h story o the Milky Way and the distr but on o the mysterious dark matter within it.

依巴谷 HIPPARCOS



圖像提供 Image Credit: ESA / Science Photo Library

蓋亞 GAIA



圖像提供 Image Credit: ESA / D. Ducros

歐洲太空總署的依巴谷 1989 1993 開啟了精確太空天體測量學的時代。依巴谷將超過 100,000 顆亮星編入星表。它測量了這些恆星在天空中的視位置的年度變化，其微細度就相等於從香港望向北京，所見的一個拇指寬度。透過測量地球沿著軌道運轉時恆星視位置的細微變化 視差），依巴谷測定了超過 20,000 顆恆星的距離，不確定性少於百分之十。

The era of precision space astrometry began with the European Space Agency s Hipparcos mission (1989–1993). Hipparcos catalogued over 100,000 bright stars. It measured annual changes in the apparent position of these stars on the sky as small as the width of a human thumb in Beijing as viewed from Hong Kong. By measuring small variations in stellar positions as the Earth travelled around its orbit parallax), Hipparcos determined distances to over 20,000 stars with uncertainties of less than 10%.

歐洲太空總署的蓋亞於 2013 年 12 月啟動，其設計以依巴谷的設計準則為基礎，但性能大幅提升。蓋亞所測量的恆星位置，數量比依巴谷多 10,000 倍，精確度亦是依巴谷的 100 倍。蓋亞幾乎將整個銀河系裏接近百分之一的恆星編入星表，目前已以視差為基準，測定超過五千萬顆恆星的距離，不確定性少於百分之十。蓋亞能夠測量恆星在天空上位置的微小變化，細如從香港望向北京，所見一絲頭髮的寬度；它亦能測量恆星在天空中的運動，可測的幅度比由地球望向月球，所見宇航員頭髮生長的視速度還要小。蓋亞的宇宙普查，無論在數量還是質量上，在未來數十年內也無法被超越。

ESA s Gaia m ssion, aunched n December 2013, s based on the same design principles as H pparcos but has vastly greater capabilities. Gaia has measured the positions of 10,000 times as many stars as Hipparcos with accuracies 100 times higher. Gaia has catalogued almost one percent of all the stars n the Mi ky Way and so far has measured paral ax based d stances to over 50 million stars with uncertainties of less than 10%. Gaia can measure changes in the position of stars on the sky as small as the width of a human hair in Beijing as viewed from Hong Kong, and motions on the sky smaller than the apparent rate of growth of a hair belonging to an astronaut on the Moon, as seen from Earth. Gaia is providing a survey of our Galaxy that will not be surpassed in quantity or quality for decades to come.

依巴谷 HIPPARCOS		蓋亞 GAIA
1989年8月8日 8 August 1989	發射日期 Launch Date	2013年12月19日 19 December 2013
1993年8月 August 1993	任務完結 Mission End	任務原定於2019年7月結束，再延長至2025年底 於2022年再作檢討 Nominal mission ended on July 2019, mission extended until end of 2025 (subject to a review in 2022
依巴谷因其中一個遠地點助推器失效，未能到達預定的地球同步軌道。之後針對新位置而修改任務後，恢復正常運作。 Hipparcos failed to reach its planned geostationary orbit after malfunction of one of its apogee boost motors. The mission was then modified for the new position and normal operations reestablished.	軌道 Orbit	利薩如軌道，圍繞日地系統的第二拉格朗日點 L2 ，距離地球150 萬公里。 Lissajous orbit, around the second Lagrange point (L2) of the Sun–Earth system, which is located 1.5 million km from the Earth.
• 製訂兩個主要的恆星數據星表： ① 依巴谷星表 包含118,218 顆恆星的高精確度測量數據； ② 第谷星表及第谷第二星表 分別包含超過100 萬顆和250 萬顆恆星的測量數據，但精確度較低。 • 證實了愛因斯坦關於星光因重力而彎曲的預測。 • 成功預測1994 年休梅克－利維九號彗星撞擊木星。 • Generation of two main catalogues of star data: ① The Hipparcos catalogue of high-precision measurements of 118,218 stars, and ② The Tycho and Tycho 2 catalogues, with less precise measurements of more than 1 million and 2.5 million stars respectively. • Confirmation of Einstein's prediction of bending of starlight by gravity. • Successful prediction of the impact of Comet Shoemaker–Levy 9 on Jupiter in 1994.	科學亮點 Science Highlights	• 分別於2016年9月、2018年4月及2022年6月三次全面發布的觀測資料。 • 探測到「星震」 一種會改變恆星形狀的不尋常振盪。 • 發現銀河系在大約100億年前與另一個大星系合併。 • 成為結合成分和軌道數據的最精確小行星普查。 • 有望在2025或之後推出內容更加豐富、數量更加龐大、精確度更加高的星表。 • Three full data releases in September 2016, April 2018 and June 2022. • Detection of 'starquakes , unusual oscillations that change the shapes of stars. • Discovery that the Milky Way Galaxy merged with another large galaxy around 10 billion years ago. • The highest accuracy survey of asteroids that combines their composition with orbits. • Production of even richer, larger and more accurate catalogues in 2025 or later.

