# 生物策略表

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| **類別** | 生物策略 (Strategy) |
| **生物策略**<br>STRATEGY | 能夠爬上平滑表面的卷鬚<br>(Tendrils enable climbing up smooth surfaces) |
| **生物系統**<br>LIVING SYSTEM | 西番蓮<br>(Passion flower) |
| **功能類別**<br>FUNCTIONS | #暫時性附著<br>#Attach temporarily |
| **作用機制標題** | 西番蓮的卷鬚透過末端黏墊吸附在相對平滑表面的微小特徵上<br>(Tendrils from passion flowers adhere to tiny features on relatively smooth surfaces via terminal adhesive pads.) |
| **生物系統/作用機制示意圖** |   |

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

西番蓮屬 (*Passiflora*) 的成員大約有 500 個物種，大部分為藤蔓植物 (vines)。它們分佈在除了非洲以外的所有熱帶地區。攀緣植物例如西番蓮屬使用外部結構作為支撐，使其能獲得陽光而不用耗費能量在生長支撐組織上。這些藤蔓透過其莖部或葉柄盤繞支撐物來依附在其它植物或固體表面，或是使用其卷鬚 (tendrils)。卷鬚可以是變形後的葉片、芽體，在西番蓮這個例子中則是花芽。

西番蓮的卷鬚一般以盤繞支撐物的方式作用。盤繞的卷鬚在依附或爬上細長圓柱狀物體例如其它植物的莖幹時能發揮良好作用，但當在爬上相對較扁平的表面如岩壁，或是大樹的樹幹時就不太有用了。一種西番蓮物種，*Passiflora discophora*，厄瓜多爾的特有種，長著末端帶有黏盤的卷鬚，能透過生長進入或填塞這些扁平表面的微小特徵來解決這個難題。

不像其它物種的西番蓮，*P. discophora* 的卷鬚會分叉，即一根卷鬚可以有多個末端。卷鬚起始時筆直的生長，除了末端之外，寬度只有 1/10 mm 的末端為勾狀。當勾狀的末端與表面接觸時，它們緊密地卷曲而細胞在表面上開始突起。這些細胞生長成黏墊 (pad)，剛好填滿物體表面所有的空間並緊密貼合。黏墊上最外層細胞特別細小，能生長進表面微小的空間及特徵中。卷鬚亦同時分泌一種蠟質物質填滿任何剩下的空隙，亦可能有黏膠的功能。當牢固地黏附後，卷鬚卷曲而縮短，拉近位於後方的植物。

Passion flowers are a genus of plants with around 500 members, of which most are vines. They grow natively in all tropical regions except Africa. Climbing plants like the *Passiflora* use external structures as supports that enable them to reach sunlight without investing energy in the growth of support tissues. Vines attach to other plants or solid surfaces by twining their stems, or leaf petioles (leaf stems) around supports, and by using tendrils. Tendrils can be modified leaves, shoots or, in the case of passion flowers, flower buds.

Passion flower tendrils generally work by twining around a support. Twining tendrils work well for attaching to and climbing up narrow cylindrical objects like the stems of other plants, but they are less useful for climbing up relatively flat surfaces such as rock faces, or the trunks of larger trees. One species of passion flower, *Passiflora discophora*, endemic to Ecuador, has tendrils with sticky pads on the ends that overcome this issue by growing into and filling tiny features on otherwise flat surfaces.

Unlike other species of passion flowers, *P. discophora* tendrils branch, meaning a single tendril might have multiple ends. Tendrils initially grow straight, except for the tips, which are hooked and as narrow as 1/10th of a millimeter across at the end. When the hooked ends make contact with a surface feature, they curl up tightly and the cells that make up their surface begin to protrude. These cells grow into a pad, filling the available space in the object's surface exactly and forming a very snug fit. The outermost layer of cells on the pad are particularly small and grow into tiny cavities and features on the surface. The tendrils also secrete a waxy substance that fills any remaining gaps and may also function as a glue. Once firmly attached, tendrils coil, shortening themselves and pulling the plant up behind them.

