生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	葉片獲取水分 (Leaves capture water)
生物系統 LIVING SYSTEM	鳳梨科植物 (Bromeliads)
功能類別 FUNCTIONS	#獲取、吸收、或過濾化學物質 #獲取、吸收、或過濾液體 #分配液體 #在固體中/上移動 #儲存液體 #Capture, absorb, or filter chemical entities #Capture, absorb, or filter liquids #Distribute liquids #Move in/on solids #Store liquids
作用機制標題	有些鳳梨科植物的葉子透過疏水性葉表獲取儲水區中的水分和養分 (The leaves of some bromeliads capture water and nutrients in a storage tank via hydrophobic leaf surfaces)
生物系統/作用機制示意圖	

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

鳳梨科 (Bromeliaceae) 的一些植物，例如鳳梨，在他們的葉片上有特殊的表面，使得它們可以在中央的儲水區集水，並吸收和利用。這種適應性不會發生在所有的鳳梨科植物，只會在營養獲取較不足的地區（像是懸掛在樹上只能依靠雨水中溶解的養分）。

這類型鳳梨科植物的葉片形狀凸起，這意味著在背離他們生長的表面形成彎曲弧形。這種形狀讓水可以藉重力向下滴入中央的儲水區。葉片內部的下凹形也有助於水的收集和流動。葉片邊緣向上彎曲，形成一個看起來像微型半管 (miniature half-pipe) 的結構。這種水分收集現象有助於鳳梨科植物，因為它使植物能夠從長時間的積水中獲取足以維持生命的養分。

鳳梨科植物葉片上覆蓋著突起如腫塊的小型表面細胞，稱為毛茸 (trichome)。這些凸起的細胞有細小的毛可以接住落下的水，隨著水接近葉片底部，形成儲水區處，細毛的數量增加。葉片上的細毛覆有微小的疏水（即防水）蠟晶體 (wax crystal)。因蠟晶體

不吸水，所以水會滾動直到集中於中央的儲水區，這些細毛比葉片的外表面高出幾毫米，因此能將水維持在葉片上方，保持水不會接觸到葉片表面。這項功能是重要的，因為葉片表面不一定有覆蓋著跟細毛表面相同的疏水性蠟質，因此，如果與其接觸，水可能會「黏附」在葉面。

由於葉片的疏水特性將水向下引導至植物中心，形成水池，充當溶解養分的儲水。

本摘要是由 Ashley Meyers 所提供。

Some plants included in the family Bromeliaceae, such as pineapples, have a unique surface on their leaves that enables them to collect water in a central tank where it can be absorbed and utilized. This adaptation does not occur in all bromeliads, but just those that grow in areas where there may be less access to nutrients (such as hanging on trees where they rely on nutrients dissolved in rainwater).

The leaves of these types of bromeliads have a convex shape, meaning that they form a curved arch away from the surface they grow on. This shape allows water to drip downward into the central tank, pulled by the force of gravity. The interior, concave shape of the leaf also aids in the gathering and shuttling of water. The edges of the leaf bend upward, creating a structure that looks like a miniature half-pipe. This water collection is helpful for the bromeliad because it enables the plant to collect life-sustaining nutrients from the standing water over a longer period of time.

The leaves of bromeliads are also coated in small surface cells that are raised like bumps, known as trichomes. These “bumpy” cells have tiny hairs that catch water as it drops. The hairs increase in number as the water moves closer toward the base of the leaves, where the tank is formed. The small hairs on the leaves are coated in tiny, hydrophobic (i.e., water-repelling) wax crystals. Because the wax crystals do not absorb any water, the water rolls off of them until it collects in the central tank. The hairs are several millimeters higher than the outer surface of the leaf and thus hold the water above the leaf itself, keeping water from contacting the leaf surface proper. This is important because the surface proper is not necessarily covered in the same hydrophobic wax as the hairs, and thus water could “stick” to this surface if it came in contact with it.

As the hydrophobic properties of the leaves direct water downward to the plant’s center, a pool forms, acting as a water reserve of dissolved nutrients.

This summary was contributed by Ashley Meyers.

文獻引用 (REFERENCES)

「鳳梨科植物的疏水性葉片表面具有高度不規則的細微凹凸，因此減少了水的黏附和擴散。疏水性毛茸層發生在許多中濕度 (mesic) 的第一型皮氏鳳梨亞科 (pitcairnioids) 葉片遠軸面上 (on the abaxial leaf blade surface)，且由於這些物種表現出被認為是較原始 (primitive) 的生態性狀，因此防水性似乎是早期鳳梨科植物的重要條件。第四型物種的毛茸特別用於從充滿水的儲水區吸收水分和養分的交替功能，有些物種採用表皮蠟質粉末 (wax powder) 使葉片上的水分流下。疏水性的毛茸層和蠟粉可能會阻擋病原體和微粒，有助於自體清潔和/或在潮濕的天氣時保持氣體交換。」(Pierce et al. 2001: 1379)

