生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	內部恆溫器調控溫度 (Internal thermostat regulates temperature)
生物系統 LIVING SYSTEM	臭菘 *Symplocarpus foetidus* (Eastern skunk cabbage)
功能類別 FUNCTIONS	#維持體內平衡 #Maintain homeostasis
作用機制標題	臭菘的內部恆溫器調控溫度，跟隨著稱為「坐禪吸子」的數學演算法 (The internal thermostat of skunk cabbage regulates temperature, following a mathematical algorithm, dubbed the "Zazen attractor.")
生物系統/作用機制示意圖	

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

文獻引用 (REFERENCES)

「在臭菘 (*Symplocarpus foetidus*) 的肉穗花序 (spadix) 中發現了自然發生的溫度觸發及不受光線影響 (light-independent) 的產熱 (thermogenic) 變動。這種被確認的產熱變動有著準確的週期性循環（每個循環約 60 分鐘），明顯以少於 0.9℃的閾值，反應在肉穗花序溫度的上升或下降。」(Ito et al. 2004: 257)

「氣味難聞的臭菘（英文名字 skunk cabbage，臭鼬甘藍菜）是天南星科家族 (arum family) 的成員，而與真正的甘藍菜不一樣，它可以告訴我們關於保持溫暖的一兩件事。這是高等植物 (complex plants) 中少數會控制其組織溫度的一種，在任何天氣下都能維持在 16℃到 24℃的舒適溫度。它甚至可以利用自身發熱而將雪融化，以保護嬌弱的花朵。臭菘透過在特殊細胞中消耗澱粉來產生熱力，但直到現時為止仍然無人徹底地瞭解臭菘是如何控制其內部溫度。」

「現在有兩位研究人員提出臭菘的溫度跟隨某種稱為奇異吸子 (strange attracter) 的數學概念。日本岩手大學 (Iwate University) 的 Takanori Ito 和 Kikukatsu Ito 在野外監測了數棵臭菘植株，記錄它們每分鐘的溫度。最初，溫度的變動似乎為隨機。但使用稱為非線性預測 (non-linear forecasting) 的統計技術後，他們發現臭菘的溫度變化遵循著一種獨特

的數學演算法 (mathematical algorithm) 。他們稱這種演算法為坐禪吸子 (Zazen attractor)，來自臭菘的日文名字「坐禪草」，意思為像禪宗打坐的植物。」(Physical Review E, vol 72, 051909).

「這個恆溫器令人驚訝地堅固耐用，除了它明顯地神經質之外。Takanori Ito 說：『當一個穩定狀態被環境的劇烈變化以災難性地破壞時，系統的調控變得非常困難。』。但臭菘的恆溫器即使在極端環境下也能妥善運作。『臭菘即使在周圍環境溫度下跌到零度以下還能調控溫度』。」(Battersby 2005: 14)

"The natural occurrence of temperature-triggered and light-independent thermogenic oscillation in the spadix of skunk cabbage, *Symplocarpus foetidus*, was discovered. The identified thermogenic oscillator had an accurate periodical cycle (ca. 60 min per cycle) that apparently responded to an increase or decrease in the spadix temperature with a threshold of less than 0.9℃." (Ito et al. 2004: 257)

"The smelly skunk cabbage (*Symplocarpus foetidus*) — a member of the arum family rather than a true cabbage — can tell us a thing or two about staying warm. It is one of the few complex plants that controls its tissue temperature, maintaining a comfortable 16 to 24 °C in all weathers. It can even melt snow as it warms itself to protect its delicate flowers. The plant generates heat by burning starch in special cells, but until now no one understood exactly how it controls its internal thermostat."

"Now two researchers say its temperature follows a kind of mathematical pattern called a strange attractor. Takanori Ito and Kikukatsu Ito of Iwate University in Japan monitored several skunk cabbages in the wild, recording their temperatures every minute. At first, the temperature fluctuation appeared to be random. But using a statistical technique called non-linear forecasting, they found it varies in a way specified by a unique mathematical algorithm. They have called the algorithm a Zazen attractor after the plant's Japanese name, Zazen-sou, meaning Zen meditation plant. (Physical Review E, vol 72, 051909).

"And the thermostat is surprisingly robust, despite its apparent jitteriness. 'When a stable state is catastrophically damaged by drastic changes of environment, it is hard to regulate the system,' says Takanori Ito. But the skunk cabbage's thermostat can cope even under extreme conditions. 'It can be regulated even when the ambient temperature drops below freezing.'" (Battersby 2005: 14)

參考文獻清單與連結 (REFERENCE LIST)

Ito, K., T. Ito, Y. Onda, and M. Uemura. (2004). Temperature-triggered periodical thermogenic oscillations in skunk cabbage (*Symplocarpus foetidus*). *Plant and Cell Physiology* 45: 257-264. (https://doi.org/10.1093/pcp/pch038)

Battersby, S. (2005). Zen and the art of central heating maintenance. *New Scientist*. Retrieved from: https://www.newscientist.com/article/mg18825265-000-zen-and-the-art-of-central-heating-maintenance/

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/symplocarpus_foetidus
https://www.onezoom.org/life/@symplocarpus_foetidus
https://eol.org/pages/1129514

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AskNature 原文連結

https://asknature.org/strategy/internal-thermostat-regulates-temperature/