2022 邵逸夫生命科學與醫學獎
The Shaw Prize in Life Science and Medicine 2022

2022 年度邵逸夫生命科學與醫學獎平均頒予美國福泰製藥公司聖地亞哥研究部高級副總裁暨研究部主管**保羅・內古列斯庫**(Paul A Negulescu 和美國愛荷華大學內科系教授 肺科、重症監護和職業病醫學);也是神經外科、神經科、分子生理及生物物理教授暨帕約翰生物醫學研究所所長**邁克爾・威爾士** Michael J Welsh ,以表彰他們發現囊腫性纖維化 Cystic Fibrosis 是分子、生物化學和功能上出現缺陷所引致,以及鑑定和研發能夠修復這些缺陷的新藥物,因而可以治療太多數患者。這些發現和藥物不但減輕人類的痛苦,並拯救了無數生命。

The Shaw Prize in Life Science and Medicine 2022 is awarded in equal shares to **Paul A Negulescu**, Senior Vice President and Site Head San Diego Research Vertex Pharmaceuticals Incorporated, USA and **Michae J Welsh** Professor o In ernal Med cine Pulmonary Critical Care and Occupational Medicine, Professor of Neurosurgery Neurology Molecular Physiology and Biophysicsand Director of Pappajohn Biomedical Institute, University of Iowa, USA for landmark discoveries of the molecular biochemical, and functional defects underlying cystic fibrosis CF and the identification and development of medicines that reverse those defects and can treat most people affected by this disorder. Together, these discoveries and medicines are alleviating human suffering and saving lives.

生命科學與醫學

Life Science and Medicine

得獎人簡介
Biographical Notes of Laureates

保羅・內古列斯庫 Paul A Negulescu

保羅·內古列斯庫現為美國福泰製藥公司聖地亞哥研究部高級副總裁暨研究部主管。1986 年及 1990 年於美國加州大學伯克萊分校分別取得生理學學士學位及博士學位。他先後在美國加州大學伯克萊分校和爾灣分校從事博士後研究工作。其後，他於 1996 年加入美國聖地亞哥極光生物科技公司成為第一批員工，並與公司一起成長，之後更成為發現生物學部高級副總裁（1999 2001 。2001 年福泰製藥公司收購極光生物科技公司，他被委任為研究部高級副總裁 2001 。

Paul A Negulescu is currently Senior Vice President and Site Head, San Diego Research, Vertex Pharmaceuticals Incorporated, USA. He received his BS and PhD in Physiology from he University of California, Berkeley, USA in 1986 and 1990, respectively. He carried ou postdoctoral works at he University of California, Berkeley and the University of California, Irvine. He joined Aurora Biosciences, San Diego, USA in 1996 as one of the first employees and grew with the company to become a Senior Vice President of Discovery Biology 1999 2001 . He has been appointed Senior Vice President of Research 2001 after Vertex acquired Aurora in 2001.

