

生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	三層裝甲外殼保護免受天敵危害 (Triple layered armored shell protects from predators)
生物系統 LIVING SYSTEM	鱗角腹足蝸牛 <i>Chrysomallon squamiferum</i> (Scaly-foot snail)
功能類別 FUNCTIONS	#分配能量 #保護免受動物危害 #應付撞擊 #應付擠壓 #防止破裂/斷裂 #Distribute energy #Protect from animals #Manage impact #Manage compression #Prevent fracture/rupture
作用機制標題	鱗角腹足蝸牛外殼以特殊的三層組成防止受到攻擊 (The shell of the golden-scale snail protects from attack with a specialized tri-layered composition)
生物系統/作用機制 示意圖	<p>Multilayered armor design of <i>C. squamiferum</i></p> <p><i>shell curvature:</i></p> <ul style="list-style-type: none"> • reduction of local bending, radial displacements • increase in exoskeletal stiffness • reduction of tensile loads in inner shell <p><i>generic penetrating threat</i></p> <p><i>rigid Fe-based granular OL:</i></p> <ul style="list-style-type: none"> • heterogeneous interfacial geometry prevents catastrophic layer delamination, energy dissipation • microfractures: potential energy dissipating mechanism • potential granular abrasion/blunting of indenter <p><i>compliant organic ML:</i></p> <ul style="list-style-type: none"> • inelastic energy dissipation • mitigates inelasticity of calcified shell • arrests cracks from calcified shell <p><i>rigid calcified shell IL:</i></p> <ul style="list-style-type: none"> • structural support • reduction of radial displacements • resistance to bending/ fatigue <p>ML arrests cracks from GL and CLL</p>
作用機制摘要說明 (SUMMARY OF FUNCTIONING MECHANISMS)	
<p>印度洋的海底會噴出熱水和礦物質的大型深海熱泉 (hydrothermal vent)。這些地方亦提供了一個生態系 (ecosystem) 給多種適應於不同嚴苛環境的奇特物種。其中一種就是鱗角腹足蝸牛 (golden snail)，牠以熱泉排水口附近的營養物為食。為了保護自己，這種蝸牛使用了具有三層結構的堅硬、盔甲狀外殼。每一層都有獨特的化學和物理特性，使它們在應付掠食攻擊 (predatory attack) 的力量時能發揮不同作用。</p>	

外層是一層薄的有機質外殼，以散熱孔 (heat dissipation hole) 噴出的鈣鈦礦 (perovskite) (硫化鐵 iron sulfide) 顆粒來加強。大多數軟體動物 (mollusk) 會從內到外 (inside out) 建造外殼。除了利用散熱孔來沉積硫化鐵外，鱗角腹足蝸牛也能做到這件事。

中間層是一層厚而緻密的有機材質，其本質是柔軟的，這意味著它很容易變形 (deform)。此特性使中間層可以作為減震器 (shock absorber)，減輕螃蟹抓握造成的壓力，並防止有毒蝸牛的猛擊。它就像是位於蛋殼下面緊密的棉花糖。外層和中間層緩衝了大部分衝擊。

At the bottom of the Indian Ocean are large hydrothermal vents that eject hot water and minerals. They also provide an ecosystem for various exotic species that adapt to various harsh conditions. One of them is the golden snail, which feeds on the nutrients from the vents. To protect itself, the snail uses a hard, armor-like shell with a three-layer structure. Each layer has unique chemical and physical properties that allow them to play different roles in managing the power of predatory attacks.

The outer layer is a thin organic shell, reinforced by perovskite (iron sulfide) particles ejected from the heat dissipation holes. Most mollusks build shells from the inside out. In addition to iron sulfide deposits using heat dissipation holes, golden snails can also do this.

The middle layer is a thick and dense layer of organic material, which is soft in nature, which means it is easily deformed. This property allows the middle layer to be used as a shock absorber, reducing the pressure on the crab's grip, and preventing the slam of the poisonous snail. It can be compared with the dense cotton candy under the eggshell. The outer layer and the middle layer alleviated most of the impact.

文獻引用 (REFERENCES)

「這些外殼有三種不同的薄層，主要由碳酸鈣 (calcium carbonate) 組成，只有少量的蛋白質 (不超過 2%)。」

「這些外殼與典型的動物結構不同，並不是由細胞組成。位於外殼內層並與外殼接觸的外套膜組織 (mantle tissue) 會以胞外式 (extracellularly) 的方式 分泌蛋白質和礦物質以形成外殼。」

「由於軟體動物的外骨骼沒有脫落，因此牠們的貝殼必須擴大以適應身體的生長。這種生長模式的結果是三種不同的殼層：含蛋白質的 (proteinaceous) 骨膜 (periosteum) 外層 (未鈣化)，稜柱形 (prismatic) 層 (鈣化) 和珍珠質珠母層 (nacre) (鈣化)。」

“Such shells have three distinct layers and are composed mostly of calcium carbonate with only a small quantity of protein (no more than 2 percent).”

“These shells, unlike typical animal structures, are not made up of cells. Mantle tissue that is located under and in contact with the shell secretes proteins and mineral extracellularly to form the shell.”

“Since their exoskeleton is not shed, molluscan shells must enlarge to accommodate body growth. This pattern of growth results in three distinct shell layers: an outer proteinaceous periosteum (uncalcified), a prismatic layer (calcified) and an inner pearly layer of nacre (calcified).”

參考文獻清單與連結 (REFERENCE LIST)

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