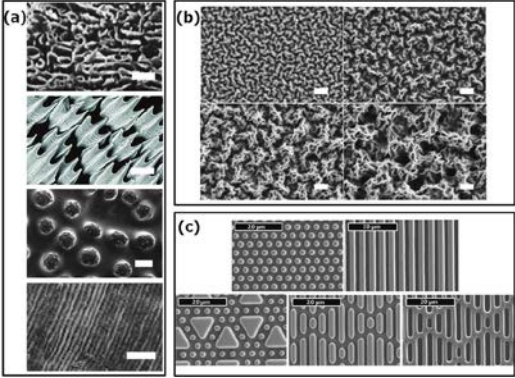


# 生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	皮膚抵禦微生物 (Skin resists microorganisms)
生物系統 LIVING SYSTEM	長肢領航鯨 <i>Globicephala melas</i> (Pilot whale)
功能類別 FUNCTIONS	#化學性分解有機化合物 #改變材料特性 #防止破裂/斷裂 #保護免受動物危害 #保護免受微生物危害 #Chemically break down organic compounds #Modify material characteristics #Prevent fracture/rupture #Protect from animals #Protect from microbes
作用機制標題	領航鯨的皮膚由於微細孔洞和奈米脊狀隆起被分泌的凝膠酶包圍，能使蛋白質和碳水化合物變性，使之具抵抗微生物的能力 (The skin of pilot whales resists microorganisms thanks to microscopic pores and nanoridges, surrounded by a secreted enzymatic gel which denatures proteins and carbohydrates.)
生物系統/作用機制 示意圖	
作用機制摘要說明 (SUMMARY OF FUNCTIONING MECHANISMS)	
<p>「Christoph Baum 和德國漢諾威獸醫學院的一個研究小組發現領航魚的皮膚具有特化的奈米結構，可以阻止藤壺幼蟲等微生物聚集，他們計劃模仿此想法到防污塗層上。Baum 與他的團隊以低溫掃描式電子顯微鏡檢視了冷凍乾燥的領航鯨皮膚，他們發現由 0.1 微米的小孔洞組成的表面，周圍被奈米脊狀隆起 (nanoridge) 圍繞著，而且隆起之間是橡膠狀凝膠，含有能使蛋白質和碳水化合物變性的酵素。於皮膚細胞之間縫隙中分泌的凝膠，會在鯨魚脫皮時重新填充。Baum 認為這是使細菌和矽藻等生物難以黏附於皮膚上的原因，如果它們嘗試依附在凝膠上，酵素就會攻擊它們。沒有這些先驅者，甲殼類或軟體動物的幼蟲等較大型生物便很難在鯨魚的皮膚上創建群落。該團隊打算為鯨魚皮膚的衍生設計申請專利，作為比現有的防污塗料更加環保的替代品。Baum 計劃使用各種可生物降解的材料來模仿皮膚。」 (由仿生協會提供)</p> <p>“Christoph Baum and a team from the Hanover School of Veterinary Medicine in Germany have discovered that a pilot whale’s skin has a specialised nano-structure that stops the build-up of microscopic organisms such as barnacle larvae. They plan to mimic the idea in an anti-</p>	

fouling paint. Baum and his team examined freeze-dried samples of pilot whale skin under a cryo-scanning electron microscope. They discovered a surface made up of tiny pores 0.1 micrometres across surrounded by raised 'nanoridges'. In between the ridges is a rubber-like gel containing enzymes that denature proteins and carbohydrates. The gel, which oozes out of the gaps between skin cells, is replenished as the whale sheds its skin. Baum thinks that organisms such as bacteria and diatoms have trouble sticking to the ridge edges, which provide little purchase. And if they try hanging onto the gel the enzymes will attack them. Without these pioneers, larger creatures such as crustacean or mollusc larvae have a hard time colonising the whale's skin. The group intends to patent a version of the pilot whale's skin as a more eco-friendly alternative to existing anti-fouling paints. To copy the skin, Baum plans on using a variety of biodegradable materials." (Courtesy of the Biomimicry Guild)