「這些技巧如此成功，可以將種子送到樹冠上，使得許多森林樹木的大部分樹枝通常會被密集的排列著未經允許即住下來的植物。這些植物被稱為附生植物，其中最常見的是鳳梨科植物。他們藉由將根纏繞在樹枝上，如錨般固定自己。他們長長的葉子圍繞著中心的芽形成密集的蓮座 (rosette) ，並將雨水引導到下方，注滿叢葉並形成一個小水池。」(Attenborough 1995: 166)

「帶有蠟質毛茸 (waxy trichome) 的葉子具有極強的防水性…葉片中有超級疏水性的關鍵因素是因為這些數百微米高的毛，這些毛是由一層疏水小蠟晶體疊合而成的…這些表面有超疏水性，但小水滴不會穿透毛和毛之間；因此無法用水將葉面的小顆粒去除…這種微毛系統對水下的系統是非常有用的，因為他們可以最大限度的減少浸濕表面的濕潤面積，因此可以大幅減少阻力 (drag)，以及形成生物薄膜 (biofilm)，這在仿生學之中令人非常感興趣。」(Koch and Barthlott 2009: 1496)

「雖然大多數功能變化的研究並沒有直接關係到從大氣到儲水區形式的過渡時期，但我們的結果與大氣階段和耐旱性增加的概念是大致相關的，而（較大的）儲水區增加了養分的獲取。」(Zotz et al. 2004: 1350)

“Hydrophobic leaf surfaces of Bromeliaceae possess a highly irregular microrelief, thereby reducing the adhesion and spread of water on the leaf blade. Hydrophobic trichome layers occur on the abaxial leaf blade surfaces of many mesic Type 1 pitcairnioids and, as these species exhibit the putative primitive ecological condition, water repellency appears to have been an important condition in early Bromeliaceae. The trichomes of Type 4 species are specialized for the alternative function of water and nutrient absorption from a water-filled tank, with epicuticular wax powders employed by some species to shed water from the leaf blades. Hydrophobic trichome layers and wax powders could potentially obstruct pathogens and particulates, aid in self-cleaning, and/or maintain gas exchange during wet weather.” (Pierce et al. 2001: 1379)

“So successful are these techniques for sending seeds up into the canopy that the massive branches of many forest trees are often densely lined with squatters. These are known as epiphytes and among the commonest are bromeliads. They anchor themselves by wrapping their roots around the branch. Their long leaves grow in a tight rosette around their central bud and channel rain water down to it so that the rosette fills and forms a small pond." (Attenborough 1995: 166)

"Leaves with waxy trichomes are extremely water repellent... The crucial factor of superhydrophobicity in...leaves is given by the hairs, several hundreds of micrometres high, which are superimposed by a layer of small hydrophobic wax crystals⋯ These surfaces are superhydrophobic, but the water droplets do not penetrate between the hairs; thus, small particles from the leaf surface would not be removed by rinsing with water⋯ Such hairy systems may also be extremely useful for underwater systems because they minimize the wetted area of immersed surfaces and therefore may greatly reduce drag, as well as the rate of biofilm formation, and are of great interest in biomimetics." (Koch and Barthlott 2009: 1496)

"...Although most studied functional changes were not directly associated with the transition from atmospheric to tank form, our results are consistent with the notion that the atmospheric stage is broadly associated with increased drought tolerance, whereas (larger) tanks allow improved access to nutrients." (Zotz et al. 2004: 1350).

參考文獻清單與連結 (REFERENCE LIST)

Pierce, S., K. Maxwell, H. Griffiths, K. Winter. (2007). Hydrophobic trichome layers and epicuticular wax powders in bromeliaceae. *American Journal of Botany* 88: 1371-1389. (https://doi.org/10.2307/3558444)

Attenborough, D. (1995). The Private Life of Plants. *BBC Books*.

Koch, K. and W. Barthlott. (2009). Superhydrophobic and superhydrophilic plant surfaces: an inspiration for biomimetic materials. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 367. 1487-1509. (https://royalsocietypublishing.org/doi/10.1098/rsta.2009.0022)

Zotz, G., A. Enslin, W. Hartung, and H. Ziegler. (2004). Physiological and anatomical changes during the early ontogeny of the heteroblastic bromeliad, *Vriesea sanguinolenta*, do not concur with the morphological change from atmospheric to tank form. *Plant, Cell & Environment* 27: 1341-1350 (https://doi.org/10.1111/j.1365-3040.2004.01223.x)

延伸閱讀

AskNature Team. (February 25, 2017). Elf shelter rainwater collector. *AskNature*. Retrieved from:
(https://asknature.org/idea/elf-shelter-rainwater-collector/)

AskNature Team. (October 1, 2016). Chaac-ha water system collector. *AskNature*. Retrieved from:
(https://asknature.org/idea/chaac-ha-water-system-collector/)

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

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

撰寫/翻譯/編修者與日期
王詩萍翻譯 (2019/04/27)；朱天愛編修 (2020/03/03)；譚國鋈編修 (2020/04/08)；許秋容編修 (2020/11/26)
AskNature 原文連結
https://asknature.org/strategy/leaves-capture-water-2/