生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	鱗片提供靈活、強大的保護 (Scales Provide Flexible, Strong Protection)
生物系統 LIVING SYSTEM	地穿山甲 (Ground pangolin)
功能類別 FUNCTIONS	#修改尺寸/形狀/質量/體積 #Modify Size/Shape/Mass/Volume
作用機制標題	穿山甲覆蓋著由角蛋白製成的厚且重疊的鱗片，角蛋白與構成人類頭髮和指甲的材料相同。 (Pangolins are covered with thick, overlapping scales made out of keratin, the same material that makes up human hair and fingernails.)
生物系統/作用機制示意圖 (確認版權、註明出處；畫質)	 出處： https://www.natgeomedia.com/environment/article/content-photo-5616-9119.html

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

導言：

動物在遭遇危險時，往往會採取動物行為(裝死、擬態、嚇阻等)；穿山甲則是捲曲成球狀，透過外層的角蛋白鱗片包裹住自己，提高自己的存活率。

策略：

地穿山甲(*Smutsia temminckii*)，一種位於非洲南部和東部的穿山甲，喜歡居住在低海拔、有適量灌木叢的稀樹草原林地。地穿山甲除了腹部之外，其餘完全被鱗片所覆蓋，並且佔體重 20%。前腳有三個長而彎曲的爪子，可用於拆除白蟻的巢穴和挖掘洞穴，因為地穿山甲沒有下顎，因此他們胃肌肉發達並含有小石頭來搗碎食物，他們還擁有長而靈動的舌頭，有助於併吞動巢穴內的螞蟻和白蟻。

地穿山甲是獨居夜行性動物，僅在交配時進行互動，會利用尿液、分泌物、糞便標記領地。當他們受到威脅時，他們會將身體蜷曲成球，發出警告的聲音，並鱗片的鋒利邊緣進行切割，也能從肛門附近的腺體釋放有毒氣體，以抵禦掠食者。

潛力：

從微觀層面，穿山甲的鱗片由三層不同的扁平橢圓形富含角蛋白的細胞組成。在底部(腹側)層，細胞平行且呈重疊的片狀；在中間層，細胞以約 45 度角向上傾斜；在背側，鱗片更快地傾斜並完全折疊，直到與底層平行。最後具有不同方向的平坦、堅韌、重疊的細胞層組合在一起，形成一種難以刺穿但又能吸收攻擊力的結構。

除了將此技術應用於裝甲，其獨特的構造能應用於建築物和橋梁等，使它們有更強的抵禦能力。

Introduction:

When animals encounter danger, they often adopt animal behaviors (playing dead, mimicking, intimidation, etc.); pangolins roll up into balls and wrap themselves in the outer layer of keratin scales to increase their mortality.

The Strategy:
The ground pangolin (*Smutsia temminckii*), a pangolin found in southern and eastern Africa, prefers to live in savanna woodlands at low altitudes with a moderate amount of shrubs. Except for the abdomen, the ground pangolin is completely covered in scales, which account for 20% of its body weight. The ground pangolin's front feet have three long, curved claws that can be used to dismantle termite nests and dig burrows. Because ground pangolins have no jaws, their stomach muscles contain small stones to crush food. They also have long and flexible tongues that help to devour the ants and termites in the nest.
Ground pangolins are solitary, nocturnal animals that only interact during mating and use urine, secretions, and feces to mark their territory. When they are threatened, they curl up into a ball, making warning sounds and cutting with the sharp edges of their scales. They also release toxic gases from glands near their anus to ward off predators.
The Potential:
At a microscopic level, a pangolin's scales are composed of three different layers of flat, oval-shaped keratin-rich cells. In the basal (ventral) layer, the cells are parallel and in overlapping sheets; in the middle layer, the cells tilt upward at about a 45-degree angle; on the dorsal side, the scales tilt more quickly and fold completely until they are parallel to the bottom layer. Finally, flat, tough, overlapping layers of cells with different orientations come together to form a structure that is difficult to puncture but also absorbs the force of an attack.
In addition to applying this technology to armor, its unique structure can be applied to buildings and bridges to make them more resistant.

文獻引用 (REFERENCES)

當受到威脅時，穿山甲會像犰狳一樣捲成一個球，使它們的體型變得不到正常尺寸的一半。這有助於它們保護沒有被保護鱗片覆蓋的胃和臉。從這個位置，穿山甲可以從尖尾底部的腺體中釋放出一種惡臭的液體，以阻止掠食者。(National Geographic: Ground pangolin PLAY DEFENSE)

“When they are threatened, they curl up into a ball, making warning sounds and cutting with the sharp edges of their scales. They also release toxic gases from glands near their anus to ward off predators.” (National Geographic: Ground pangolin PLAY DEFENSE)

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

National Geographic: Ground pangolin (https://kids.nationalgeographic.com/animals/mammals/facts/pangolin)

延伸閱讀: Harvard 或 APA 格式（取自 AskNature 原文；若為翻譯者補充，請註明）

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

https://patents.google.com/patent/CN101766147B/en

撰寫/翻譯/編修者與日期

李冠衡翻譯 (2024/03/09)；陳柏宇編修 (2024/11/30)

AskNature 原文連結

https://asknature.org/strategy/scales-provide-flexible-strong-protection/#references

更多補充的圖片 (1. 確認版權、註明出處 2. 品質: 盡量 72dpi 或 300K)