

生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	花瓣自潔而不滑溜 (Petals self-clean without being slippery)
生物系統 LIVING SYSTEM	野生種三色堇、植物 <i>Viola tricolor</i> (Wild pansy, plants)
功能類別 FUNCTIONS	#保護免受過多液體危害 #Protect from excess liquids
作用機制標題	三色堇花瓣利用錐狀細胞維持自我潔淨而不需犧牲抓握力 (Petals of pansy flowers maintain self-cleaning without sacrificing grip because of cone-shaped cells.)
生物系統/作用機制 示意圖	

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

植物的自潔作用 (self-cleaning) 是非常有用的表面特性，因為它們無法以機械的方式自我清潔。最有名的例子就是荷花，它們利用表面覆蓋著細微蠟針的微尺度突起 (micro-scale bumps)，在水滴和葉片表面之間形成非常穩定的氣泡。當水滴從葉片表面滾落時，會帶起並沖走塵土以及造成污染的微生物。

花朵常具有防水性 (疏水性 hydrophobic)，不過，它們的主要功能是吸引授粉者，而花朵的蠟質表面就像是在荷葉上的一樣，都是滑溜的，這讓授粉者難以牢固地抓住花

朵。花朵是壽命很短的器官，所以髒污並不會造成太大影響，很多花朵為了能被授粉者牢牢抓住而犧牲了自潔能力。例如玫瑰的花瓣上具有類似荷葉表面的突起，不過，包覆它們的是一層平滑的蠟質而不是針狀的。這讓它們變得較不滑溜，但同時亦較不防水。玫瑰花瓣仍然具有疏水性，可以避免花朵積水。但是，水滴會黏附在花瓣表面而不會滾落，因此髒污物無法被清洗掉。

另一方面，三色堇的花瓣具有如同荷葉的自我潔淨特性，不過它們是藉由像玫瑰花瓣般的平滑蠟質包覆，確保來訪的授粉昆蟲仍然可以牢牢抓住它們。

三色堇花瓣表面通常具有高而尖的突起，高度為 45 微米：大約是玫瑰花瓣突起高度的三倍。玫瑰和三色堇的花瓣突起都具有皺褶的表面。在玫瑰花瓣上，皺褶的寬度足以讓水分以毛細作用的方式進入，使水滴留在原地而防止其滾動。但在三色堇花瓣上，皺褶太狹窄以至於水分無法進入。此外，三色堇花瓣上突起的尖端比在玫瑰花瓣及荷葉上的更為細小與密集，使得花瓣及水滴之間的總接觸面積變小，以防止氣泡消失。結果造成疏水性的增加，並形成一個昆蟲仍然能緊抓的自潔表面。

Self-cleaning is a very useful surface property for plants as they are unable to clean themselves mechanically. The most famous example of plant self-cleaning is the sacred lotus, which uses micro-scale bumps coated in tiny wax needles to form very stable air bubbles between droplets of water and the leaf surface. When the droplets roll off the surface, they pick up dirt and contaminating microbes and wash them away.

Flowers are also often water-repellent (hydrophobic), however, their main function is to attract pollinators, and waxy surfaces like those on lotus leaves are slippery, making it more difficult for visiting insects to grip them. As flowers are short-lived organs and consequently contamination doesn't matter as much, many flowers may have sacrificed self-cleaning for grip. Petals on flowers like roses have bumps similar to those found on lotus leaves, but they are covered with a smooth layer of wax instead of needles. This makes them less slippery, but also less repellent. Rose petals are still hydrophobic, enabling the flower to avoid becoming waterlogged, but water droplets stick to the petal surface instead of rolling off. As a result, contaminating particles are not washed away.

Pansy petals, on the other hand, do show self-cleaning properties comparable to those of lotus leaves, but they do so with a smooth wax coating like that of rose petals, ensuring that visiting pollinating insects are still able to grip them.

Pansy petals have unusually tall and pointed bumps on their surfaces that are 45 microns in height: nearly three times the height of similar bumps on rose petals. The bumps of both rose and pansy petals have a wrinkled surface. In roses, the wrinkles are wide enough that water can enter by capillary action, holding droplets in place and preventing them from rolling. But on

pansy petals, the wrinkles are too narrow for water to enter. In addition, the tips of the bumps are smaller and closer together on pansy petals than they are for rose petals or lotus leaves. This keeps the total contact area between the petal and the water droplet small and prevents the air bubble from collapsing. The result is enhanced hydrophobicity and a self-cleaning surface that insects can still get a grip on.

文獻引用 (REFERENCES)

「經過了數萬年的共同演化，花瓣演化出不同的形態適應性。掃描式電子顯微鏡研究亦證實了花瓣微結構有著非常大的結構差異。這些表面微結構造成了視覺訊號 [30, 31] 或作為蜜蜂的觸覺線索 [32]。對我們來說「花瓣效應 petal effect」或花瓣的防水性看來是個副作用而不是花朵主要的目的。花瓣是相對短命的植物器官，為吸引授粉者而發育，而這短暫的花瓣壽命讓防禦病原的自潔特性變得浪費。此觀點或許可以解釋為何花瓣的防水性並不普遍。」(Schulte et al. 2011: 233)

“Over millions of years of co-evolution, different morphological adaptations have evolved in petals. Scanning electron microscopy studies also revealed large structural variations in petal microstructures. These surface microstructures cause optical signals [30,31] or function as a tactile cue for bees [32]. For us the “petal effect” or the repellence of petals seems to be a side effect and not the primary aim of the flower. A petal is a relatively short lived organ of plants, developed for pollinator attraction, but the short duration of petal lifetime makes a self-cleaning property for pathogen defence expendable. The last point might explain why water repellence is not widespread in petals” (Schulte et al. 2011: 233)

參考文獻清單與連結 (REFERENCE LIST)

Schulte, A. J., D M. Droste, K. Koch, and W. Barthlott. (2011). Hierarchically structured superhydrophobic flowers with low hysteresis of the wild pansy (*Viola tricolor*) – new design principles for biomimetic materials. *Beilstein J. Nanotechnol.* 2: 228-236.
(<https://www.beilstein-journals.org/bjnano/articles/2/27>)

延伸閱讀

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

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

https://www.onezoom.org/life/@Viola_salvatoriana=6106270?img=best_any&anim=flight#x978,y476,w0.2122

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

撰寫/翻譯/編修者與日期

譚國銓翻譯 (2021/03/22)；洪麗分編修 (2021/04/10)

AskNature 原文連結

<https://asknature.org/strategy/petals-self-clean-without-being-slippery/>