邁克爾・威爾士 Michael J Welsh

邁克爾·威爾士現為美國愛荷華大學內科系教授 肺科、重症監護和職業病醫學；也是神經外科、神經科、分子生理及生物物理教授暨帕帕約翰生物醫學研究所所長。1974 年於美國愛荷華大學取得醫學博士學位。他先後於美國加州大學三藩市分校和美國德克薩斯大學擔任研究員後，便轉到愛荷華大學工作，擔任助理教授 1981 1984)、副教授 1984 1987 、內科醫學教授 1987 、囊性纖維化研究所所長 1988 和分子生理學教授 1989)。他是霍華德休斯醫學研究所研究員 1989 、美國國家科學院、美國國家醫學院及美國人文與科學院院士。

Michael J Welsh is currently Professor of nternal Medicine Pulmonary, Critical Care and Occupational Medicine, Professor o Neurosurgery, Neurology, Molecular Physiology and Biophysics and Director of Pappajohn Biomedical Institute, University of Iowa, USA. He received his MD from the University o owa, USA in 1974. He was a Research Fellow at the Univers ty of California, San Francisco, USA and the University of Texas, USA. He then worked at the University of Iowa, where he was successively Assistant Professor 1981–1984 , Associate Professor 1984–1987 , Professor of Internal Medicine 1987– , Director of Cystic Fibrosis Research Center 1988– and Professor of Molecular Physiology 1989– He is also an Invest gator of the Howard Hughes Medical Institute 1989– , a member of the US National Academy of Sciences, the US National Academy of Medicine and the American Academy of Arts and Sciences.

邁克爾・威爾士的貢獻
Contributions of Michael Welsh

来自愛荷華大學的邁克爾・威爾士教授於 1990 至 1991 年間發現囊腫性纖維化跨膜調節器 Cystic Fibrosis Transmembrane Conductance Regulator, CFTR 蛋白是一條氯離子通道，並揭示CFTR 蛋白的活性是如何被調節的。他通過提供正常的 *CFTR* 基因去糾正培養中的病人細胞的囊腫性纖維化缺陷，從而證明糾正有缺陷的基因是一種可行的治療方法。在這個非同尋常的研究 (1992–1993 中，威爾士證明了不同的囊腫性纖維化致病突變是如何影響CFTR 蛋白 有些是抑制CFTR 蛋白的製造，有些是干擾CFTR 蛋白輸送到細胞膜 有些是阻止CFTR 蛋白的氯離子運輸通道的開放或令該通道失去運輸功能。威爾士根據這些機制對不同的人類囊腫性纖維化突變進行分類，並製定出一個方案來糾正每種類型的潛在缺陷。重要的是， 威爾士表明具有常見的 F508del 突變的 CFTR 蛋白有多種缺陷，該蛋白不能到達細胞膜，並且在氯離子運輸方面也出現問題。非常關鍵的是，威爾士研發出一個實驗條件，使 CFTR F508de 蛋白能夠進入細胞膜，他遺證明當該蛋白確實到達細胞膜時，就能發揮其作用。這個突破性的發現意味著如果可以研發一種治療策略使 CFTR F508de 蛋白進入細胞膜，將有利於對抗這種疾病。

Michael Welsh rom the Univers ty o owa discovered n 1990 /1991 that the Cystic Fibrosis Transmembrane Conductance Regulator (CFTR) protein is a chloride channel and he revealed how its activity can be regulated. He corrected the CF defect in cultured cells by providing a normal *CFTR* gene, thereby showing that correcting the defect was a feasible therapeutic strategy. In extraordinary studies 1992–1993 , Welsh then demonstrated how different CF disease-causing mutations affect the CFTR protein some eliminated its production, some interfered with its trafficking to the cell membrane, and some prevented the opening or function of its chloride-transporting channel. Welsh categorised the different human CF mutations according to mechanism and laid ou a scheme o correct each type of underlying defect. Importantly, Welsh showed hat the CFTR protein with the common F508del mutation has multiple defects, the protein did not reach the cell membrane and was also defective for chloride transport. Very crucial y We sh d scovered an expe men al condi on ha enab ed he CFTR F508de pro ein o make to the membrane, and he showed that when the protein did reach the membrane, it functioned. That landmark discovery meant that if a therapeutic strategy could be developed to get CFTR F508de protein to the cell membrane, it would be beneficial in combating the disease.

