生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	瓣膜調控水分通透性 (Valve regulates water permeability)
生物系統 LIVING SYSTEM	木本羽扇豆 *Lupinus arboreus* (Tree lupin)
功能類別 FUNCTIONS	#保護免受過多液體危害 #Protect from excess liquids
作用機制標題	某些沙漠植物的種皮透過對濕度敏感的種臍瓣膜調整對水氣的通透性 (The seed coats of some desert plants adjust their permeability to moisture via a humidity-sensitive hilar valve.)
生物系統/作用機制示意圖	  

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

種子需要合適的條件才能發芽，而對大部分種子來說就是代表有充足的水分。對沙漠植物來說，適當份量的水可能需要幾個月甚至幾年才會到來，所以部分種子會進入休眠。它們的種皮 (seed coats) 變得不透水 (impermeable to water)，這與種子需要吸收水分才發芽有所衝突。然而，想像一下如果種子會對任何水分相關事件 (water event) 都作出反應，甚至只是暫時的濕度提高，會有什麼災難降臨到整個植物族群。

豆科植物 (Legume family) 某些成員的種子有一片瓣膜 (valve)，能夠根據濕度變化而有所調整，其它部分的種皮則保持不透水。種臍瓣膜 (hilar valve) 或種臍 (hilum) 是種子以前連接著母株的疤痕。瓣膜容許水氣進出而維持安全的內部濕度水平，但不允許液態水分通過。如果濕度水平突然下降、維持低水平，然後突然重新上升，瓣膜會防止濕氣回流。基本上，種臍有著單向瓣膜的作用，當濕度水平很高時不允許水氣進入，但在濕度水平下

降時會讓水氣離開。然而，如果濕度水平逐漸提升到足夠高度，種臍瓣膜會保持開啟並在最終容許液態水分進入，直到如果種子浸泡在水中就能夠發芽的狀態。

不同類型的細胞控制著種臍瓣膜。在不透水層開口兩邊及外面的圓柱形細胞 (columnar-shaped cells) ，稱為反向柵狀細胞 (counter palisade cells)，具有吸濕性 (hygroscopic)，它們會從大氣中吸收水分子。當外部濕度水平非常高時，它們會膨脹並使瓣膜關閉，防止水分吸入到種子中。當濕度水平低時，它們會皺縮，使瓣膜打開，容許種子變得更乾燥。另一種細胞，即控制種臍瓣膜的柵狀表皮細胞 (palisade epidermis cells)，則位於種皮不透水層內部的薄層。這些細胞以及在不透水層外面的反向柵狀細胞之間有著一定份量的水分張力 (moisture tension)。要讓種臍關閉，這種張力需要超過某個最低水平。如果在種臍瓣膜開啟時（即在低相對濕度下）濕度突然上升，張力會達到最低水平而種臍關閉，防止水氣進入。然而如濕度逐漸上升，提示了合適的發芽及生長條件即將到來，將不會達到張力水平，種臍會保持開啟，容許水氣持續進入。

我們可以從三葉草 (clovers) 及羽扇豆 (lupines) 中學習到如何調控大樓、包裝、繃帶及衣服中的濕度水平。以一棟大樓作為例子，它可以有一層能呼吸的皮膚或外殼，能夠自行調整濕度水平、溫度差異、大氣壓力，或是各種液體。一棟可以呼吸的大樓可能帶來較健康的室內空氣品質及濕度水平，創造一個更舒適及更具生產力的工作空間。

Seeds need the right conditions to germinate and for most, that means sufficient water. For desert plants, the right amount of water could take months or years to arrive, so some seeds become dormant. Their seed coats become impermeable to water, which appears to be contradictory if a seed needs to absorb water to germinate. However, imagine what disaster could befall a plant population if its seeds respond to any water event that comes along, or even just temporary high humidity.

