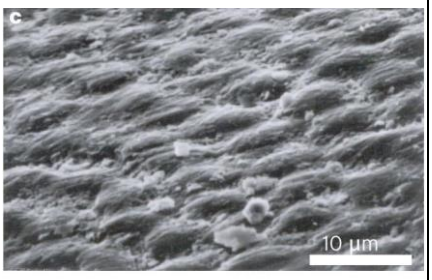
生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	從空氣中喝水的甲蟲 (The beetles that drink water from air)
生物系統 LIVING SYSTEM	擬步甲/暗甲蟲 (Darkling beetles)
功能類別 FUNCTIONS	#獲取、吸收、或過濾液體　　#適應行為 #Capture, absorb, or filter liquids　　#Adapt behaviors
作用機制標題	暗甲蟲的翅膀和一些身體部位上的奈米結構有助於從潮濕的空氣中凝結水　(Nanostructures on darkling beetle wings and certain body positions help condense water from humid air.)
生物系統/作用機制示意圖 (確認版權、註明出處；畫質)	  Scanning electron micrograph of the textured surface of the depressed areas on Stenocara surface.

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

位於非洲西南海岸的納米比沙漠的暗甲蟲(擬步行蟲科, family Tenebrionidae)，生活在世界最乾燥的棲息地之一。但是一些種類的暗甲蟲可以運用他們特有的體表從露水和海霧中獲取他們所需的水分。

一些研究人員正在研究甲蟲和藉由甲蟲身體所啟發的合成表面，以揭露結構、化學、和行為在空氣中捕捉水分此一過程所扮演的角色。

甲蟲硬化前翅上的微型凹槽和凸起可以幫助凝結水和將水導向甲蟲等待的嘴巴，這些結構上的親水 (hydrophilic)　(吸引水) 和疏水 (hydrophobic) (排斥水) 區域的組合可能會增加霧和露水的收集效率。對於某些暗甲蟲物種來說，面向霧風且將其後部舉起的行為 (稱為沐霧行為) (或譯為霧曬) (fog-basking behavior) 被認為跟成功地從空氣中收集水分的體表結構一樣重要。

根據世界野生動物基金會 (世界自然基金會) 的數據，世上有 10%的動物依賴著淡水棲息地，而淡水棲息地在我們的地表上僅僅只佔有 1%。然而這些不足的資源正日漸受到發展、汙染、和氣候變遷的威脅。隨著全球氣溫上升，更多的水分被吸收到大氣中，且在稱為「水氣反饋」(water vapor feedback) 的過程中增加了濕度和提供了額外的溫暖。

暗甲蟲從大氣中收集水分的方法可以幫助人類在缺乏可用地表水的偏遠地區收集淡水。它還可能啟發更多可以減少發電廠和工業設備用水量的有效的蒸發冷卻設計。也許學習怎麼有效地移除大氣中的水分可以提供我們一種放慢或停止水氣反饋的方法，幫助我們緩解全球的升溫。

Darkling beetles (family *Tenebrionidae*) of the Namib Desert, located on the southwest coast of Africa, live in one of the driest habitats in the world. But some species of Darkling beetle can get the water they need from dew and ocean fog, using their very own body surfaces.

Several researchers are studying the beetles, as well as synthetic surfaces inspired by the beetle's body, to uncover the roles that structure, chemistry, and behavior play in capturing water from the air.

Micro-sized grooves or bumps on the beetle's hardened forewings can help condense and direct water toward the beetle's awaiting mouth, while a combination of hydrophilic (water attracting) and hydrophobic (water repelling) areas on these structures may increase fog- and dew-harvesting efficiency. For certain species of Darkling beetle, the act of facing into the foggy wind and raising its rear end up in the air (known as fog-basking behavior) is thought to be just as important as body surface structure for successfully harvesting water from the air.

According to the World Wildlife Fund, 10% of all animals depend on freshwater habitats that occupy a mere 1% of the surface of our planet. And these scant resources are increasingly jeopardized by development, pollution, and climate change. As global temperatures rise, more water absorbs into the atmosphere, raising humidity and providing additional warming in a process called "water vapor feedback."

