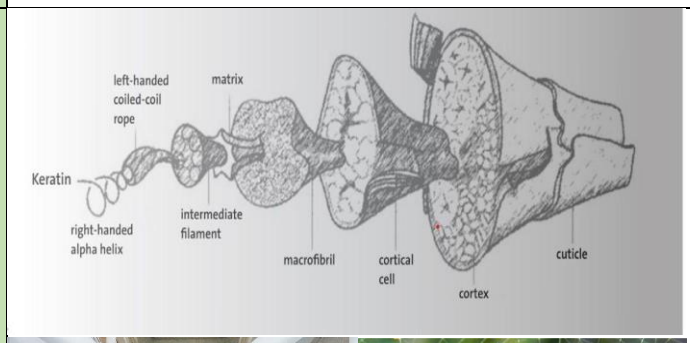
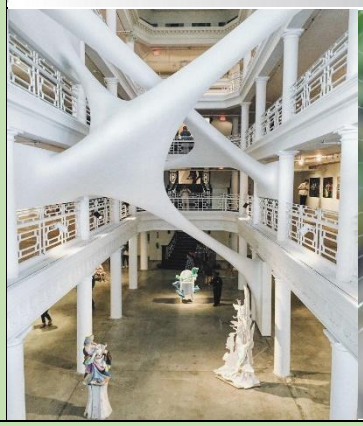
生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	蜘蛛網吸收衝擊 (Web absorbs impacts)
生物系統 LIVING SYSTEM	蜘蛛 Arachnids (Spider)
功能類別 FUNCTIONS	#應付撞擊 #Manage impact
作用機制標題	圓蛛科的蜘蛛網透過精微的工程來吸收衝擊 (Webs of araneid spiders absorb impacts via microscopic engineering)
生物系統/作用機制示意圖	  

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

蜘蛛網的優越性能不僅歸功於絲線的極限強度，還歸功於其對於壓力的非線性變化反應 (nonlinear response)，以及蜘蛛網的幾何形狀排列。蛛絲的納米晶體 (nanocrystal) 呈現堆疊排列，每一層都轉向 (dial) 不同方向進行堆疊。 它們透過弱氫鍵 (hydrogen bond) 連結在一起，氫鍵在堆疊中共同作用以抵抗外力。

Spider webs owe their superior performance not just to the ultimate strength of the silk thread, but also from its nonlinear response to stress and its alignment within the geometry of the web. The

silk nanocrystals are a stacked arrangement with each layer dialed in a different direction. They are held together by weak hydrogen bonds that act together in the stack to resist external force.

文獻引用 (REFERENCES)

「在這個研究中，我們報告了一種機制，能增強蜘蛛網吸收能量的能力。透過對螺旋狀和放射狀蛛絲機械性能的系統測量 (systematic measurement)，我們發現螺旋狀蛛絲沿著纖維網徑向方向 (radial direction) 的直徑和抗拉剛度 (tensile stiffness) 具有明顯的梯度變化 (gradient variation)，而放射狀蛛絲則具有更高但接近均勻的剛性。」

「蜘蛛利用不同的絲線和幾何結構來構築這些輕量級 (lightweight) 的網絡，以增加強度和彈性。」

「蜘蛛絲以其不尋常地結合了輕巧又非常結實的特質而聞名，在某些情況下強度還比鋼鐵強。」

"In this work, we report a mechanism that enhances the energy absorption ability of spider webs. Through systematic measurements of the mechanical properties of both spiral and radial silks, we find that the spiral silks feature a distinct gradient variation in the diameter and tensile stiffness along the radial direction of the web, while the radial silks have a much higher but approximately uniform stiffness."

"Spiders architect these lightweight networks for strength and elasticity using different silks and geometric structures."

"Spider silk is well-known for its unusual combination of being both lightweight and extremely strong and in some cases, stronger than steel."

參考文獻清單與連結 (REFERENCE LIST)

Guo, Y., Z. Chang, B. Li, Z. Zhao, H. Zhao, X. Feng, and H. Gao. (2018). Functional gradient effects on the energy absorption of spider orb webs. *Appl. Phys. Lett.* 113: 103701. (https://www.colorado.edu/lab/vernerey/sites/default/files/attached-files/gradient_effects.pdf)

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