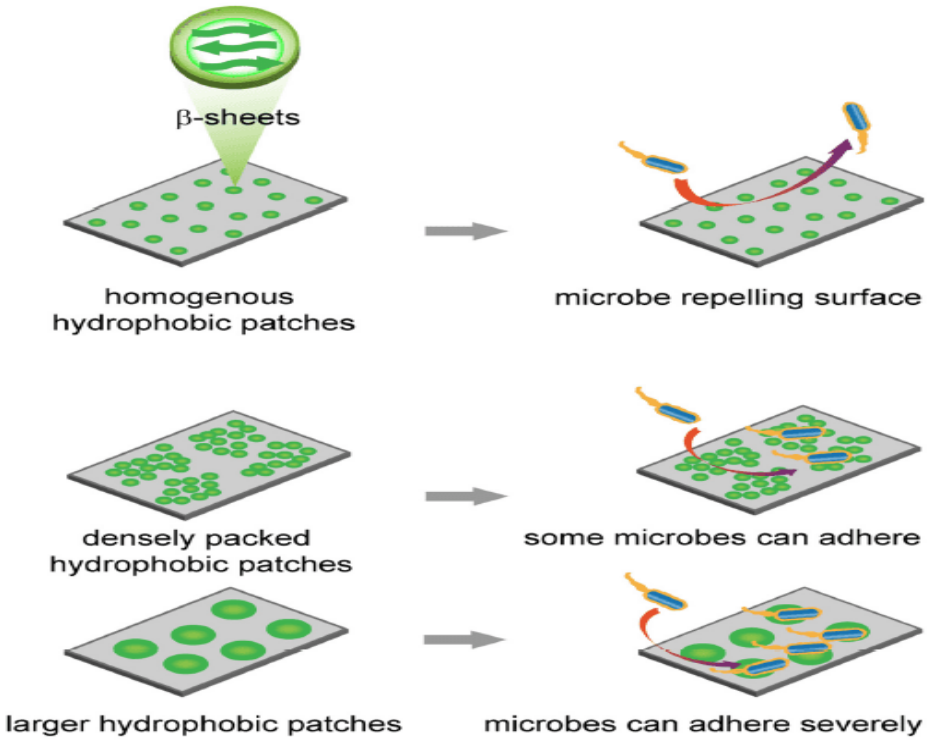
生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	蜘蛛的抗菌能力 (Spider Silk's Antibacterial Power)
生物系統 LIVING SYSTEM	蜘蛛(Spiders)
功能類別 FUNCTIONS	#抵擋微生物入侵 # Resist microbial invasion
作用機制標題	一些蜘蛛絲蛋白的奈米結構可防止細菌附著 (The nanostructure of some spider silk proteins prevents bacterial attachment)
生物系統/作用機制示意圖 (確認版權、註明出處；畫質)	 (圖片來源:asknature)  (圖片來源:asknature)

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

蜘蛛網可以在幾天甚至幾週的最小修復下存活數天甚至數週，而不受真菌和細菌等分解生物破壞。人類已使用蜘蛛絲包紮傷口，這代表它們可能具有抗菌的超能力。為什麼這些網不會被細菌和真菌降解，即便它們是由微生物最喜歡的食物製成的？蜘蛛絲的外層是由各種蛋白質和脂肪分子組成。蛋白質由數百個單獨的建構組件 (building blocks) 組成，稱為胺基酸。不同的胺基酸具有不同的特性，以及正電荷或負電荷。相反的電荷相互吸引，而相似的電荷相互排斥。這些相互作用意味著根據鏈中胺基酸的種類和順序，蛋白質的不同部分最終會組織成不同的形狀。這些形狀之一被稱為螺旋 (helix)，它包含稱為β片的部分。這就是蜘蛛絲的微生物排斥技能的來源。科學家們發現一些稱為絲心蛋白 (fibroins) 的蜘蛛絲蛋白聚集體 (protein conglomerations) 具有帶相似電荷的 β 片層部分，導致它們相互排斥，從而在蛛絲表面形成規則排列的疏水（防水）斑塊。這些斑塊有效地防止微生物找到著陸和黏住的地方——就像散佈在球場上的一群熟練的排球運動員可以防止球撞擊地面的任何地方一樣。

