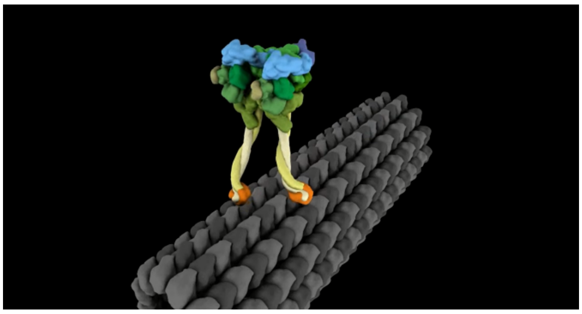
生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	高負載運輸蛋白捕獲鍵 (Heavily Loaded Transport Protein Catch-bonds)
生物系統 LIVING SYSTEM	所有生物體共有的 (Common to all organisms)
功能類別 FUNCTIONS	#暫時性附著 #分佈固體 #Attach Temporarily #Distribute Solids
作用機制標題	真核生物中的轉運蛋白只有在重載時才會透過分子力傳遞更緊密地結合到其軌道上。 (Transport protein in eukaryotes binds more tightly to its track via molecular force transmission only when heavily loaded.)
生物系統/作用機制示意圖 (確認版權、註明出處；畫質)	 https://youtu.be/-7AQVbrmzFw?si=U12d7jEZQxD_g0SN
作用機制摘要說明 (SUMMARY OF FUNCTIONING MECHANISMS)	

導言：
交通是生活所必需的。無論是我們開車去商店購買食物，還是細胞內的蛋白質將單一分子從製造地運送到需要的地方，有時東西只需要攜帶即可。
策略：
在我們的細胞內，分子的運輸是透過蛋白質稱為動力蛋白，它沿著稱為微管的軌道行走。動力蛋白是一種大型蛋白質，與自身的第二個副本配對，看起來非常像一雙腿。每條腿的末端都有與微管軌道結合的“腳”，而貨物則拴在另一端。動力蛋白使用細胞的能量貨幣三磷酸腺苷 (ATP) 為每一步提供動力，並沿著軌道搖搖晃晃地拖著後面的貨物。
當運載小型或中型貨物時，動力蛋白沿著軌道行進有點隨機。分子的腳被輕輕束縛，它們可能會向前或向後邁出一步，甚至完全鬆開。總的來說，動力蛋白分子向前移動的可能性比向後移動的可能性更大，因此貨物會被運送到正確的方向。透過這種方法的運輸速度非常慢，但這並不重要，因為行駛的距離非常短。
當運載大型貨物時，拴住貨物的桿上會承受較重的負載。這可能會使動力蛋白更有可能鬆開軌道，然而，莖上的張力會導致分子改變形狀，從而更緊地抓住軌道。由於蛋白質附著得更緊且不太可能鬆脫，因此平均而言，對於較重的負載，貨物的運輸速度實際上會增加。

Introduction
Transport is necessary for life. Whether it's us driving to the shops to buy food, or proteins inside our cells carrying individual molecules from where they were made to where they are needed, sometimes things just have to be carried.
The Strategy
Inside our cells, transport of molecules is carried out by a protein called dynein which walks along a track called a microtubule. Dynein is a large protein that pairs up with a second copy of

itself to look very much like a pair of legs. At the end of each leg are "feet" that bind to the microtubule track, while the cargo is tethered to the other end. Dynein uses adenosine triphosphate (ATP), the energy currency of the cell, to power each step and staggers its way along the track dragging the cargo behind it.

When carrying a small or intermediate cargo, dynein proceeds along the track somewhat randomly. The molecule's feet are lightly bound and they might step forwards or backwards, or even let go entirely. Taken together, on average, dynein molecules are more likely to move forwards than back, and so the cargo gets carried in the right direction. Transport via this method is exceedingly slow, however this doesn't matter as the distances traveled are exceedingly small.

When carrying a large cargo, there is a heavier load on the stalk tethering the load. This might be expected to make the dynein more likely to let go of the track, however, the tension on the stalk causes the molecule to change shape, gripping the track more tightly. Because the protein is holding on more tightly and is less likely to let go, the velocity of transport of the cargo actually increases, on average, for heavier loads.

文獻引用 (REFERENCES)

最近的實驗表明，動力蛋白馬達表現出*捕獲結合*行為，其中在一定的力範圍內，單個動力蛋白的解結合率隨著力的增加而降低。受這些實驗的啟發，我們研究了捕獲鍵結對*多個*動力蛋白馬達攜帶的細胞貨物的單向運輸特性的影響。我們引入了與實驗一致的閾值力黏合變形（TFBD）模型，其中捕捉黏合在超過臨界施加負載力時開始。我們發現捕捉鍵結可以導致運輸特性發生巨大變化，這與驅動蛋白驅動的單向運輸形成鮮明對比，後者不存在捕捉鍵結。我們預測，在某些條件下，細胞貨物的平均速度實際上會隨著施加負載的增加而增加。我們根據捕獲黏合強度和馬達失速力的參數空間中的速度剖面圖來表徵傳輸特性。此圖產生的預測可以透過對運動運輸和結合特性進行適當修改來實驗獲得。 (Anil Nair、Sameep Chandel、Mithun K. Mitra、Sudipto Muhuri 和 Abhishek Chaudhuri 物理修訂版 E 94 , 032403 – 2016 年 1 月 1 日發布)

Recent experiments have demonstrated that dynein motors exhibit *catch bonding* behavior, in which the unbinding rate of a single dynein decreases with increasing force, for a certain range of force. Motivated by these experiments, we study the effect of catch bonding on unidirectional transport properties of cellular cargo carried by *multiple* dynein motors. We introduce a threshold force bond deformation (TFBD) model, consistent with the experiments, wherein catch bonding sets in beyond a critical applied load force. We find catch bonding can result in dramatic changes in the transport properties, which are in sharp contrast to kinesin-driven unidirectional transport, where catch bonding is absent. We predict that under certain conditions, the average velocity of the cellular cargo can actually increase as applied load is increased. We characterize the transport properties in terms of a velocity profile plot in the parameter space of the catch bond strength and the stall force of the motor. This plot yields predictions that may be experimentally accessed by suitable modifications of motor transport and binding properties. (Anil Nair, Sameep Chandel, Mithun K. Mitra, Sudipto Muhuri, and Abhishek Chaudhuri Phys. Rev. E 94, 032403 – Published 2 September 2016)

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

Nair A, Sameep Chandel S, Mitra MK, Muhuri S, Chaudhuri A (2016). Effect of catch bonding on transport of cellular cargo by dynein motors. *Phys Rev* (https://academic.oup.com/jb/article-abstract/140/4/467/761958?login=false)

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