生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	黏液可防止昆蟲叮咬 (Glue Protects From Insect Bites)
生物系統 LIVING SYSTEM	聖十字蛙 (Crucifix Toad)
功能類別 FUNCTIONS	#保護自身免受動物危害 #獲取、吸收、或過濾 #永久性附著 #Protect From Animals #Capture, absorb, or Filter Organism #Attach Permanently
作用機制標題	產於澳大利亞的 Notaden 屬(架紋蟾)的外皮能分泌一種使昆蟲口器黏住的黏液，進而保護自身免受昆蟲叮咬。 (The skin of Australian frogs of the genus Notaden protects from insect bites via a secreted glue, which gums up insect mouthparts.)
生物系統/作用機制示意圖 (確認版權、註明出處；畫質)	 https://en.wikipedia.org/wiki/File:Notaden_bennettii.JPG#filehistory (96dpi)

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

兩種澳洲青蛙會分泌一種黏性物質於皮膚上，以保護自己免受昆蟲的侵害。這種黏液會使昆蟲的口器黏在青蛙的皮膚上，青蛙之後可以吃掉黏在皮膚上的昆蟲。阿得雷德大學的環境生物學家邁克·泰勒（Mike Tyler）發現了這種皮膚黏液，他與新南威爾斯大學的骨科醫生喬治·默爾爾（George Murrell）合作，將這種黏液用於半月板軟骨撕裂的羊身上進行了測試。他們發現這種黏液在幾秒鐘內就會凝固並且具有良好的黏附性，即使在潮濕的環境中也能保持穩定狀態。一旦凝固，它具有柔軟的特性以及多孔的結構，如此一來可以促進氣體和營養物質的滲透，幫助傷口的癒合。在羊身上使用時，它能夠有效地將損壞的膝蓋軟骨固定在一起。科學家與墨爾本的聯邦科學與工業研究組織合作，歸納了此黏液的關鍵成分，並且現在正在開發這種蛋白質的基因工程版本。

“Two species of Australian frogs secret a sticky substance over their skin to protect themselves from biting insects. The glue jams up the insects’ jaws, causes them to stick to the frogs’ skin, and the frogs can later eat the stuck insects. Mike Tyler, an environmental biologist from the University of Adelaide who discovered the skin glue, teamed up with orthopaedic surgeon George Murrell of the University of New South Wales to test the glue in sheep with torn knee cartilage. They found that the glue hardens within seconds and sticks well, even in moist environments. When set, it is flexible and has a porous structure that should make it permeable to gas and nutrients, which would encourage healing. When used on the sheep, it worked well at holding damaged knee cartilage together. Working with colleagues at the Commonwealth

Scientific and Industrial Research Organisation in Melbourne, the scientists have characterized a key component of the glue and are now developing a genetically engineered version of this protein."

文獻引用 (REFERENCES)

「當被刺激時，聖十字蛙會分泌一種會迅速形成一種具黏性及彈性的固態分泌物(蛙膠)。這種基於蛋白質的材料作為一種廣泛適用的壓敏黏著劑即使是在潮濕條件下也能發揮作用。我們在空氣環境中進行了宏觀測試，評估了的濕潤狀態下蛙膠的拉伸強度（高達78+8 千帕）和乾燥狀態下的剪切強度（1.7+0.3 兆帕）。我們還在水中進行了奈米力學測量，以確定以不同方式收集的固體蛙膠的黏附力（1.9-7.2 nN 或更大）、彈性（43-56%）和彈性模量（170-1035 千帕）。乾膠主要由少量碳水化合物，以及數種蛋白質組成。其中富含 Gly（15.8 莫耳%）、Pro（8.8 莫耳%）和 Glu / Gln（14.1 莫耳%）；它還含有一些 4-羥脯氨酸（4.6 莫耳%），但沒有 5-羥基賴氨酸或 3,4-二羥基苯丙氨酸（L-Dopa）。蛙膠的變性凝膠電泳顯示了一種蛋白質的特性模式，涵蓋了 13-400 千道爾頓的蛋白質。最大的蛋白質（Nb-1R，顯示分子量為 350-500 千道爾頓）也是最豐富的，這種蛋白質似乎是關鍵的結構組分。固體的蛙膠可以在稀釋酸中溶解；提高離子強度使蛙膠的成分自行自我組裝成一種與原成份相似的固體。我們歸納了對溶解狀態下及固體蛙膠的研究，得到了膠表面和截面的顯微鏡圖像，顯示了與濕膠的高含水量特性（85-90 wt %）一致的多孔內部。除了與其他生物組織黏著劑和眾所周知的彈性體蛋白質的組成相似之外，溶解狀態下的蛙膠的圓二色光譜幾乎與可溶性彈性蛋白質相同，電子和掃描探針顯微鏡圖像也可與絲蛋白纖維進行比較。欲使膠凝固共價交聯似乎是不必要的。」(Graham et al. 2005:3300)