#### 文獻引用 (REFERENCES)

「在海豚的皮膚表面上的小型生物污垢微生物，在海豚的跳躍過程中面臨到高剪切水流和氣泡的液態-氣態界面的挑戰。由均勻分布的奈米粗糙凝膠包覆的表皮能有助這種狀況的自我清潔。目前針對於長肢领航鯨的細胞間的凝膠形成演化和皮膚表面光滑凝膠的化學組成的研究...在表皮的表層中，也就是角質層，顯示了細胞間物質...是在角質細胞往皮膚表面運移時，由較小到較大的共價鍵交叉鏈接聚集而成。XPS 測量 (X-ray photoelectron spectroscopy) 顯示皮膚表面和細胞間凝膠包含數量相同的極性基團 (尤其是游離胺和酰胺) 和非極性基團，對應於分散在凝膠組成中出現的脂肪液滴。從結果得皮膚表面的凝膠塗層是化學異質皮膚產物的結論。化學異質斑塊有助於微量的生物污垢在產生過程中去除的益處也一併討論。」 (Baum et al. 2003: 181)

"On the skin surface of delphinids small biofoulers are challenged to high shear water flow and liquid-vapor interfaces of air-bubbles during jumping. This state of self-cleaning is supported by the even, nano-rough gel-coated epidermal surface of the skin. The present study focused on the intercellular evolution of gel formation and the chemical composition of the gel smoothing the skin surface of the pilot whale, *Globicephala melas*...In the superficial layer of the epidermis, the stratum corneum, intercellular material was shown...to assemble from smaller into larger covalently cross-linked aggregates during the transit of the corneocytes towards the skin surface. XPS measurements showed that the surface of the skin and the intercellular gel included approximately the same amounts of polar groups (especially, free amines and amides) and non-polar groups, corresponding to the presence of lipid droplets dispersed within the jelly material. It was concluded from the results that the gel-coat of the skin surface is a chemically heterogeneous skin product. The advantages of chemically heterogeneous patches contributing to the ablation of traces of the biofouling process are discussed." (Baum et al. 2003: 181)

#### 參考文獻清單與連結 (REFERENCE LIST)

Baum, C., F. Simon, W. Meyer, L. G. Fleischer, D. Siebers, J. Kacza, and J. Seeger. (2003). Surface properties of the skin of the pilot whale *Globicephala melas*. *Biofouling* 19: 181-186. (<https://reurl.cc/exM4zW>)

Baum, C., W. Meyer, R. Stelzer, L. G. Fleischer, and D. Siebers. (2002). Average nanorough skin surface of the pilot whale (*Globicephala melas*, Delphinidae): considerations on the self-cleaning abilities based on nanoroughness. *Marine Biology*. 140: 653-657. (<https://reurl.cc/QdYkRO>)

Brebbia, C. A., L. J. Sucharov, and P. Pascolo. (2002). *Design and nature (comparing design in nature with science and engineering)*. WIT Press / Computational Mechanics

d'Auzac, J., J. L. Jacob, H. Chrestin. (2018). *Physiology of rubber tree latex: the laticiferous cell and latex-a model of cytoplasm*. CRC press.

#### 延伸閱讀

Rigo, S., C. Cai, G. Gunkel-Grabole, L. Maurizi, X. Zhang, J. Xu, and C. G. Palivan. (2018). Nanoscience-based strategies to engineer antimicrobial surfaces. *Advanced science* 5: 1700892. (呂佳宜提供)

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

[https://en.wikipedia.org/wiki/Long-finned\\_pilot\\_whale](https://en.wikipedia.org/wiki/Long-finned_pilot_whale)

#### 撰寫/翻譯/編修者與日期

呂佳宜翻譯 (2020/05/01)；許秋容編修 (2020/06/08)；譚國鏞編修 (2020/06/16)

AskNature 原文連結

<https://asknature.org/strategy/skin-resists-microorganisms/>