保羅・內古列斯庫的貢獻
Contributions of Paul Negulescu

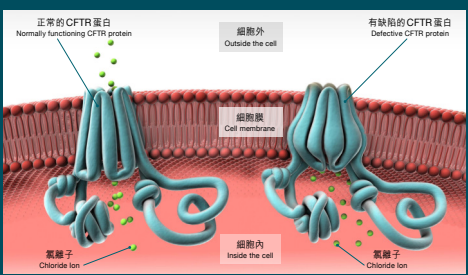
來自福泰製藥公司的保羅·內古列斯庫在從機制至治療方面邁出了一大步。他和福泰團隊利用一種十分冒險的方法来篩選出可以「修復」缺陷蛋白的化合物，因而發現了能治療囊腫性纖維化的小分子。此外，由於有許多不同的突變會引發囊腫性纖維化，他們仍不確定是否可以研發出一種能夠治療大部分囊腫性纖維化患者的藥物。內古列斯庫首先發現了一種可刺激 CFTR 通道功能的 CFTR「增強劑」。這種被稱為 Kalydeco 的藥物獲得了突破性的肯定。然而，Kalydeco 只對一小撮患有特定罕見 *CFTR* 突變的囊腫性纖維化患者有用，而對絕大多數具有 *CFTR* F508de 突變的囊腫性纖維化患者沒有效用。在一項更加大膽的研究中，內古列斯庫篩選出能夠糾正運輸功能失常的 CFTR F508de 蛋白的分子。值得注意的是，他發現了這種名為「蛋白質矯正劑」的分子。他將新的分子與Kalydeco 結合在一起，命名為 Orkamb 。他又對 Orkambi 進行了兩次改良，將兩種「蛋白質矯正劑」與一種「增強劑」相結合，製造出三聯療法 Trikafta），並於 2019 年獲得批准臨床應用。三聯療法能夠幫助患有 *CFTR* F508de 突變以及177 種罕見 *CFTR* 突變的病人。目前，有百分之五十的囊腫性纖維化患者服用福泰囊腫性纖維化藥物。

Paul Negulescu from Vertex Pharmaceuticals made the leap from mechanism to therapy. He and the Vertex team discovered small molecules to treat CF by embarking on an enormously risky strategy of screening for compounds that could "fix" a defective protein. Moreover, because there are many different CF causing mutations, it was not clear that one medicine capable of treating the majority of CF patients could be developed. Negulescu first discovered a CFTR "potentiator" that stimulated CFTR channel function. This medicine, called Kalydeco, received breakthrough designation. However, Kalydeco was useful only for the subset of CF patients with certain rare mutations, not for the vast majority of CF patients with the *CFTR* F508de mutation. In an even bolder effort, Negulescu then screened for molecules that could correct the trafficking defect of the CFTR F508de protein. Remarkably he discovered such a molecule, a "protein-corrector" He combined the new molecule with Kalydeco, now named Orkambi. He improved on Orkambi twice more, combining two "protein correctors" with a "potentiator" to make Trikafta, approved in 2019. Trikafta helps patients with the *CFTR* F508de mutation and patients with 177 rare *CFTR* mutations. Currently, 50% of all CF patients take Vertex CF medicines.

囊腫性纖維化
Cystic Fibrosis

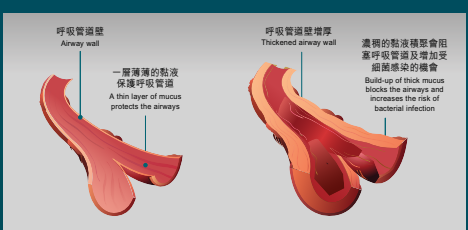
囊腫性纖維化是一種很常見的嚴重單基因遺傳疾病，全球有超過 80,000 人受影響。發生突變而致病的單個基因稱為囊腫性纖維化跨膜調節器，簡稱 *CFTR*。CFTR 蛋白的功能是確保氯離子的正常流動。氯離子是腺的一種成分，存在於人體分泌出來的體液，如汗液、唾液和黏液之中。這些液體能保持細胞潤滑，對器官功能的正常運作十分重要。在囊腫性纖維化患者中，這些分泌物會變得濃縮而黏稠，不能充當潤滑劑，尤其是肺部的分泌物，更會堵塞通道，引起致命的病變。很多 *CFTR* 中不同的突變都會導致患病，但其中一種稱為 F508del 的突變尤其重要，因為大約百分之九十的患者的 *CFTR* 都發現帶有這種突變。

