生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	翅膀有鮮豔的顏色 (Wings Have Bright Color)
生物系統 LIVING SYSTEM	非洲白鳳蝶 (African swallowtail)
功能類別 FUNCTIONS	#修改光線/顏色 #傳遞光訊號（可見光譜） #Modify Light/Color #Send Light Signals in the Visible Spectrum
作用機制標題	由於奈米結構及色素的結合，非洲鳳蝶的翅膀呈現出絢麗的色彩。 (Wings of African swallowtail butterflies have brilliant colors thanks to a combination of nanoscale structures and pigments.)
生物系統/作用機制示意圖 (確認版權、註明出處;畫質)	 版權：可自由共享、改編，需提供來源連結 出處：https://www.flickr.com/photos/27461854@N04/5495442940/in/gallery-191538957@N07-72157719738896574/ 畫質：122500 dpi

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

導言：
在花園裡飛舞的蝴蝶總是有著絢麗顏色的翅膀，事實上這些顏色並不只是透過色素呈現，而是結合了奈米結構及螢光色素，幾乎所有蝴蝶都運用了此機制，非洲白鳳蝶就包括在其中。
機制說明：
非洲白鳳蝶翅膀內的色素會填充在奈米級結構的小孔內，這些色素產生的波長與晶體的規律性互相匹配，限制光只能垂直傳播，當波長向下傳播時會到達下方的另一角質層（作為反射器）使得所有光線都讓觀察者接收，才能顯示出明亮的顏色。
結構色的產生是通過複雜的微小結構，例如幾丁質和空氣的週期性排列，使得特定波長的光線被反射或折射，呈現出不同的顏色效果。

Introduction:
Butterflies fluttering in the garden always have wings with vibrant colors. In fact, these colors are not merely presented through pigments; they are a combination of nanostructures and fluorescent pigments. Almost all butterflies utilize this mechanism, including the African white butterfly.
Mechanism Explanation:
The pigments inside the wings of the African white butterfly fill the small pores of nanostructured layers. These pigments generate wavelengths that match the regularity of the crystals, restricting light to propagate only vertically. When the wavelength propagates downward, it reaches another keratin layer below (acting as a reflector), ensuring that all light is received by the observer, thus displaying bright colors.

The generation of structural color is achieved through complex microstructures, such as chitin and the periodic arrangement of air, causing specific wavelengths of light to be reflected or refracted, presenting various color effects.

文獻引用 (REFERENCES)

「對這些物種的選擇壓力導致大量多層膜的發展，這些多層膜的尺寸適當可以產生這種非常顯著的反射率。這種結構色還可以隨翅膀方向改變色調、窄光譜純度、強紫外線反射成分的可能性以及色素也無法實現的獨特偏振效果。」(P. Vukusic et al. 1999:1410)

“Selection pressures on these species have caused the evolution of large numbers of multilayers that are appropriately dimensioned for producing this very significant reflectivity. Such structural coloration also enables change of hue with wing orientation, narrow spectral purity, the possibility of a strong component of UV refection, and distinct polarization effects that are also not attainable with pigments.” (P. Vukusic et al. 1999:1410)

參考文獻清單與連結 (REFERENCE LIST) Harvard 或 APA 格式

Prum, R. O., Quinn, T., & Torres, R. H. (2006). Anatomically Diverse Butterfly Scales All Produce Structural Colours by Coherent Scattering. *The Journal of Experimental Biology*, 209: 748–765. (https://pubmed.ncbi.nlm.nih.gov/16449568/)

Vukusic, P., Sambles, J. R., Lawrence, C. R., & Wootton, R. J. (1999). Quantified Interference and Diffraction in Single Morpho Butterfly Scales. *The Royal Society*, *266*, 1403–1411. (https://royalsocietypublishing.org/doi/epdf/10.1098/rspb.1999.0794)

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AskNature 原文連結

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