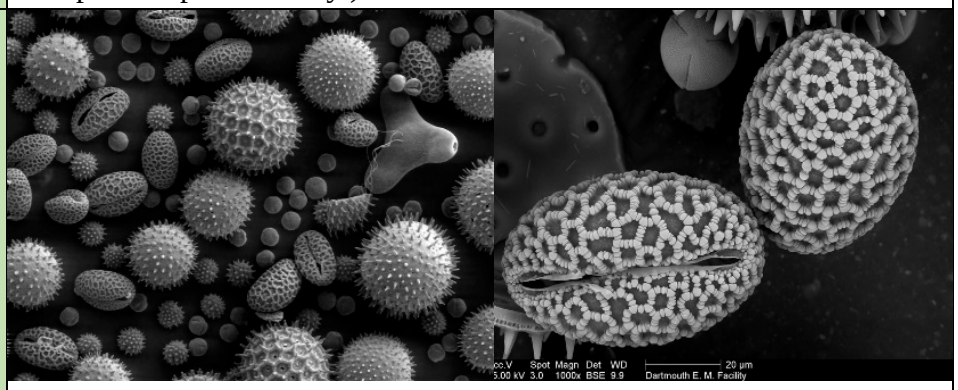
生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	花粉在極端脫水環境下存活 (Pollen survives extreme dehydration)
生物系統 LIVING SYSTEM	開花植物 (Flowering plants)
功能類別 FUNCTIONS	#改變大小/形狀/質量/體積 #保護免受液體流失危害 #Modify size/shape/mass/volume #Protect from loss of liquids
作用機制標題	開花植物的花粉可以透過幾種機制，包括可逆的花粉壁折疊途徑達到完全不透水性，以在極端脫水情況下存活 (Pollen of flowering plants can survive extreme dehydration via several mechanisms, including a reversible wall-folding pathway that results in complete impermeability.)
生物系統/作用機制示意圖	

作用機制摘要說明 (SUMMARY OF FUNCTIONING MECHANISMS)

「關於花粉其中一個很大的謎題是它如何承受乾燥。即使一些花粉形狀接近球形的物種能產生可最小化的水分散失的表面積和體積比值，以及花粉壁被一種不透水的花粉外壁外層給包覆，這結構仍被花粉壁上提供「物質」出口路線的孔洞給打破。並且，花粉粒被盡可能的乾燥，失去過多的水分將會導致其死亡。因此了解花粉粒如何調控維持含水量是引人入勝的。依照 Elena Katifori et al. (PNAS 107: 7635–7639, 2010)之見，這些現象可以被精簡的歸類為簡單的幾何學和一種現象，叫做花粉粒防止失去水分(harmomegathy)。雖然 Katifori 和同事們並非創造這個詞彙的人，然而他們的確示範了以幾何和力學的原則解釋了花粉壁的結構如何引導花粉朝向獨特的折疊方式。在花粉防止水分喪失的過程中，花粉的表面進行折疊的步驟，使那些可通透的孔洞整齊的被塞入不透水的花粉外壁，進而產生而一個密封的花粉粒。」(Chaffey 2010: vi)

"[O]ne of [pollen's] great mysteries is how it can withstand desiccation. Even though the near-spherical shape of some species' generates surface-area-to-volume ratios that minimise water loss, and their walls are surrounded by an impermeable outer layer of exine, this is interrupted by apertures that provide exit routes for 'materials'. And, as dry as pollen grains can be, loss of too much water will result in their death. So, it is intriguing to know how they

manage to stay hydrated. Well, according to Elena Katifori et al. (PNAS 107: 7635–7639, 2010) it's all down to 'simple geometry' and a phenomenon called harmomegathy. Although Katifori and colleagues did not invent the term, they do demonstrate that geometrical and mechanical principles explain how the wall structure guides pollen grains toward distinct folding pathways. During harmomegathy the pollen surface undergoes a folding process to produce a sealed pollen grain in which those permeable apertures become neatly tucked inside the impermeable exine." (Chaffey 2010: vi)

文獻引用 (REFERENCES)

「一旦從花藥中釋放，開花植物的花粉粒會面臨乾燥的環境和脫水作用。為了在這過程中存活，花粉粒進行了各式各樣生理上和結構上的適應。而在這些適應的方式中最引人注目的是花粉壁能夠藉由向自己內部摺疊以預防進一步的乾燥。Roger P. Wodehouse 為這個折疊過程創造了花粉防止失去水分這個專有名詞，辨識到其在花粉粒存活所扮演的關鍵性作用。然而卻還是沒有大量的假說可解釋花粉壁的結構是如何導致花粉防止失去水分的作用。在這邊我們示範藉由簡單的幾何和力學原理解釋花粉壁構造如何引導花粉粒向特有的路徑折疊。我們發現有著高度一致的軸向細長孔洞的存在，對於達成可預測性和可逆的折疊模式是相當重要的。而且，複雜精細的壁紋可以藉由防止表面的鏡像彎曲以輔助花粉關閉。這些結果為花粉防止失去水分構築了大量結構和功能之間的關係，並且提供我們一個架構得以闡明在目前已知被子植物中非常多樣花粉形態之功能的重要性」。 (Katifori et al. 2010: 7635)

"Upon release from the anther, pollen grains of angiosperm flowers are exposed to a dry environment and dehydrate. To survive this process, pollen grains possess a variety of physiological and structural adaptations. Perhaps the most striking of these adaptations is the ability of the pollen wall to fold onto itself to prevent further desiccation. Roger P. Wodehouse coined the term harmomegathy for this folding process in recognition of the critical role it plays in the survival of the pollen grain. There is still, however, no quantitative theory that explains how the structure of the pollen wall contributes to harmomegathy. Here we demonstrate that simple geometrical and mechanical principles explain how wall structure guides pollen grains toward distinct folding pathways. We found that the presence of axially elongated apertures of high compliance is critical for achieving a predictable and reversible folding pattern. Moreover, the intricate sculpturing of the wall assists pollen closure by preventing mirror buckling of the surface. These results constitute quantitative structure-function relationships for pollen harmomegathy and provide a framework to elucidate the functional significance of the very diverse pollen morphologies observed in angiosperms." (Katifori et al. 2010: 7635)

參考文獻清單與連結 (REFERENCE LIST)

Chaffey, N. (2011). Plant cuttings. *Annals of Botany* 107: iii–vi. (https://academic.oup.com/aob/article/107/3/iii/146468)

2.Katifori, E., S. Alben, E. Cerda, D. R. Nelson, and J. Dumais. (2010). Foldable structures and the natural design of pollen grains. *PNAS* 107: 7635-7639. (https://dx.doi.org/10.1073/pnas.0911223107)

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生物系統延伸資訊連結 (LEARN MORE ABOUT THE LIVING SYSTEM/S)

https://en.wikipedia.org/wiki/Plantae

撰寫/翻譯/編修者與日期

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AskNature 原文連結

https://asknature.org/strategy/pollen-survives-extreme-dehydration/