Cystic fibrosis is one of the most common, severe single gene disorders, a fecting more than 80,000 people g obally. The single gene in which the disease-causing mutations all is called *CFTR*. The CFTR protein ensures the proper flow of chloride ions, a component of salt, tha is present in secreted body fluids such as sweat saliva and mucus. These fluids keep cells lubricated and are thus vital for the proper function of organs. In CF patients, these secretions become thick and sticky and, rather than acting as lubricants, clog passageways, especially in the lungs. The disease is fatal. There are many different mutations in *CFTR* that cause the disease, but a mutation called F508del is particularly important, and is present in about 90% of patients.



一些會產生黏液的細胞 例如氣管和腸臟內壁細胞 ，其細胞膜的 CFTR 蛋白在運送氯離子離開細胞中擔任重要角色。基因突變會導致 CFTR 蛋白失去運輸氯離子的功能，氯離子因而積聚在細胞內。帶有負電荷的氯離子亦會吸引正電荷的鈉離子進入細胞，細胞內高濃度的離子繼而妨礙水分離開細胞，最後導致細胞外的黏液缺乏水分，變得濃縮而黏稠。

Mucus-secreting cel s (e.g. in the tracheal o intestina wa l) which have CFTR prote ns on hei cell membrane serve an important role in transporting chloride ions out of the cells. Genetic mutations will cause the CFTR protein to lose its function in transporting ions, causing the build-up of chloride ions within the cell. Negatively-charged chloride ions will attract positively-charged sodium ions into the cells, and the high concentration of ions in the cells in turn prevent water from leaving. As a result, the mucus outside the cells lacks water, and becomes thick and sticky.