**文獻引用** (REFERENCES)

最初，幼嫩的卷鬚以一個或多個帶勾的末端接觸支撐基質，並進行機械性的扣鎖 (interlocking)。這種接觸刺激啟動了卷鬚末梢頂端表皮細胞的過度生長 (outgrowth) 及細胞分裂。從這些細胞中，癒合組織狀的細胞促使新型態的組織在兩到五週內生成，即墊狀組織 (pad tissue)。有趣的是，這種墊狀組織並不局限於卷鬚尖端。受到觸覺刺激的觸發，卷鬚成熟部位的表皮細胞同樣能夠發育成墊狀組織。(Bohn et al. 2015: 302)

在平坦的基質上，完全生長的黏墊呈半球形，而在具有凹洞的基質上，黏墊會長進這些空洞中，以墊狀組織完全填滿並使卷鬚固定在凹洞中。在兩種情況下，墊狀組織都會建立出最適合的型態來與基質緊密貼合。一般來說，一個黏墊的黏附強度取決於與基質接合的接觸面大小（表面接觸面積），以及接合型態的品質（實際接觸面積），即是黏墊根據基質表面形成結構鏡像 (structurally mirrored) 的好壞程度。由於 *P. discophora* 的黏墊呈輻射狀生長，在相同的黏墊體積下，凹洞會比扁平基質有更大的表面接觸面積。墊狀組織中細小的末端細胞即使是接觸區域中微細的空隙和凹洞也能填滿，另外細胞外分泌物也會填滿餘下的微型及奈米層級的空隙及細胞間隙，因此增加了接合型態的品質。 (Bohn et al.

2015: 302)

"Initially, young tendrils establish contact with a supporting substrate by mechanical interlocking with one or more of their hook-shaped tips. This touch stimulus initializes outgrowth and cell division of the epidermal cells at the apex of the tips. Originating from these cells, callus-like cell growth leads to the formation of a new tissue type, the pad tissue, within 2–5 wk. Interestingly, the development of such a pad tissue is not limited to the tendril tips. Induced by a touch stimulus, epidermal cells in mature parts of the tendril axes can likewise develop into a pad tissue." (Bohn et al. 2015: 302)

"On a flat substrate, fully grown pads possess a hemispherical shape, while on a substrate with cavities, pads grow into these holes, completely filling them with pad tissue and anchoring the tendril in the cavity. In both cases, the pad tissue establishes an optimal form closure with the substrate. In general, the attachment strength of an adhesive pad is determined by the size of the contact interface (apparent contact area) with the substrate and the quality of the form closure (real contact area), i.e., how well the surface of the substrate is structurally mirrored by the pad. Since the adhesive pads of *P. discophora* grow radially, cavities allow for a larger apparent contact area than a flat substrate for a given pad volume. The quality of the form closure is enhanced by tiny terminal cells of the pad tissue filling up even minute gaps and cavities in the contact zone and by additional secretion of an extracellular substance that fills up remaining micro- and nanogaps and intercellular spaces." (Bohn et al. 2015: 302)

**參考文獻清單與連結** (REFERENCE LIST)

Bohn, H. F., F. Günther, S. Fink, T. Speck, and A. Nicotra. (2015). A passionate free climber: structural development and functional morphology of the adhesive tendrils in *Passiflora discophora*. *International Journal of Plant Sciences* 176: 294-305. (https://doi.org/10.1086/680231)

Shah, J. J. and Y. S. Dave. (1970). Tendrils of *Passiflora foetida*: histogenesis and morphology. *American Journal of Botany* 57: 786-793. (https://www.jstor.org/stable/2441335?seq=1#metadata_info_tab_contents)

**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/passiflora_discophora
https://www.onezoom.org/life/@passiflora_discophora
https://eol.org/pages/5741329

**撰寫/翻譯/編修者與日期**

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| 譚國鎏翻譯 (2021/03/22)；趙怡姍編修 (2021/04/20) |
| **AskNature 原文連結** |
| https://asknature.org/strategy/tendrils-enable-climbing-up-smooth-surfaces/ |