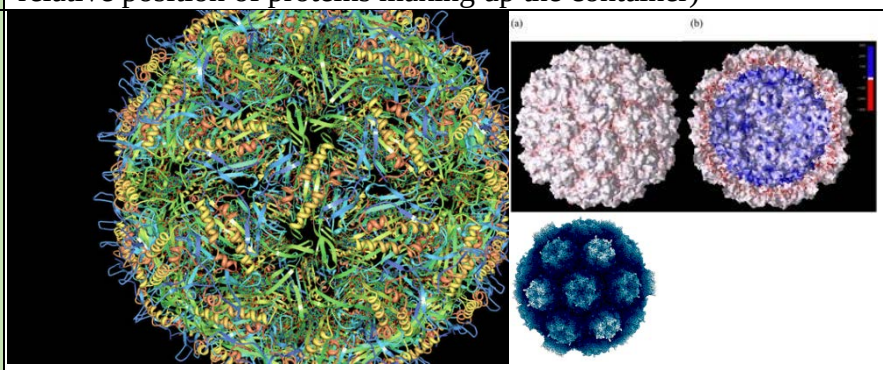
生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	病毒殼體蛋白質自組裝來形成穩定的外殼 (Capsid proteins self-assemble to form stable shell)
生物系統 LIVING SYSTEM	病毒 (Viruses)
功能類別 FUNCTIONS	#化學性組成分子裝置 #化學性組成所需物 #物理性組成結構 #Chemically assemble molecular devices #Chemically assemble on demand #Physically assemble structure
作用機制標題	殼體，存放著病毒 DNA 的容器，它們依靠構成 DNA 儲存容器的蛋白質相對位置引起弱吸引力或排斥力所結合提供的淨力，成為一個穩定且自行組裝的構造 (Capsids, the containers housing viral DNA, are stable, self-assembling structures because they rely on the net strength afforded by a combination of weak attractive or repulsive forces arising from the relative position of proteins making up the container)
生物系統/作用機制示意圖	

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

病毒本質上是一個移動的 DNA 容器，它們將自己插到活體細胞中以盜用細胞的生殖機能繁殖自身 DNA。病毒 DNA 儲存在奈米大小的保護容器中，稱作殼體，這些容器會在宿主細胞裡自行組裝。這些具有彈性復原力 (resilient)、自行組裝的蛋白質包裝能對多種弱作用力反應，使殼體有良好的穩定能力。這些弱作用力包含了在淨電荷 (electrostatic charge) 之間的吸引及排斥力、水溶性和殼體各部份的胺基酸組成。

Viruses are essentially mobile DNA containers that implicate themselves into living cells by usurping the cell's reproductive machinery to reproduce their own DNA. Viral DNA is housed in protective nano-scale containers, called capsids, that self-assemble within the host cell. These resilient proteinaceous packets self-assemble in response to a variety of weak forces that, in concert, provide the capsid with a great deal of stability. The weak forces at work include attraction or repulsion between electrostatic charges, water solubility, and constituent amino acid structures in various parts of the capsid.

文獻引用 (REFERENCES)

「病毒是奈米級、基因組填充 (genome-filled) 的蛋白質容器，它具有良好的熱力學和機械性質，能通過在受感染細胞裡擁擠的異質 (heterogeneous) 細胞質內自發組裝形成。病毒的自行組裝似乎遵循熱力學可逆性自行組裝的原則，但它組裝的殼（殼體）強烈地抵抗拆卸。在殼組裝時，有些病毒外殼通過一系列協調的成熟步驟，逐步加強殼體。病毒外殼具有有力的楊氏模量 (Young's modulus)，其模量範圍可從聚乙烯到有機玻璃 (Plexiglas) 之間，其中一些可以承受大氣壓幾十倍的內部滲透壓。」(Roos et al. 2010: 733)

「病毒並不進行代謝活動，完全依賴宿主細胞分子機器進行繁殖。這種代謝和生殖活動的缺失表明它與細胞不同，病毒的組裝或許可以從平衡熱力學的基礎上獲得理解.....殼體的蛋白質或『次單位 (subunit)』主要通過靜電排斥、疏水性吸引和在某些氨基酸對（稱為「卡斯帕對 Caspar pair」）特定接觸的組合之間相互作用...周圍環境中存在的大多數感染性球狀 ssRNA 病毒的自組裝需要有病毒 RNA 基因分子，病毒的 RNA 分子扮演著非專一性「靜電膠 electrostatic glue」的作用，將相反電荷的殼體蛋白質連接在一起，而 RNA 分子的特定“莖環”側枝則會對殼體蛋白質具有特定親和力...另一方面，大多數 ds 基因組病毒蛋白質膜的自行組裝，例如有尾 dsDNA「噬菌體 bacteriophage」病毒（即捕食細菌的病毒），並不需要基因組分子的存在，彎曲剛性較強的 dsDNA 分子可能阻止了它們充當“靜電膠”。在這些情況下，通常在殼體組裝完成之後，通過嵌入殼體中的旋轉分子馬達的作用，基因組已經插入完成了。」(Roos et al. 2010: 733-734)

“Viruses are nanosized, genome-filled protein containers with remarkable thermodynamic and mechanical properties. They form by spontaneous self-assembly inside the crowded, heterogeneous cytoplasm of infected cells. Self-assembly of viruses seems to obey the principles of thermodynamically reversible self-assembly but assembled shells (‘capsids’) strongly resist disassembly. Following assembly, some viral shells pass through a sequence of coordinated maturation steps that progressively strengthen the capsid. Viral shells have effective Young’s moduli ranging from that of polyethylene to that of plexiglas. Some of them can withstand internal osmotic pressures that are tens of atmospheres.” (Roos et al. 2010: 733)

“Viruses do not carry out metabolic activity and rely entirely on host-cell molecular machinery for reproduction. This absence of metabolic and reproductive activity suggests that, unlike cells, the assembly of viruses could perhaps be understood on the basis of equilibrium thermodynamics...Capsid proteins, or ‘subunits’, interact mainly through a combination of electrostatic repulsion, hydrophobic attraction and specific contacts between certain pairs of amino acids (known as ‘Caspar pairs’)...Self-assembly of most infectious sphere-like ssRNA viruses under ambient conditions requires the presence of the viral RNA genome molecules. Viral RNA molecules act in part as a non-specific ‘electrostatic glue’ that links together the oppositely charged capsid proteins, and particular ‘stem-loop’ side branches of the RNA molecules have specific affinity for the capsid proteins...On the other hand, self-assembly of viral shells of most ds genomes, such as the tailed dsDNA ‘bacteriophage’ viruses (that is,

viruses that prey on bacteria), does not require the presence of genome molecules. The much larger bending rigidity of dsDNA molecules presumably prevents them from acting as 'electrostatic glue'. In these cases, the genome is usually inserted, after capsid assembly has been completed, by the action of a rotary molecular motor imbedded in the capsid." (Roos et al. 2010: 733-734)

參考文獻清單與連結 (REFERENCE LIST)

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延伸閱讀

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

https://en.wikipedia.org/wiki/Virus

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AskNature 原文連結

https://asknature.org/strategy/capsid-proteins-self-assemble-to-form-stable-shell/