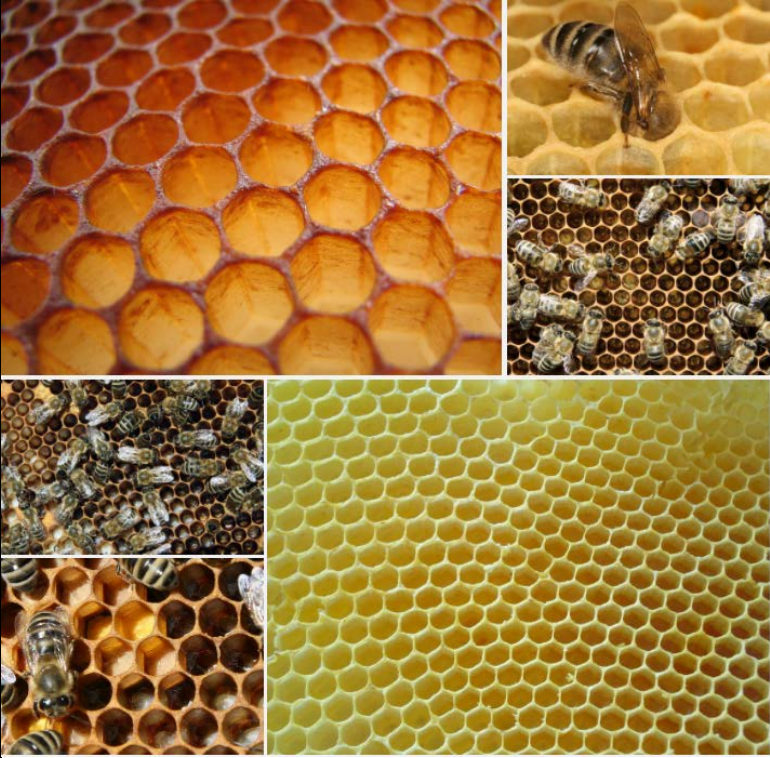


生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	熱力製造精確的形狀 (Heat creates precise shapes)
生物系統 LIVING SYSTEM	蜜蜂 <i>Apis</i> (Bees)
功能類別 FUNCTIONS	#物理性組成結構 #在生物系統中感應形狀及型態 #Physically assemble structure #Sense shape and pattern in a living system
作用機制標題	藉由使用熱塑性蜂蠟，蜜蜂得以透過體熱來幫助製造出角度及大小精確的蜂巢 (The body heat of bees helps create precise angles and size within honeycombs via use of thermoplastic wax.)
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)	
<p>「蜂窩的幾何學 (geometrical) 研究，以及關於蜜蜂如何測量及建構出六角形與菱形隔間的推測已有數百年的歷史。我們在此證實了我們所觀察到的蜂窩式樣既不需蜜蜂測量，也無需建構出蜂窩的高度規則結構，便可以蜂蠟 (wax) 在液體平衡狀態 (equilibrium) 下的流動來簡約地解釋。蜂窩結構導因於蜂蠟是具有熱塑性 (thermoplastic) 的建築介質 (building medium)，會隨著溫度上升與下降而軟化或硬化。它會在瞬間、緊密排列的氣缸 (cylinder) 陣列之間流動，而這些氣缸實際上是自行發熱 (self-heated) 的蜜蜂本身。形成每個隔間底部的三個明顯的長菱形 (rhomboids) 並不存在，而是透過半透明蜂窩觀察時出現的光學假影 (optical artifact)。」 (Pirk et al. 2004: 350)</p>	

“Geometrical investigations of honeycombs and speculations on how honeybees measure and construct the hexagons and rhombi of their cells are centuries old. Here we show that honeybees neither have to measure nor construct the highly regular structures of a honeycomb, and that the observed pattern of combs can be parsimoniously explained by wax flowing in liquid equilibrium. The structure of the combs of honeybees results from wax as a thermoplastic building medium, which softens and hardens as a result of increasing and decreasing temperatures. It flows among an array of transient, close-packed cylinders which are actually the self-heated honeybees themselves. The three apparent rhomboids forming the base of each cell do not exist but arise as optical artefacts from looking through semi-transparent combs.” (Pirk et al. 2004: 350)

參考文獻清單與連結 (REFERENCE LIST)

Tributsch, H. (1983). How life learned to live: adaptation in nature. *The MIT Press*.

Pirk, C. W. W., H. R. Hepburn, S. E. Radloff, and J. Tautz. (2004). Honeybee combs: construction through a liquid equilibrium process? *Naturwissenschaften* 91: 350-353.
(<https://link.springer.com/article/10.1007/s00114-004-0539-3>)

延伸閱讀

AskNature Team. (1 October, 2016). Tubes 84 mattress. *AskNature*. Retrieved from:
<https://asknature.org/idea/tubes-84-mattress/>

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

<https://en.wikipedia.org/wiki/apidae>
<https://www.onezoom.org/life/@apidae>
<https://eol.org/pages/677>

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AskNature 原文連結

<https://asknature.org/strategy/heat-creates-precise-shapes/>