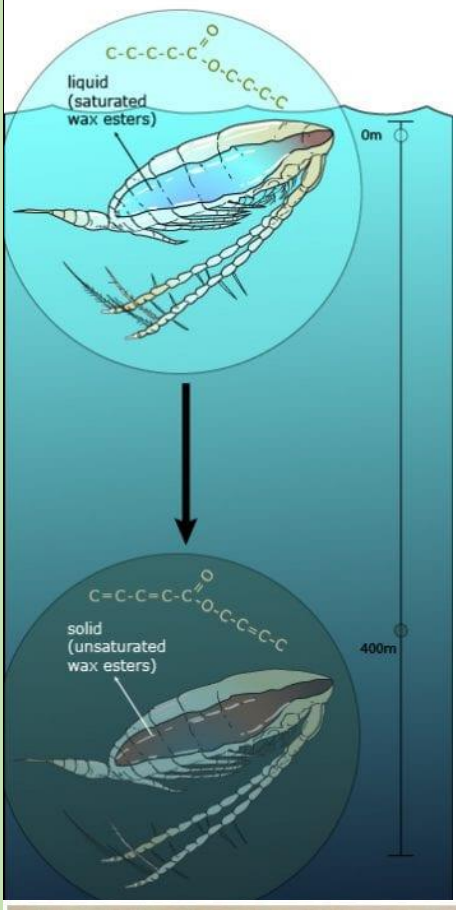
生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	蠟改變密度以幫助下沉或漂浮 (Wax Changes Density to Help Sink or Float
生物系統 LIVING SYSTEM	*Calanoides acutus* 橈足亞綱 (*Calanoides acutus* Copepod)
功能類別 FUNCTIONS	#移入/移至液體 #Move in/on liquids
作用機制標題	南極甲殼類動物體內會產生蠟質，幫助它們深入水中冬眠。 (Antarctic crustaceans create wax within their bodies to help them sink deep into the water to hibernate for winter.)
生物系統/作用機制示意圖 (確認版權、註明出處；畫質)	 

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

冬季，一種微小的南極海洋甲殼類動物（*Calanoides acutus*）在海洋深處冬眠，那裡的寒冷減緩了它的新陳代謝。 往下游泳進入水中會消耗大量能量，但這種甲殼類動物使用一種特殊材料來提供幫助。

一旦它到達 400 米（四分之一英里）以下的深度，寒冷的溫度會導致甲殼類動物體內的一小塊蠟狀液體變成緻密的固體，從而幫助生物體自行下沉。

蠟是一種有浮力的材料，這意味著它通常會在水中漂浮而不是下沉。 蠟會漂浮，因為它的密度比水小。 南極甲殼類動物體內的蠟狀液體是蠟酯 (wax ester)，是脂肪酸和脂肪醇分子的混合物。這些分子可以分解並用作肌肉和器官的能量。它們還可以用來儲存能量，並可以通過血液輸送到全身。蠟由通過單個化學鍵相互連接的碳原子長鏈組成。隨著甲殼類動物在水中游得更深，蠟從單鍵變為雙鍵。這種變化使蠟分子更緊密地結合在一起，從而增加了它們的密度並使其更重。

密度是衡量一個空間可以容納多少“東西”的指標。 想像一個裝滿衣服的袋子。看起來很滿，但是當你往下壓時，你實際上可以在包裡添加更多的衣服。 袋子現在更“密集”了，因為裡面的東西更多了，而且也更重了。南極甲殼類動物也是如此。一旦它的蠟從單鍵變為雙鍵，該生物就可以在同一空間內容納更多的蠟，從而使其更加緻密。這使得甲殼類動物沉入水中，直到其密度與其周圍的水相同的深度，並且它變得中性浮力。然後它可以在該深度停留並冬眠，而無需使用任何額外的能量。

在春天，甲殼類動物會消耗蠟質，這會使生物體變得更輕，並使其漂浮回水面。

來自南極甲殼類動物等物種的創造性浮力方法可以為潛艇、飛艇和機器人設計師的工作提供更多選擇。

A tiny Antarctic marine crustacean (*Calanoides acutus*) hibernates deep in the ocean during winter where the cold slows its metabolism. Swimming down into the water can take a lot of energy, but this crustacean uses a special material to help.

Once it reaches depths below 400 meters (one quarter mile), cold temperatures cause a pocket of waxy liquid within the crustacean’s body to turn into a dense solid, helping the organism to sink on its own.

Wax is a buoyant material, which means that it normally floats, rather than sinks, in water. Wax floats because it is less dense than the water. The waxy liquid inside the Antarctic crustaceans is a wax ester, which is a mixture of fatty acids and fatty alcohol molecules. These molecules can be broken down and used as energy for muscles and organs. They can also be used to store energy and can be transported throughout the body through the bloodstream. The wax is made up of long chains of carbon atoms attached to each other by single chemical bonds. As the crustacean swims deeper into the water, the wax changes from having single bonds to having double bonds. This change allows the wax molecules to fit together more tightly, which increases their density and makes them heavier.

Density is a measure of how much ‘stuff’ you can fit into a space. Imagine a bag that is stuffed with clothes. It seems full, but when you press down you can actually add more clothes into the bag. The bag is now more ‘dense’ because there is more stuff inside it, and it is also heavier.

The same is true for the Antarctic crustacean. Once its wax changes from single bonds to double bonds, the creature can fit more wax inside the same space, which makes it more dense. This makes the crustacean sink into the water until it reaches a depth at which its density is the same as the water around it, and it becomes neutrally buoyant. It can then stay and hibernate at that depth without needing to use any extra energy.

In the spring the crustacean consumes the wax, which makes the organism lighter and allows it to float back up to the surface.

Creative approaches to buoyancy from species like Antarctic crustaceans could provide submarine, blimp, and robotic designers more options for their work.

文獻引用 (REFERENCES)

“抹香鯨利用了一種類似的浮力調節機制……抹香鯨頭部空間內的一個大型鯨蠟器 (spermaceti organ) 中含有它們的脂質。 下降時，脂質被冷卻到凝固點，密度的增加使鯨魚能夠在沒有大幅度向下游泳的情況下下沉。” (Pond and Tarling 2011:1316)

“A comparable mechanism of buoyancy regulation is utilized by sperm whales…sperm whales contain their lipid in a large spermaceti organ within the head space. To descend, the lipid is cooled to the point at which it solidifies, and the increase in density makes the whale able to sink without large amounts of downward swimming.” (Pond and Tarling 2011:1316)

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

Limnol. Oceanogr. | 21/06/2011 | David W. Pond, Geraint A. Tarling

Phase transitions of wax esters adjust buoyancy in diapausing Calanoides acutus

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AskNature 原文連結

https://asknature.org/strategy/antarctic-crustaceans-use-wax-to-sink-in-water/

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