生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	表面形狀控制冰的的形成 (Surface Shape Controls Ice)
生物系統 LIVING SYSTEM	植物 (plants)
功能類別 FUNCTIONS	#抗凍 #Protect from ice
作用機制標題	宏觀的幾何結構直接影響水凝固及霜形成的位置。 (Macro-scale geometry directs where water condenses and frost forms.)
生物系統/作用機制示意圖 (確認版權、註明出處；畫質)	 https://asknature.org/wp-content/uploads/2021/10/frost-leaves-pub-dom-2160x671.jpg

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

潮濕空氣中的水蒸氣接觸溫度低於凝固點的表面會形成霜。平滑表面上的任何位置都同樣適合水滴形成。然而，圍繞突出物體的空氣（和水蒸氣）體積比圍繞凹陷表面的空氣體積還大，所以水蒸氣有更大的機率在這些地方凝固。此外，當霜傾向在突起處形成，各顆冰晶會吸引更多冰形成並生長。

相似的原理作用在液態水凝固於相對較大的隆起—納米布沙漠甲蟲 (*Onymacris unguicularis*）的背上。凝固更可能發生在這些較沒有遮蔽且比其他地方突出於空氣的位置，且蒸發往往會去除凝結在凹陷處的少量水。

Frost forms when water vapor in humid air makes contact with a surface that is below freezing temperature. Every location on a smooth surface is equally suitable for becoming the site of a water droplet. However, the volume of air (and water vapor) around things that “stick out” is greater than the volume of air around embedded, concave surfaces that “stick in”. So there are simply more chances for a quantity of water vapor to condense at these locations. Moreover, as frost appears preferentially on convex features, individual ice crystals attract more ice formation and grow.

Similar principles are at work with water in liquid form condensing on the relatively large bumps on the back of the Namib Desert Beetle (*Onymacris unguicularis*). Condensation is more likely to happen on these more exposed, convex features that stick out into the air volume than elsewhere, while evaporation tends to remove what little water has condensed on concave features.

文獻引用 (REFERENCES)

「有些種類的沙漠甲蟲會用牠們崎嶇不平的背收集水，但這些表面的地形特徵卻被忽視，主因是之前大部分的研究在以微尺度和奈米級紋路研究為基礎的情況下，將優先冷凝 (preferential condensation) 歸因於表面化學（親水性的隆起和疏水性的環境），並將凸起的地貌 (convex topography)劣於凹陷地貌 (concave)。然而，甲蟲的背部隆起很大(毫米以上)，且近來的研究顯示，整個隆起表面均勻的覆蓋著一層疏水性的蠟，進而對局部表面化學在促進凝固中的作用產生疑問。因此我們認為，即使沒有局部化學模式或微尺度/奈米級紋路，只有毫米大小突起表面結構的特定幾何形狀，就能促進凝固，而人造突起表面也能設計出可透過在尖端聚集水蒸氣擴散通量使水滴快速、集中的成長。」 (Park 等人 2016: 78)

"Several desert beetle species harvest water using their bumpy backs, but the topography of these surfaces has been overlooked, primarily because most previous studies attributed preferential condensation to surface chemistry (hydrophilic bumps with hydrophobic surroundings) and discounted convex topography as inferior to concave, on the basis of research into microscale and nanoscale textures. However, the beetle bumps are large (millimetres across), and recent studies have reported that the entire bumpy surfaces are homogeneously covered with hydrophobic wax, thus questioning the role of localized surface chemistry in promoting condensation. We considered instead that even in the absence of localized chemical patterning or microscale/nanoscale textures, the specific geometry of convex millimetre-sized surface structures alone could facilitate condensation, and therefore the topography of synthetic bumpy surfaces could potentially be designed to optimize fast, localized droplet growth by focusing vapour diffusion flux at the apex." (Park et al. 2016: 78)

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

Condensation on slippery asymmetric bumps
Nature | 2016 | Park, K.C., Kim, P., Grinthal, A., He, N., Fox, D., Weaver, J.C. and Aizenberg, J.

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)

撰寫/翻譯/編修者與日期

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AskNature 原文連結

https://asknature.org/strategy/surface-shape-controls-ice/

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