Darkling beetles' method of harvesting water from the atmosphere could help humans gather fresh water in remote areas that lack access to surface water. It may also inspire more efficient evaporative cooling designs that reduce water consumption in power plants and industrial facilities. Perhaps learning how to efficiently remove water from the atmosphere could even provide a means of slowing or stopping water vapor feedback, helping us mitigate rising global temperatures.

文獻引用 (REFERENCES)

納米比沙漠有種類繁多的暗甲蟲，其中少數會積極地利用霧來攝取水份。其中一些會建造沙溝和山脊來捕捉霧氣，而其他像是 *Onymacris unguicularis* 和 *O. bicolor* 則利用他們自己身體的表面做為霧水的收集器。透過採取迎風的像是倒立的姿勢，霧水收集在他們的鞘翅上並流入他們的嘴中，最終被甲蟲吸收。這種獨特的行為被稱為沐霧。在極度乾燥的沙漠中，收集霧氣取水的優勢是顯而易見的，當有很長一段時間都沒有降雨時，這就變得很重要。長期對納米比沙漠的暗甲蟲種群密度的研究清楚地顯示在降雨量少的期間，會收集霧氣的甲蟲仍佔有很多的數量，反之大部分缺乏這種適應性的暗甲蟲則消失或減少到不到平均豐富度的 1%。 (Norgaard and Dacke 2010:1-2)

…我們調查了… *Physasterna cribripes* (擬步行蟲科) 甲蟲鞘翅表面保存標本的潤濕度和結構性質，其宏觀結構為一系列凸起且之間有凹槽。結露實驗在冷凝室中進行。表面性質 (紅外線放射率、潤濕性) 被鞘翅表面的蠟所控制，在較小的程度上，他的微觀結構…結露會發生在昆蟲的鞘翅上，這可以用表面性質來解釋。從冷凝水的表面覆蓋率來看，露水主要在凸起之間的凹槽形成。凸起和凹槽之間液滴成核率的差異可以歸因於凹槽而表面上的六邊形顯微結構，而凸點的表面是光滑的。當液滴達到一定的大小時，就會滑下並匯聚於昆蟲的口中。 (Guadarrama et al. 2014)

The Namib Desert has a remarkably high variety of Darkling beetles (Tenebrionidae) and a handful of them actively exploit fog for water intake [5,6]. Some of these construct sand trenches or ridges to catch the fog, while *Onymacris unguicularis* and *O. bicolor* instead utilise

their own body surface as a fog water collector [7-9]. By adopting a head standing posture facing into the wind, the fog water collects on their elytra and runs down to their mouth, to be imbibed by the beetles. This unique behaviour is termed fog-basking [7]. The advantage of fog collection for water intake in the extremely arid desert is obvious, and becomes critical when rainfall is absent over prolonged periods of time. Long term studies on the population density of Darkling beetles in the Namib Desert clearly shows that the fog collecting beetles are still present in great numbers during periods of low rainfall, whereas the large majority of Darkling beetles that lack this adaptation disappear or decline to less than 1% of their mean abundance. (Norgaard and Dacke 2010:1-2)

…we investigated…the wetting and structural properties, of the surface of the elytra of a preserved specimen of *Physasterna cribripes* (Tenebrionidæ) beetle, where the macro-structure appears as a series of "bumps", with "valleys" between them. Dew formation experiments were carried out in a condensation chamber. The surface properties (infra-red emissivity, wetting properties) were dominated by the wax at the elytra surface and, to a lower extent, its micro-structure… Dew formation occurred on the insect's elytra, which can be explained by these surface properties. From the surface coverage of the condensed drops, it was found that dew forms primarily in the valleys between the bumps. The difference in droplet nucleation rate between bumps and valleys can be attributed to the hexagonal microstructure on the surface of the valleys, whereas the surface of the bumps is smooth. The drops can slide when they reach a critical size, and be collected at the insect's mouth. (Guadarrama et al. 2014)

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

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