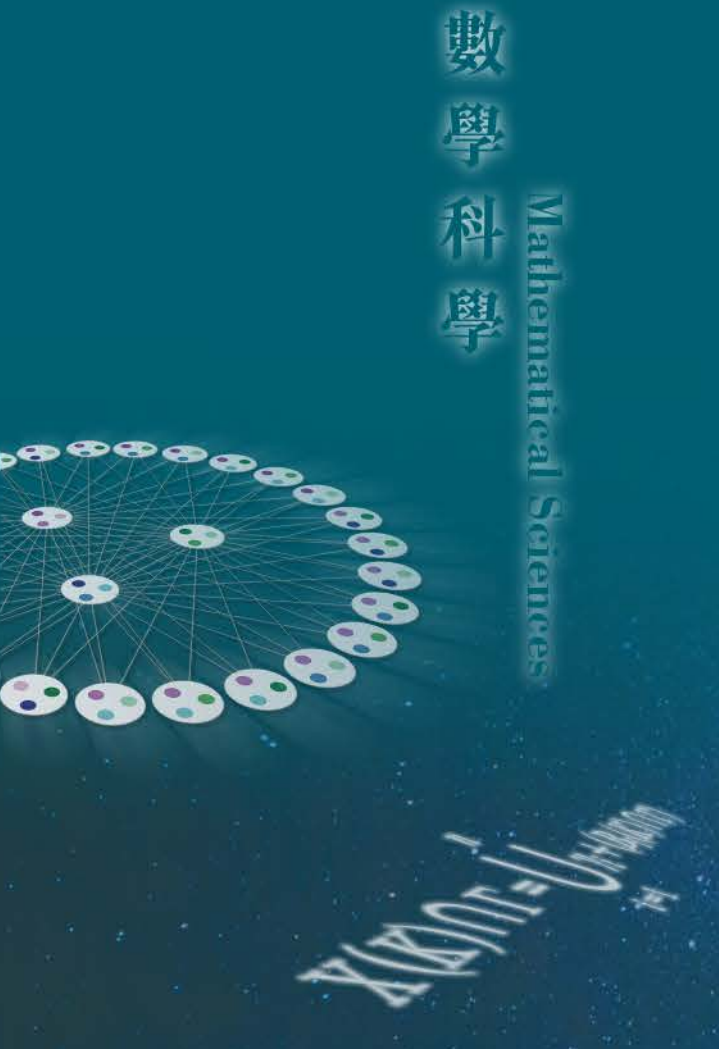
健康人士的呼吸管道
Airways of a healthy person

囊腫性纖維化病人的呼吸管道
Airways of a patient with cystic fibrosis

2022 邵逸夫數學科學獎
The Shaw Prize in Mathematical Sciences 2022

2022年度邵逸夫數學科學獎平均頒予美國普林斯頓大學數學教授諾加・阿隆（Noga Alon）和英國牛津大學默頓數理邏輯講座教授埃胡德・赫魯索夫斯基（Ehud Hrushovsk），以表彰他們對離散數學和模型論的非凡貢獻，尤其是與代數幾何、拓撲和計算機科學的相互影響。

The Shaw Prize in Mathematical Sciences 2022 is awarded in equal shares to **Noga Alon**, Professor of Mathematics at the Princeton University, USA and **Ehud Hrushovski**, Merton Professor of Mathematical Logic, University of Oxford, UK for their remarkable contributions to discrete mathematics and model theory with interaction notably with algebraic geometry, topology and computer sciences.



得獎人簡介
Biographical Notes of Laureates

諾加・阿隆 Noga Alon

諸加·阿隆在1956年於以色列出生，現為美國普林斯頓大學數學教授暨以色列 特拉維夫大學數學和計算機科學鮑姆里特榮休教授。他分別於以色列理工學院和特拉維夫大學取得學士和碩士學位。1983年於以色列耶路撒冷希伯來大學獲得 數學博士學位。1985年他加入特拉維夫大學，先後擔任高級講師 1985 1986)和 副教授 1986 1988 ，自1988 年起成為教授直到退休。期間，他在該校曾擔任數學科學院院長 1999 2000 。他於 2018 年轉到普林斯頓大學擔任教授。他是以色列科學與人文學院和歐洲科學院院士。他亦是匈牙利科學院榮譽院士。

Noga Alon was born in 1956 in Israel and is currently Professor of Mathematics at Princeton University, USA and Baumritter Professor Emeritus of Mathematics and Computer Science at Te Aviv Univers ty Israel. He received his Bachelor s and Master s degree from Technion srael nstitute o Techno ogy and Te Av v Un vers ty respect ve y He ater earned h s PhD n Mathematics n 1983 from the Hebrew University o Jerusalem, Israel He joined Tel Aviv University in 1985 and was successively Sen or Lecturer 1985 1986 , Associate Professor 1986 1988 and was appointed Full Professor from 1988 until retirement. He had also served as the Head of the School of Mathematical Sciences 1999 2000 . He moved to Princeton University in 2018, where he has since held the position of Professor. He is a member of the Israel Academy of Sciences and Humanities and the Academy o Europe He is also an honorary member of the Hungarian Academy of Sciences.

埃胡德・赫魯索夫斯基 Ehud Hrushovski

埃胡德·赫魯索夫斯基在 1959 年於以色列出生，現為英國牛津大學默頓數理邏輯講座教授及牛津大學默頓學院院士。他分別在 1982 年和 1986 年於美國加州大學伯克萊分校獲得數學學士學位和博士學位。他曾是美國普林斯頓大學講師 1987–1988 和客席助理教授 1988–1989)。他其後加入美國麻省理工學院 MIT)，先後擔任助理教授 1988 1991 、副教授 1992 1994)和教授 1994 。在 MIT 工作期間，他還擔任以色列耶路撒冷希伯來大學助理教授 (1991–1992 ，並於1994年至 2017年間擔任教授。他於2016年轉到牛津大學擔任默頓數理邏輯講座教授 2016– 。他是以色列科學與人文學院和美國人文與科學學院院士。

