生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	葉子快速關閉 (Leaves Rapidly Snap Shut)
生物系統 LIVING SYSTEM	捕蠅草 (Venus flytrap)
功能類別 FUNCTIONS	#捕獲、吸收或過濾生物體 #生命系統中的觸覺與機械力 #Capture, Absorb, or Filter Organisms #Sense Touch and Mechanical Forces in a Living System
作用機制標題	捕蠅草的葉子會在幾毫秒內關閉並透過將物理訊號轉化為電訊號來捕獲獵物。 (The leaves of the Venus flytrap snap shut and trap prey within milliseconds by turning physical signals into electrical signals.)
生物系統/作用機制示意圖 (確認版權、註明出處；畫質)	 https://www.flickr.com/photos/freetheimage/30722055053/in/gallery-191538957@N07-72157719749952342/

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

食肉植物，如捕蠅草（Dionaea muscipula），在營養貧乏的土壤中生長時，依賴小型獵物的營養。當毫無戒心的獵物碰到陷阱形狀葉子內側的兩根觸敏毛髮時，陷阱就會突然關閉，誘捕獵物以供日後消化。

觸敏毛髮（稱為觸發毛髮）使用鈉激活動作電位（AP）發出陷阱關閉訊號。動作電位是細胞以電訊號形式相互發送訊息的一種方式。當帶正電的離子（例如鈉）進入細胞並導致細胞膜的電環境變化直到達到某個閾值時，就會發生這種情況。達到這個閾值後，細胞“放電”，將電信號發送到另一個細胞以激活響應。就捕蠅草而言，兩根觸發毛會向葉子發出關閉訊號。對一根毛髮的物理刺激會將鈉離子釋放到毛細胞中，觸發第一個動作電位。刺激第二根毛髮會釋放更多鈉離子，引發第二次 AP。一旦兩個 AP 在 15-20 秒內被激發，這些電訊號就會刺激葉子中的運動細胞，使陷阱迅速關閉。這個訊號的速度非常快，第二根毛髮觸發後 100 毫秒內陷阱就會突然關閉。

一旦獵物被捕獲，它就會奮力逃跑，不斷地刷動更多的觸發毛髮，從而激發更多的動作電位。這些訊號被傳送到葉子上的腺體，腺體釋放酵素來消化獵物。獵物富含必需的營養物質，包括鈉，它的消化提供了新的鈉離子來源，以觸發下一個動作電位來捕捉植物的下一個受害者。

Carnivorous plants, such as the Venus flytrap (Dionaea muscipula), rely on nutrients from small prey animals when growing in nutrient-poor soil. When an unsuspecting prey brushes up against two touch-sensitive hairs on the inside of the trap-shaped leaves, the trap snaps shut, ensnaring the prey for later digestion.
The touch-sensitive hairs, known as trigger hairs, signal trap closure using sodium-activated action potentials (APs). An action potential is a way for cells to send information to one another in the form of an electrical signal. It occurs when positively charged ions, such as sodium, enter a
cell and cause the electrical environment of the cell membrane to change until it reaches a certain threshold. After it reaches this threshold the cell "fires," sending the electrical signal to another cell to activate a response.
In the case of the Venus flytrap, the two trigger hairs send a signal to the leaves to snap shut. Physical stimulation of one hair releases sodium ions into the hair cell, triggering the first action potential. Stimulating a second hair will release more sodium ions, triggering a second AP. Once two APs are elicited within 15-20 seconds of each other, these electrical signals stimulate motor cells in the leaves to snap the trap shut. This signal is incredibly fast, and the trap snaps shut within 100 ms of the triggering of the second hair.
Once the prey is captured it struggles to escape, continuously brushing more trigger hairs that fire more action potentials. These signals are sent to glands that line the leaves, which release enzymes to digest the prey. The prey is loaded with essential nutrients, including sodium, and its digestion provides a source of new sodium ions to trigger the next action potential to capture the plant's next victim.

文獻引用 (REFERENCES)

「捕蠅草（Dionaea muscipula）葉子在大約 100 毫秒內快速閉合，是植物界最快的運動之一。這使得達爾文將這種植物描述為「世界上最奇妙的植物之一」。陷阱關閉是透過觸發毛的機械刺激來啟動的。先前的研究主要集中在觸發毛對刺激的生化反應，並量化了葉子中動作電位的傳播。」（Forterre 2005:421）。
「當昆蟲訪問陷阱並傾斜內表面的機械感測器時，動作電位（AP）就會被激發。當移動的物體引發兩個 AP 後，陷阱就會突然關閉，將受害者困住。驚慌失措的獵物在接下來的幾個小時內反覆觸摸扳機毛，形成一個密封的陷阱，透過基於腺體的內分泌系統，該陷阱被獵物分解的酸性酶混合物淹沒」（Böhm 等人，2016:286）。
「我們已經證明，機械能在多細胞觸發毛處被接收並轉化為電訊號，即 AP。源自一側葉上的觸發毛的 AP 穿過整個誘捕器到達兩個主要目標：(1) 運動組織，它啟動誘捕器快速關閉並形成綠色胃，以及 (2) 腺體、內分泌腺負責長時間加工營養豐富且富含鈉的動物粉的系統。」（Böhm 等人，2016:291）。

"The rapid closure of the Venus flytrap (Dionaea muscipula) leaf in about 100 ms is one of the fastest movements in the plant kingdom. This led Darwin to describe the plant as 'one of the most wonderful in the world'. The trap closure is initiated by the mechanical stimulation of trigger hairs. Previous studies have focused on the biochemical response of the trigger hairs to stimuli and quantified the propagation of action potentials in the leaves." (Forterre 2005:421).
"When an insect visits the trap and tilts the mechanosensors on the inner surface, action potentials (APs) are fired. After a moving object elicits two APs, the trap snaps shut, encaging the victim. Panicking preys repeatedly touch the trigger hairs over the subsequent hours, leading to a hermetically closed trap, which via the gland-based endocrine system is flooded by a preydecomposing acidic enzyme cocktail" (Böhm et al. 2016:286).

“We have demonstrated that the mechanical energy is received at the multicellular trigger hair and converted into an electrical signal, an AP. The APs originating from the trigger hair on one lobe travel through the entire trap to reach two major targets: (1) the motor tissue, which initiates fast trap closure and the formation of the green stomach, and (2) the glands, the endocrine system responsible for the prolonged processing of the nutrient and sodium-rich animal meal.” (Böhm et al. 2016:291).
參考文獻清單與連結 (REFERENCE LIST) **Harvard 或 APA 格式**
The Venus flytrap Dionaea muscipula counts prey-induced action potentials to induce sodium uptake *Current Biol.* | 01/01/2016 | Böhm J, Scherzer S, Krol E, Kreuzer I, von Meyer K, Lorey C, Mueller TD, Shabala L, Monte I, Solano R, et al. **How the Venus flytrap snaps** *Nature* | 01/01/2005 | Forterre, Yoel; Skotheim, Jan M.; Dumais, Jacques; Mahadevan, L.
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