A spider's web can survive with minimal repairs for days or even weeks without being destroyed by decomposing organisms like fungi and bacteria. People have used spider silk to dress wounds, suggesting that they may have antimicrobial super powers. Why aren't these webs degraded by bacteria and fungi, even though they're made of microbes' favorite foods? The outer layer of spider silk is made up of various proteins and fat molecules. The proteins are composed of hundreds of individual building blocks, called amino acids. Different amino acids have different traits, as well as positive or negative charges. Opposite charges attract, while similar charges repel each other. These interactions mean that, depending on the kinds and order of amino acids in the chain, different parts of a protein end up organized into different shapes. One of these shapes is known as a helix that contains parts known as beta sheets. This is where spider silk's microbe-repelling skills appear to come from. Scientists have discovered that some spider silk protein conglomerations called fibroins have beta-sheet sections with similar charges that cause them to repel each other, creating a regular arrangement of hydrophobic (water-repelling) patches across the surface of the silk. These patches effectively prevent microorganisms from finding a place to land and stick—much as a team of skilled volleyball players scattered over a court can keep the ball from hitting the ground anywhere.

文獻引用 (REFERENCES)

「蜘蛛絲蛋白（絲心蛋白 3 和 4）的共有序列的不同重組蜘蛛絲蛋白被加工成 2D 圖案薄膜和 3D 水凝膠。引人注目的是奈米級蛋白質結構特徵是檢測到微生物排斥性的基礎。設計的蜘蛛絲材料促進了哺乳動物細胞的附著和增殖，同時抑制了微生物的侵擾。」 (Kumari 等人, 2020:21)

"The consensus sequences of Araneus diadematus dragline silk proteins (fibroin 3 and 4) were processed into 2D-patterned films and 3D-hydrogels. Strikingly, protein structure characteristics on the nanoscale are the basis for the detected microbe-repellence. Designed spider silk materials promoted mammalian cell attachment and proliferation while inhibiting microbial infestation." (Kumari et al., 2020:21)

「我們證明了 *Tegenaria domestica* 的原生網絲可以抑制革蘭氏陽性細菌枯草芽孢桿菌的生長。沒有檢測到對革蘭氏陰性細菌大腸埃希氏菌的生長有顯著抑制作用。對枯草芽孢桿菌的抗微生物作用似乎是短暫的，因此活性劑可能以抑菌而不是殺菌的方式起作用。用蛋白酶 K 處理絲似乎降低了抑制細菌生長的能力。這與活性劑（包括通過處理變性或切割的蛋白質元素）是一致的。」（Write 和 Goodacre，2012）

"We demonstrate that native web silk of *Tegenaria domestica* can inhibit the growth of the Gram positive bacterium, Bacillus subtilis. No significant inhibition of growth was detected against the Gram negative bacterium, Escherichia coli. The antimicrobial effect against B. subtilis appears to be short lived thus the active agent potentially acts in a bacteriostatic rather than bactericidal manner. Treatment of the silk with proteinase K appears to reduce the ability to inhibit bacterial growth. This is consistent with the active agent including a protein element that is denatured or cleaved by treatment." (Write and Goodacre, 2012)

參考文獻清單與連結 (REFERENCE LIST) **Harvard 或 APA 格式**

Kumari (2021) Engineered spider silk-based 2D and 3D materials prevent microbial infestation https://www.sciencedirect.com/science/article/pii/S1369702120302236

Write,Goodacre(2012) Evidence for antimicrobial activity associated with common house spider silk https://pubmed.ncbi.nlm.nih.gov/22731829/

延伸閱讀: Harvard 或 APA 格式（取自 AskNature 原文；若為翻譯者補充，請註明）

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

蜘蛛網堅固而富有彈性

受蜘蛛絲啟發的抗菌生物材料

鹽和擠壓將液體變成蜘蛛絲

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AskNature 原文連結

https://asknature.org/strategy/spider-silks-antibacterial-power/