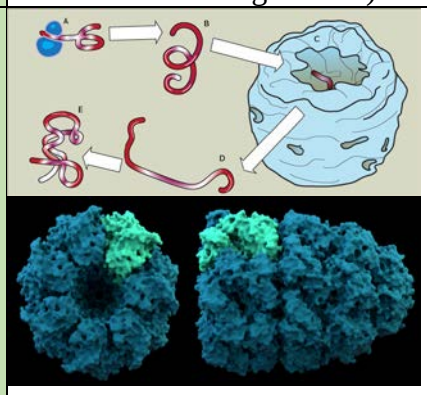
生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	伴護蛋白更正錯誤摺疊的蛋白 (Chaperonins correct misfolded proteins)
生物系統 LIVING SYSTEM	人類 (Human)
功能類別 FUNCTIONS	#改變大小/形狀/質量/體積 #調節細胞代謝過程 #Modify size/shape/mass/volume #Regulate cellular process
作用機制標題	人類細胞中的伴護蛋白透過將錯誤折疊的蛋白質捕捉放進密閉空間使其展開，並再次摺疊成正確且有功能的三維結構來修復它們 (Chaparonins in human cells rehabilitate misfolded proteins by capturing them in confined spaces causing them to unfold, giving them a second chance at refolding into their properly functioning, three-dimensional configuration.)
生物系統/作用機制示意圖	

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

蛋白質執行細胞中大多數必需的生化「工作」，諸如細胞的生存、生長、繁殖、交流等—而每種蛋白質正確的功能取決於他們精確的三維摺疊結構 (three-dimensionally folded structure)，此狀態被稱作「自然態 native state」。

基於這些大分子不同部分的相互作用，新合成的蛋白質會自行組裝成自然態。帶著相異電荷的區域會互相靠近，而帶著相同電荷的區域則互相排斥；極性區域向水性的外部移動，而疏水性則向內部聚集。短程的凡得瓦力 (van der Waals force) 和氫鍵 (hydrogen bond) 也有助於形成摺疊正確之蛋白質分子的螺旋、片和褶 (spiral, sheet, and pleat)。但有時候折疊過程會出錯，輕者頂多浪費細胞資源，重者卻會導致疾病。伴護蛋白 (chaparonin) 是一種可以鬆開錯誤折疊的蛋白質，並且再讓它們摺疊成正確模樣的細胞工具。

Proteins perform the vast majority of biochemical ‘jobs’ necessary for the cell’s survival, growth, reproduction, communication, etc. – correct functionality is dependent on each protein’s very precise three-dimensionally folded structure called the ‘native’ state.

Newly synthesized proteins self-assemble into their native state based on the interaction of different parts of these large molecules. Oppositely charged areas move towards each other, while similarly charged areas repel; polar areas migrate towards the watery exterior, while hydrophobic areas aggregate towards the interior. Short range van der Waals forces and hydrogen bonds also contribute to forming the spirals, sheets, and pleats that characterize a properly folded protein molecule. But sometimes, the folding process goes awry resulting in a misfolded protein that at best is a waste of cellular resources, or at worse, a cause of disease. Chaparonins are cellular devices that relax misfolded proteins giving them a second chance at proper folding.

文獻引用 (REFERENCES)

「蛋白質能夠快速且有效地變成自然態。這是一種集體細胞機器作用的結果，被稱為分子伴護蛋白，為折疊過程提供動能輔助，使蛋白質不受動能陷阱影響，且有效地，'通順'能量圖景 (位能鳥瞰) (energy landscape)。過去 15 年的研究顯示分子伴護蛋白會因為蛋白質的非自然（錯誤折疊）狀態而起作用，非自然態蛋白質的疏水性表面最後會被包進內部成為自然態，從而有效防止凝集 (aggregation) (e.g. Bukau & Horwich, 1998; Hartl & Hayer-Hartl, 2002)。在許多情況下，束縛的蛋白質利用 ATP 使自己鬆開，並且進行另一次折疊。某些情況下，蛋白質結合和/或放鬆使結構產生淨變化；而在其他情況下不會有明顯的變化，但總體作用的目的是保護蛋白質免於錯誤折疊和凝集，直到它成功進行生物作用的下一步。」 (Fenton and Horwich 2003: 230)

"[P]roteins are able to rapidly and efficiently reach the native state. This is the result of actions by a collective of cellular machines, known as molecular chaperones, that provide kinetic assistance to the folding process, keeping proteins out of kinetic traps and effectively serving to 'smooth' the energy landscape. Studies of the past 15 years indicate that molecular chaperones function as a class by specifically binding non-native [misfolded] states of proteins through exposed hydrophobic surfaces that eventually become buried to the interior in the native state, effectively forestalling aggregation (e.g. Bukau & Horwich, 1998; Hartl & Hayer-Hartl, 2002). Bound proteins are then released, in many cases via the action of ATP, for another attempt at folding. In some cases, a net change of protein conformation attends the step of binding and/or release, whereas in others there is no observable change, but the overall action is rather one of protecting the protein from misfolding and aggregation until it can successfully proceed to a next step of biogenesis." (Fenton and Horwich 2003: 230)

參考文獻清單與連結 (REFERENCE LIST)

Fenton, W. A. and A. L. Horwich. (2003). Chaperonin-mediated protein folding: fate of substrate polypeptide. *Quarterly Reviews of Biophysics* 26: 229-256. (https://doi.org/10.1017/S0033583503003883)

延伸閱讀

生物系統延伸資訊連結 (LEARN MORE ABOUT THE LIVING SYSTEM/S)
https://en.wikipedia.org/wiki/Homo_sapiens
撰寫/翻譯/編修者與日期
吳亭葳翻譯 (2019/04/12)；譚國鎏編修 (2020/04/13)；許秋容編修 (2020/11/26)
AskNature 原文連結
https://asknature.org/strategy/chaperonins-correct-misfolded-proteins/