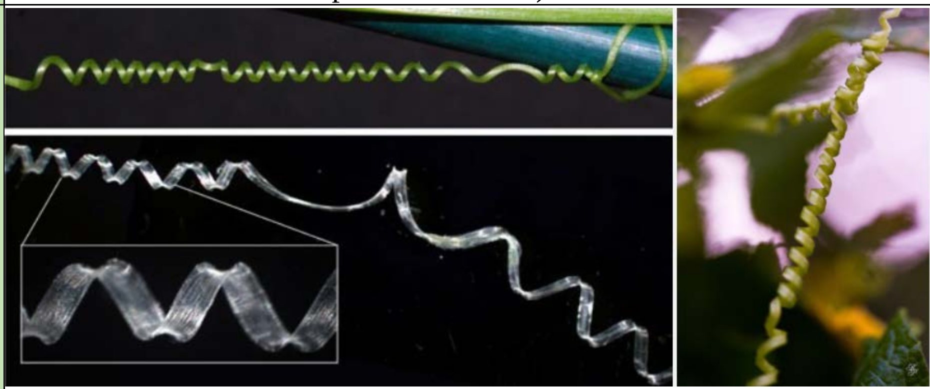
生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	植物的卷鬚充當彈簧 (Plant tendrils act as spring)
生物系統 LIVING SYSTEM	黃瓜 *Cucumis sativus* (Garden cucumber)
功能類別 FUNCTIONS	#物理性組成結構 #Physically assemble structure
作用機制標題	黃瓜卷鬚的扭轉肇因於特化細胞組成的內部纖維條帶產生不對稱性收縮 (Cucumber plant tendrils twist due to an asymmetric contraction of an internal fiber ribbon of specialized cells.)
生物系統/作用機制示意圖	

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

文獻引用 (REFERENCES)

「螺旋狀盤繞的植物卷鬚 (tendril) 已經讓科學家們著迷了數個世紀之久，但潛在機制仍不清楚。再者，儘管達爾文將盤繞的卷鬚視作柔軟彈簧 (soft spring) 的說法已被廣為接受，但其力學性能仍是未知。我們對於黃瓜卷鬚的實驗顯示卷鬚的盤繞是藉由特化細胞組成的內部纖維條帶產生不對稱性收縮所致。在張力作用下，萃取出來的纖維條帶和老熟的卷鬚皆展現無扭轉 (twistless) 的過度卷繞 (overwinding)，而不是解開卷繞 (unwinding) [亦即黃瓜的卷鬚並非如同解開的線圈般，在拉力下展開成扁平的條帶，實際上它變得更加卷曲]，而在拉張初始卷鬚表現柔軟 (soft response)，隨後在大幅拉展下則展現強烈的應變硬化 (strain-stiffening) [亦即隨著卷鬚承受的應變增加，盤繞並非如預期般被拆開，而是增加了線圈的數目]。我們利用預先拉伸的橡膠條帶物理模型、幾何論點、以及彈性細絲的數學模型來解釋這種行為。總括來說，我們的研究闡明了卷鬚盤繞的根源，量化了達爾文原本的構想，並為具有可調性力學反應的無扭轉彈簧提供了仿生設計的建議。」(Gerbode 2012: 1087)

“The helical coiling of plant tendrils has fascinated scientists for centuries, yet the underlying mechanism remains elusive. Moreover, despite Darwin’s widely accepted interpretation of coiled tendrils as soft springs, their mechanical behavior remains unknown.

Our experiments on cucumber tendrils demonstrate that tendril coiling occurs via asymmetric contraction of an internal fiber ribbon of specialized cells. Under tension, both extracted fiber ribbons and old tendrils exhibit twistless overwinding rather than unwinding [that is, instead of unwinding to a flat ribbon under stress, as an untwisted coil normally would, the cucumber's tendrils actually coil further], with an initially soft response followed by strong strain-stiffening at large extensions [i.e., as the strain on the tendril increases instead of the coils unravelling as might be expected the number of coils increases]. We explain this behavior using physical models of prestrained rubber strips, geometric arguments, and mathematical models of elastic filaments. Collectively, our study illuminates the origin of tendril coiling, quantifies Darwin's original proposal, and suggests designs for biomimetic twistless springs with tunable mechanical responses." (Gerbode 2012: 1087).

參考文獻清單與連結 (REFERENCE LIST)

Gerbode, S. J., J. R. Puzey, A. G. McCormick, and L. Mahadevan. (2015). How the cucumber tendril coils and overwinds. *Science* 337: 1087-1091. (https://science.sciencemag.org/content/337/6098/1087)

Cambridge, Mass. (30 August, 2012). Uncoiling the cucumber's enigma. *Wyss Institute of Harvard University*. Retrieved from: https://wyss.harvard.edu/news/uncoiling-the-cucumbers-enigma/

延伸閱讀

AskNature Team. (10 March, 2017). New type of spring. *AskNature*. Retrieved from: https://asknature.org/idea/new-type-of-spring/

（譚國鋈提供）

https://www.youtube.com/watch?v=Vbzgv5iKEyY

https://www.youtube.com/watch?v=n3MAOIBOWgE

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

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

https://www.onezoom.org/life/@cucumis_sativus

https://eol.org/pages/584402

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AskNature 原文連結

https://asknature.org/strategy/plant-tendrils-act-as-spring/