生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	海洋生物如何感知電力 How Sea Creature Sense Electricity
生物系統 LIVING SYSTEM	鯊魚 Sharks
功能類別 FUNCTIONS	#從環境中感知電/磁力 #Sense Electricity / Magnetism From The Environment
作用機制標題	一些海洋生物使用填滿凝膠的孔來感受生物電場，這些孔將外部電場與內部神經細胞連接 (Some marine animals sense bioelectric fields using gel-filled pores that electrically connect external fields to internal nerve cells.)
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)

介紹

一隻大白鯊在沿海區域尋找獵物，就像牠幾億年前的祖先一樣。雖然牠依賴視覺、嗅覺跟聽覺，但他也有人類所缺乏的感官。

特別是鯊魚(和其他動物)有特殊的器官叫做勞倫氏壺腹 (ampullae of Lorenzini) 讓牠們可以感知其他動物散發的電場。

策略

所有活著的個體都會在身體周圍產生電場，運動——特別是當肌肉和神經纖維因動作被點燃時——創造出電場。其他電場由正常生物過程的一部分產生的帶電離子而形成。像是魚的嘴和鰓會散發生物電場，因為這些區域的黏膜直接接觸海洋，並將離子溢出到周圍水中。鹹的海水本身就充滿帶電離子，而有助於從魚身上散播這些電場。

但只有一些個體可以感知到生物電場。板鰓亞綱——一個魚的亞綱包括鯊魚和鰩——是一個擁有這種感覺的動物群體，稱為「電覺 (electroreception)」。

鯊魚有鼻可以聞、有眼可以看、有耳可以聽，與人類和其他動物相似。我們需要那些器官將感覺訊號轉變成神經衝動讓大腦可以理解。為了感應電場，具有電覺的動物有稱為「勞倫氏壺腹」的器官，得名於科學家覺得他們的球狀結構和叫做安瓿 (ㄆㄡˇ) (ampules) 的小燒瓶相似。
外部生物電場導致負電荷在特殊皮膚毛孔表面累積。單獨的通道將電訊號從毛孔傳到勞倫氏壺腹(其中包含感覺受體細胞)。具有相似於海水傳導性質的膠原蛋白凝膠填滿每隔通道和壺腹並像延長線一樣連接毛孔表面和受體細胞。質子在凝膠中移動，被外部負電荷吸引，受體細胞偵測累積的電荷。電場越強，累積的電荷就越多，受體細胞就越難刺激與其相關的神經纖維。通過這種方式，壺腹扮演電子傳感器的角色，將生物電場數據轉換成神經衝動並經由環繞在其外部的神經網絡傳到大腦。
就像摩天大樓的天線比牙籤大小的天線接收更多無線電訊號一樣，生物學差異影響物種電覺的強度和敏感度。毛孔的數量和他們分布在身體上的方式決定了大腦將外部電場的多重訊號整合成完整的「圖像」的能力。毛孔的數量可能會有很大的差異；科學家發現澳大利亞虎鯊的毛孔數量少於 150 個，然而路氏雙髻鯊有大於 3000 個毛孔。
毛孔的位置也會影響他們的功能。有些魟魚的嘴部和頭部周圍圍有毛孔可以感知獵物。掠食者可能潛伏在上方或後方時，牠們背上的毛孔會感知到。
類似收音機可以調到特定電台，電感受體可以在生命階段中轉移以專注於特定訊號。
對掠食者的敏銳感知有助於年輕且脆弱的青少年。鰩科和天竺鯊科還在卵內發育的胎兒會感知附近掠食者的生物場，並停止尾部運動以減少牠們自己的電場讓牠們成為潛在的零食的機會。
生命後期，有些物種變得更善於感知獵物，到了交配的時候，賀爾蒙的激增似乎會幫助雄性魟魚變成純愛機器，成為偵測正在繁殖雌性的探測杖。