Ehud Hrushovsk was born in 1959 in Israel and is currently Merton Professor of Mathematical Logic, University o Ox ord, UK and a Fellow of Merton College, Oxford University, UK. He obtained his Bachelor s degree and PhD in Mathematics from the University of California, Berkeley, USA in 1982 and 1986 respectively. He was an Instructor 1987 1988 and Visiting Assistant Professor 1988 1989 at Princeton University, USA. He joined the Massachusetts Institute of Technology MIT , USA where he was successively Assistant Professor 1988 1991 , Associate Professor 1992 1994 and Full Professor 1994 . While working at MIT, he also served as an Assistant Professor 1991 1992 and became a Full Professor 1994 2017 at the Hebrew University of Jerusalem, Israel He moved to he Unive s y o Ox o d in 2016, where he has been appo nted Mer on Professor of Mathematica Logic 2016 . He is a member of the Israel Academy of Sciences and Humanities and the American Academy of Arts and Sciences.

諾加・阿隆的貢獻
Contributions of Noga Alon

諾加·阿隆專注於廣泛的離散數學。他引進新方法，並取得重要成果，從而全面地影響了這個領域。從一系列可觀的成果及應用中，我們可以特別留意以下的貢獻。他與馬蒂亞斯（Matias 和塞格迪 Szegedy 一起開創了數據流分析的領域。他與米爾曼 Milman 將擴張圖的組合特性和代數特性聯繫起來。他與克萊特曼（Kleitman 一起解決了於 1957 年提出的哈德威格德布倫納 Hadwiger Debrunner 猜想。在他的「組合零點定理」中，他從代數幾何中的希爾伯特零點定理制定了一個特殊情況的顯式版本，可以廣泛應用於離散問題上。由此促成了高爾文 Galvin）於 1995 年證明有關拉丁方的迪尼茲（Dinitz 猜想，並令其得到進一步推廣。他與塔西（Tars）定出圖的色數的界。他與納桑森（Nathanson）和魯薩 Ruzsa 一起研發出一種代數技術，可以解決加法數論中的柯西達文波特 Cauchy Davenport）問題。他與斯賓塞 Spencer 合著關於概率方法的書，更成為概率、組合學及其他方面的重要基礎手冊。

Noga Alon works in the broad area of discrete mathematics. He introduced new methods and achieved fundamental results which entirely shaped the field. Among a long list of visible results with applications, one can extract the following contributions. With Matias and Szegedy he pioneered the area of data stream analysis. With Milman he connected the combinatorial and algebraic properties o expander graphs With Kle tman he solved the Hadwiger Debrunner con ecture 1957 In his comb na orial Nullstellensatz" he formulated in a special case an explicit version of Hilbert s Nullstellensatz from algebraic geometry which is widely applicable for discrete problems. This led to a proof 1995 of the Dinitz conjecture on Latin squares by Galvin and further generalizations. With Tarsi he bounded the chromatic number of a graph. With Nathanson and Ruzsa he developed an algebraic echn que yie ding a solut on to he Cauchy Davenport problem in additive number theory. His book with Spencer on probabilistic methods has became the essential basic manual on probability, combinatorics and beyond.

阿隆・諾加教授的許多貢獻是在離散數學。離散數學研究的問題是甚麼？

Many of Professor Noga Alon's contributions are in discrete mathematics. What is discrete mathematics about?

離散數學是一系列關於離散對象的數學分支，所謂「離散對象」是指

- 一些可分的東西
- 可以一個一個地數算的東西
- 一些東西的特性是可以用自然數 {1, 2, 3, ...} 來描述的
- 例子：整數本身、一個圖的頂點

Discrete mathematics refers to those branches of mathematics related to discrete objects. By discrete objects, they mean

- Objects that are separable
- Objects that can be counted one by one
- Objects that can be described by natural numbers { 1, 2, 3, ... }
- Examples: The integers itself, vertices in a graph

離散數學常見於日常生活，是我們熟識的，例如

- 整數四則運算
- 畢氏定理 (勾股定理) 的整數解
- 帕斯卡三角形 (楊輝三角形)
- 雞兔問題
- 數獨遊戲

帕斯卡三角形 Pascal's triangle

Discrete mathematics is common in daily life and familiar to us, e.g.

