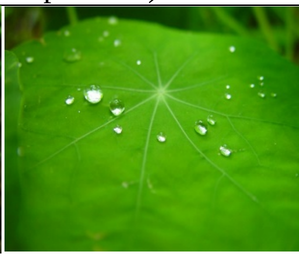
生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	葉脊減少與水分接觸的時間 (Leaf ridges reduce contact time with water drops)
生物系統 LIVING SYSTEM	金蓮花 *Tropaeolum majus* (Nasturtium)
功能類別 FUNCTIONS	#改變大小/形狀/質量/體積 #改變速度 #在液體中/上移動 #保護免受過多液體危害 #Modify size/shape/mass/volume #Modify speed #Move in/on liquids #Protect from excess liquids
作用機制標題	庭園金蓮花的葉脊透過加快水滴回彈作用來減少與水滴接觸的時間 (Ridges on garden nasturtium leaves reduce contact time with water drops by enabling faster drop recoil.)
生物系統/作用機制示意圖	  

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

許多植物都有疏水性的葉片。當雨滴落在這些植物表面上時，它們往往會彈落，並且水滴與表面接觸的時間越短，其附著並留下水分的可能性則越小。

庭園金蓮花 (Garden nasturtium, *Tropaeolum majus*) 是一種常見的園藝植物，其葉子可以透過改變具有較大葉脈和葉脊 (ridge) 表面的宏觀紋理 (macrotextured) 來改變液滴的水動力，從而減少水滴與葉子的接觸時間。

在大多數光滑或具有微型紋理 (microtextured) 的表面上，水滴撞擊表面，然後受到「軸對稱回彈力 (axisymmetric recoil) 」：水滴散佈成厚度均勻的煎餅狀然後彈回，以大致圓形的形狀並以均勻的速度繞著邊緣。展開的液滴的中心是靜態的，在回彈作用上只有少部分參與。在具有宏觀紋理（最高 150 微米高）的葉脊和葉脈表面上，例如金蓮花葉片，如果水滴碰到了葉脊，則將受到「中心輔助回彈力」。葉脊改變了水滴的行為，使得其以不對稱的形狀回彈，而且每個散開區域的中心的液體均有助於回彈。這是有可能的，原因在於葉脊上的液體層比表面上的其他任何地方都薄，因此與水滴的其他部分相比，有較少量的液體可以反向加速而能以較快速度回彈。水滴內這種不均勻的回彈速度會使其破碎，從而導致較小而連接的碎片能更快地回彈。此外，與大量水相比，更多的水滴會造成更多的反作用力。

Many plants have hydrophobic (water repellent) leaves. When raindrops fall on these surfaces, they tend to bounce off, and the less time a liquid drop spends in contact with a surface, the lower the likelihood that it will stick and leave some moisture behind.

Garden nasturtium (*Tropaeolum majus*), a common backyard garden plant, has leaves that appear to reduce the contact time of incoming liquid drops by altering drop hydrodynamics with a “macrotextured” surface of relatively large veins and ridges.

On most smooth or microtextured surfaces, incoming drops hit the surface and then experience “axisymmetric recoil”: the drop spreads out into a pancake shape with uniform thickness, and then bounces back up, recoiling with a roughly circular shape and uniform speed around its edges. The center of the spread out drop is static, and has little role in the recoil. On surfaces with macrotexture (up to 150 microns high) ridges and veins, like nasturtium leaves, if a drop hits a ridge, it experiences “center-assisted recoil” instead. The ridge alters the behavior of the drop so that it recoils in an asymmetrical shape, and the liquid in the center of each spread out region contributes to recoil. This is possible because the liquid layer above the ridge is thinner than elsewhere on the surface, so it has less liquid to accelerate back up and recoils faster than other parts of the drop. This non-uniform recoil speed within the drop tends to make it fragment, resulting in small, connected fractions that recoil more quickly. In addition, more of the drop contributes to recoil than would be the case with one big mass of water.

文獻引用 (REFERENCES)

葉面讓水滴不會附著而是彈離表面的設計得到了大量的關注，因為它們有保持乾燥及體潔淨的能力，還可以抵抗結冰。水滴碰到這種乾燥表面時其直徑將會擴散到最大值，接下來水滴會完全回彈並離開固體物質。水滴與固體的接觸時間取決於水滴的慣性跟毛細作用、內部消散以及液體與表面的相互作用。因為接觸時間決定了水滴與表面的質量、動量和能量交換程度，所以必須要讓接觸時間最小化。常見的方法是減少可以導致接觸線停滯不前的表面與液體相互作用；但是即使在沒有任何表面相互作用的情況下，水滴的流體動力學也會讓其造成最小的接觸時間，這通常被認為是藉由軸對稱的擴散以及反彈水滴的作用所影響。在這裡，我們示範了使用具有重新分配液體質量從而改變水滴流體動力學形態的超疏水表面，可以將接觸時間減少到理論上的極限以下。(Bird et al. 2013: 385)

“Surfaces designed so that drops do not adhere to them but instead bounce off have received substantial attention because of their ability to stay dry, self-clean5,6,7 and resist icing8,9,10. A drop striking a non-wetting surface of this type will spread out to a maximum diameter11,12,13,14 and then recoil to such an extent that it completely rebounds and leaves the solid material15,16,17,18. The amount of time that the drop is in contact with the solid—the ‘contact time’—depends on the inertia and capillarity of the drop1, internal dissipation19 and surface–liquid interactions20,21,22. And because contact time controls the extent to which mass, momentum and energy are exchanged between drop and surface23, it is often advantageous to minimize it. The conventional approach has been to minimize surface–liquid interactions that can lead to contact line pinning20,21,22; but even in the absence of any surface interactions, drop hydrodynamics imposes a minimum contact time that was conventionally assumed to be attained with axisymmetrically spreading and recoiling drops21,24. Here we demonstrate that it is possible to reduce the contact time below this theoretical limit by using superhydrophobic surfaces with a morphology that redistributes the liquid mass and thereby alters the drop hydrodynamics." (Bird et al. 2013: 385)

參考文獻清單與連結 (REFERENCE LIST)

Bird, J. C., R. Dhiman, H. M. Kwon, and K. Varanasi. (2013). Reducing the contact time of a bouncing drop. *Nature* 503: 385-388. (https://www.nature.com/articles/nature12740)

延伸閱讀: Harvard 或 APA 格式

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

https://en.wikipedia.org/wiki/Tropaeolum_majus

撰寫/翻譯/編修者與日期

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AskNature 原文連結

https://asknature.org/strategy/leaf-ridges-reduce-contact-time-with-water-drops/