「目前的組織膠和密封劑要麼是主要是蛋白質組成的，它們表現出較低的粘合強度，要麼是合成的，它們形成固化且不透水的屏障，阻礙了傷口癒合。我們的研究結果表明，Bennett's 屬（N. bennetti）分泌物迅速且自發地形成了一種由蛋白質組成的壓敏性黏著劑，且在潮濕環境中表現良好。水合狀態下的固體具有很高的彈性，由多孔的網狀組織所組成，在臨床情況下允許氣體和營養物質的擴散。由於一些腔半徑.....等於直徑超過10 微米的孔，因此水合材料很可能也允許一定程度的細胞滲透。初步實驗表明，這種膠具有很高的生物相容性，已成功用於外科手術中，黏合體外以及體內斷裂的軟骨組織。」(Graham et al. 2005:3311)

"When provoked, *Notaden bennetti* frogs secrete an exudate which rapidly forms a tacky elastic solid ('frog glue'). This protein-based material acts as a promiscuous pressure-sensitive adhesive that functions even in wet conditions. We conducted macroscopic tests in air to assess the tensile strength of moist glue (up to 78 $\pm$ 8 kPa) and the shear strength of dry glue (1.7 $\pm$ 0.3 MPa). We also performed nanomechanical measurements in water to determine the adhesion (1.9-7.2 nN or greater), resilience (43-56%), and elastic modulus (170-1035 kPa) of solid glue collected in different ways. Dry glue contains little carbohydrate and consists mainly of protein. The protein complement is rich in Gly (15.8 mol %), Pro (8.8 mol %), and Glu/Gln (14.1 mol

%); it also contains some 4-hydroxyproline (4.6 mol %) but no 5-hydroxylysine or 3,4-dihydroxyphenylalanine (L-Dopa). Denaturing gel electrophoresis of the glue reveals a characteristic pattern of proteins spanning 13-400 kDa. The largest protein (Nb-1R, apparent molecular mass 350-500 kDa) is also the most abundant, and this protein appears to be the key structural component. The solid glue can be dissolved in dilute acids; raising the ionic strength causes the glue components to self-assemble spontaneously into a solid which resembles the starting material. We describe scattering studies on dissolved and solid glue and provide microscopy images of glue surfaces and sections, revealing a porous interior that is consistent with the high water content (85-90 wt %) of moist glue. In addition to compositional similarities with other biological adhesives and well-known elastomeric proteins, the circular dichroism spectrum of dissolved glue is almost identical to that for soluble elastin and electron and scanning probe microscopy images invite comparison with silk fibroins. Covalent cross-linking does not seem to be necessary for the glue to set." (Graham et al. 2005:3300)

"Current surgical glues and sealants are either protein-based, in which case they exhibit low bond strength, or synthetic, in which case they form rigid and impervious barriers that hinder wound healing. Our results show that the exudate from N. bennetti frogs rapidly and spontaneously forms a proteinaceous pressure-sensitive adhesive that functions well in wet environments. The hydrated solid is highly elastic and consists of a porous mesh that in clinical contexts should allow the diffusion of gases and nutrients. Since some of the cavity radii…equate to pores with diameters in excess of 10 μm, it is likely that the hydrated material will also permit a degree of cellular infiltration. Initial experiments suggest that the glue is highly biocompatible, and it has been used successfully to bond severed cartilage tissue both ex vivo and in vivo." (Graham et al. 2005:3311)

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

Lloyd D. Graham (2005) Characterization of a Protein-based Adhesive Elastomer Secreted by the Australian Frog Notaden bennett (https://pubs.acs.org/doi/10.1021/bm050335e)
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