Seeds of several members of the Legume family have a valve that adjusts to changes in humidity while the rest of the seed coat remains impermeable. The hilar valve or hilum is the scar where the seed once attached to the parent plant. The valve allows water vapor to enter and exit to maintain a safe internal moisture level, but does not allow liquid water to pass. If humidity levels suddenly drop, stay low, then suddenly rise again, the valve doesn't allow moisture back in. Essentially, the hilum then acts as a one-way valve, not allowing moisture in when humidity levels are high, but letting moisture out as humidity levels decrease. However, if humidity levels gradually rise to a high enough level, the hilar valve stays open and eventually allows liquid water to enter to the point when germination can occur if the seed is immersed in water.

Different types of cells control the hilar valve. Columnar-shaped cells on either side of the opening and outside the impermeable layer, called counter palisade cells, are hygroscopic—they absorb water molecules from the atmosphere. When external humidity levels are high, they

swell and close the valve, preventing water absorption into the seed. When humidity levels are low, they shrivel, causing the valve to open, allowing the seed to dry out more. Other cells, palisade epidermis cells, that control the hilar valve are found in a layer lining the inside of the seed coat's impermeable layer. There is a certain amount of moisture tension between these cells and the counter palisade cells on the other side of the impermeable layer. For the hilum to close, this tension needs to exceed some minimum level. If while the hilar valve is open (i.e., at low relative humidity) there is a sudden increase in humidity, the tension reaches that minimum level and the hilum closes, preventing moisture from entering. If, however, there is a gradual rise in humidity, which signals the coming of suitable germination and growing conditions, the tension level never gets met, and the hilum stays open, allowing moisture to continue entering.

We can learn from clovers and lupines how to regulate moisture levels for buildings, packaging, bandages, and clothing. A building, for example, could have a breathing skin or envelope that self-adjusts to humidity levels, differences in temperature, atmospheric pressure, or liquids. A breathing building could result in healthier indoor air quality and moisture levels, creating a more comfortable and productive work space.

文獻引用 (REFERENCES)

「在白花三葉草 (*Trifolium repens*)、紅花三葉草(*T. pratense*)，以及木本羽扇豆 (*Lupinus arboreus*) 的種子中，種臍是一個在外種皮 (testa) 的不透水表皮上會因吸濕性而活化的瓣膜。當相對濕度很高時，這道裂縫會關閉並防止吸收水氣。在種子成熟期間，水分含量會快速下降至大約 25%，而在其後更緩慢地下降，直到水分含量大約 14%時表皮變得不透水。在此之後種子的失水只會透過水氣從種臍以擴散作用進行。硬實 (hard seed) 中的水分含量傾向與它們曝露在的最低相對濕度所平衡。它們在逐漸提升的相對濕度下，種臍會保持開啟以吸收水氣。不透水的持續時間會隨著從種臍失去水分所帶來的脫水程度而增加。」(Hyde 1954: 241)

"In seeds of *Trifolium repens, T. pratense,* and *Lupinus arboreus,* the hilum is a hydroscopically activated valve in the impermeable epidermis of the testa. When relative humidity was low the fissure in the hilum opened permitting the seed to dry out; when the relative humidity was high the fissure closed obstructing the absorption of moisture. During seed-ripening the moisture content fell readily to approximately 25 per cent., and thereafter more slowly until the epidermis became impermeable at approximately 14 per cent. moisture content. Further drying of the seed took place only by diffusion of water vapour through the hilum. 'Hard' seeds tended to have a moisture content in equilibrium with the lowest relative humidity to which they had been exposed. They absorbed moisture under conditions of gradually increasing relative humidity such that the hilar fissure remained open. The duration of the impermeable condition increased with the degree of desiccation brought about by loss of water through the hilum." (Hyde 1954: 241)

參考文獻清單與連結 (REFERENCE LIST)

Hyde, E. O. C. (1954). The function of the hilum in some Papilionaceae in relation to the ripening of the seed and the permeability of the testa. *Annals of Botany* 18: 241-256. (https://doi.org/10.1093/oxfordjournals.aob.a083393)

延伸閱讀

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

https://en.wikipedia.org/wiki/lupinus_arboreus
https://www.onezoom.org/life/@lupinus_arboreus
https://eol.org/pages/704002

撰寫/翻譯/編修者與日期

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https://asknature.org/strategy/valve-regulates-water-permeability/