潛力
想像一下漁船可以散發電場吸引特定的物種，而不是撒網將海裡的一切抓起來。這種「聰明」的捕魚可以防止受脅和瀕危物種被過度捕撈。水下機器人可以裝備局部生物場發射器，在不淹沒這個區域的自然生物場訊號的情況下
，阻止海洋生物採礦或是其他工業作業。或許電覺裝置可以幫助人們以新的方式「看」這個世界。當我們超越人類目前對這個世界的認知時，我們可以學習的可能性令人振奮。

Introduction
A great white shark cruises through coastal waters searching for prey, much as its ancestors have done for hundreds of millions of years. While it relies on sight, smell, and sound, it also has senses that humans lack.
Specifically, sharks (and other animals) have special organs called ampullae of Lorenzini that allow them to sense electric fields that other animals emit.

The Strategy
All living organisms generate electric fields around their bodies. Movement—especially when muscle and nerve fibers ignite with action—creates some electric fields. Other fields result from charged ions produced as part of normal biological processes. Fish, for example, exude bioelectric fields at their mouths and gills because mucous linings in these areas directly contact the ocean and spill ions into the surrounding water. The salty seawater itself is laden with charged ions that help spread these fields out from the fish’s bodies.
But only some organisms can sense bioelectric fields. The Elasmobranchii, a subclass of fish which includes sharks, rays, and skates, is one group of animals that possesses this sense, called “electroreception.”

Sharks have noses to smell, eyes to see, and ears to hear similar to humans and other animals. We need those organs to convert sensory signals into nerve impulses that our brains can interpret. To detect electric fields, animals with electroreception have organs called "ampullae of Lorenzini," named for the scientist who thought their bulbous structure resembled tiny flasks called ampules.

External bioelectric fields cause negative electric charges to accumulate at the surfaces of special skin pores. Individual canals conduct the electric signal from each pore to an ampulla of Lorenzini, which contains sensing receptor cells. A glycoprotein gel that has conductive properties similar to that of seawater fills each canal and ampulla and works like an extension cord to electrically "connect" the pore's surface to the receptor cells. Protons move through the gel, attracted by the external negative charge, and the receptor cells detect the accumulated charges.

The stronger the field, the more charge accumulates, and the harder the receptor cells stimulate their associated nerve fibers. In that way, the ampullae act like electrical transducers, converting the bioelectric field data into impulses sent to the brain via a network of nerves that wrap around their outsides.

Just as a sky-scraping antenna picks up more radio signals than a toothpick-sized version, biological differences affect the strength and sensitivity of a species' electroreception. The quantity of pores and how they're distributed on the body determine how well the brain integrates multiple signals into a complete "picture" of the external electric field. The number of pores can vary significantly; scientists found that a Port Jackson shark has fewer than 150 pores while a scalloped hammerhead has more than 3,000.

The location of pores also influences their function. Some stingrays have pores around their mouths and heads for sensing prey. Pores on their backs sense when another predator may be lurking above or behind.

Similar to tuning a radio to a particular station, electroreception can shift during different life stages to focus on particular signals.

Acute sensing of predators benefits juveniles when they are young and vulnerable. When skates and bamboo sharks are embryos still developing inside eggs, they sense the biofields of nearby predators and stop their tail movements to reduce the chances that their own electric fields will give them away as potential snacks.

Later in life, some species become more adept at sensing prey. When it's time to mate, a surge in hormones appears to help male stingrays turn into true love machines, becoming divining rods that detect breeding females.

The Potential

Instead of casting nets that capture everything under the sea, imagine fishing boats that could emit electric fields to attract a specific species. Such "smart" fishing could help prevent overfishing of threatened and endangered species. Underwater robots could be outfitted with localized biofield emitters to deter marine life from mining or other industrial operations without overwhelming the area's natural biofield signals. Perhaps electoreception devices could help people "see" the world in a new way. When we look beyond what humans currently perceive in the world, the possibilities of what we can learn are positively electrifying.

文獻引用 (REFERENCES)
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