- Integer arithmetic
- Integer solutions of Pythagoras' Theorem
- Pascal's triangle
- Chicken and Rabbit problem
- Game of Sudoku

埃胡德·赫魯索夫斯基的貢獻
Contributions of Ehud Hrushovski

埃胡德·赫魯索夫斯基專注在模型理論的廣泛領域上，並應用於代數算術幾何和數論方面。在一系列可觀的成果及應用中，我們可以特別留意以下的貢獻。他提出群構形定理，作為對齊爾伯 Zilber 和馬爾切夫 Malcev 定理的重大推廣，而這定理就成為幾何穩定理論的有力工具，其後更有助他解決了有關穩定理論的庫克 Kueker 猜想。他與皮萊 Pillay 一起證明了一個關於群的結構定理，促使他其後證明了正特徵代數幾何中的莫德爾 蘭 Mordel Lang 猜想。這個發現頗為出人意表。此外，他否定了齊爾伯關於強極小集的猜想，當中引進了一種方法，這種方法成為估算複雜性的基本技術。他與查齊達基斯 Chatzidakis 一起編寫了差分域理論，其後他展示這理論在有限域上的幾何的動力學有驚人的應用，例如，它是解決關於有限域上 *D* 模結構的吉塞克 Gieseker 猜想的關鍵工具。他使用自己從邏輯發展出的工具來證明馬寧 芒福德 Manin Mumford 猜想（雷諾定理 。他研究出計算線性微分方程的伽羅瓦群的算法。最後，他提出有值域和非阿基米德馴順幾何中的積分理論，這項工作始於 2006 年與卡茲丹 Kazhdan 合作，並於 2016 年與洛瑟 Loeser 一起完成。

Ehud Hrushovski works in the broad area of model theory with applications to algebraic–arithmetic geometry and number theory. Among a long list of visible results with applications, one can extract the following contributions. He introduced the group configuration theorem as a vast generalization of Zilber s and Malcev s theorems, which became a powerful tool in geometric stability theory and eventually enabled him to solve the Kueker s conjecture for stable theories. With Pillay he proved a structure theorem on groups which led him to then prove the Mordel Lang conjecture in algebraic geometry in positive characteristic. This came as a big surprise. He disproved a conjecture by Zilber on strongly minimal sets, introducing a method which became an essential technique for estimating complexity He wrote with Chatzidakis a theory of difference fields which, he showed later has str king applications o dynam cs in geometry over fini e ield, and was or examp e a key tool to so ve the Gieseke conjecture on the structure of *D* modules over finite fields. He found a proof of the Manin Mumford conjecture Raynaud s theorem using his tools ultimately stemming from logic. He gave algorithms to compute Galois groups of linear differential equations. Finally, he developed a theory of integration in valued fields and non archimedean tame geometry, starting rom his work with Kazhdan 2006 and finishing with his work with Loeser 2016

埃胡德・赫魯索夫斯基教授在模型論的研究有所貢獻。甚麼是模型論？

Professor Ehud Hrushovski's contributions are in the field of model theory. What is model theory?

- 模型論是數理邏輯的一個分支
- 它是以形式語言來研究數學結構，和了解這些結構如何被詮釋
- 模型論起源於 20 世紀初對數理邏輯的研究，到 1950 年代之後發展成一個獨立的數學分支
- 經過多年發展，這門學科不只累積了許多本身的理論和成果，更轉而應用於許多不同的數學範疇，例如：圖論、代數幾何
- 除了理論上的應用之外，模型論亦有實際的應用，特別在與電腦有關的範疇，例如：數據庫理論、人工智能、機器學習

- Model theory is a branch of mathematical logic
- It is the study of mathematical structures by formal languages, and how these structures are interpreted
- Model theory stemmed from the study of mathematical logic which started in the early 20th century, and developed as an independent branch of mathematics after the 1950s.
- Through years of development, this discipline has not only accumulated a number of its own theories and results, it has also turned out to have many applications in other areas of mathematics, e.g. graph theory, algebraic geometry
- Beyond theoretical applications, model theory also has practical applications, particularly in computer related areas, e.g. database theory, artificial intelligence, machine learning.

數學科學展板內容意見提供：鄺志良先生

Provision of advice on the content of Mathematical Sciences panels: Mr. Kong Chi Leung