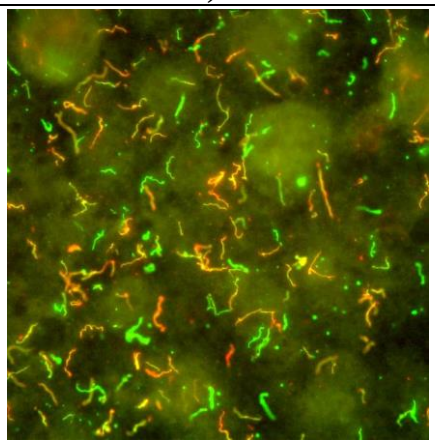
生物策略表

類別	生物策略 (Strategy)
生物策略 STRATEGY	引起萊姆病的細菌隱藏於免疫系統的防禦之下 (Lyme Disease Bacteria Hide From Immune Defenses)
生物系統 LIVING SYSTEM	柏氏疏螺旋體 (*Borrelia burgdorferi*) 細菌(bacteria)
功能類別 FUNCTIONS	#調節細胞的過程 #防護微生物 #Regulate Cellular Processes #Protect From Microbes
作用機制標題	萊姆病的病原體柏氏疏螺旋體擁有特殊的能力，能夠用錳，而不是鐵製造酶，並且幫助它躲避免疫系統的防禦和偵測其存在。 (The Lyme disease pathogen Borrelia burgdorferi has an unusual ability to substitute manganese for iron to build enzymes, which helps it elude immune defenses as well as tests to detect it.)
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)

所以是什麼特性使 *Borrelia burgdorferi* 這種細菌異於其他的細菌呢?答案或許就如 Sherlock Holmes 所說的，因為使用元素的不同。普遍來說，細菌自己所製造的酶中都含有鐵這個元素。但是科學家發現引起萊姆病 (Lyme disease) 的細菌在製造酶時，並沒有用到鐵元素，取而代之的是它在週期表中的鄰居—錳 (Mn)。

不像其他的細菌，*B. burgdorferi* 不需要鐵元素就能成長。在標準的偵測細菌的測試中，血液、尿液和其它樣本會在實驗室中被用來培養細菌並且顯示他們的存在。然而 *B. burgdorferi* 無法在這樣的檢測環境下有良好的生長，因此有可能會規避掉偵測。

此外，測定 *B. burgdorferi* 的方式為檢測是否身體中存在著為了對抗細菌而製造出來的抗體。然而，通常製造抗體需要花上一段時間，並且抗體的出現也有可能是因為原先就有的抗原或是其它的病原體所引起。因此利用抗體來偵測萊姆病 (Lyme disease) 並不能非常及時、精準以及易於推斷是否染病。

引起萊姆病 (Lyme disease) 的細菌其使用錳元素的機制也幫助它躲避了免疫系統的防衛機制。其中一個機制為使身體分泌一種物質，這種物質會抑制腸道吸收鐵元素以及將

其運輸至血流中。這個機制會導致貧血，這就是為什麼當我們感冒的時會感覺特別累和虛弱。這樣的機制對於需要使用鐵來製造酶的病原體來說相當有效。

不過對於 *B. burgdorferi* 來說並不是如此。它依然能夠繼續使用錳—而不是鐵來製造酶。而部分製造出來的酶還能夠用來抵禦其它的免疫系統。身體也會用超氧化物來打擊細菌。這種具有高活性的分子能夠傷害大部分的細菌，但是 *B. burgdorferi* 製造的含錳的酶能夠中和超氧化物。

So what makes *B. burgdorferi* different from other bacteria? The answer, as Sherlock Holmes might put it, is elemental. Bacteria typically use iron to make enzymes that they need to grow and function. But scientists have found that Lyme disease-causing bacteria has evolved to substitute iron's next-door neighbor on the periodic table: manganese.

Unlike most bacteria, *B. burgdorferi* doesn't need iron to grow. In standard detection tests, blood, urine, or other samples are cultured in labs to grow bacteria and reveal their presence. But iron-free *B. burgdorferi* doesn't grow well in these tests and evades detection.

Instead, Lyme disease tests rely on detecting the presence of antibodies that the body makes to fight bacteria. But it can take a while to produce antibodies. They can also linger from older or different illnesses. So results from Lyme disease antibody tests aren't very timely, accurate, or easy to interpret.

The Lyme disease-causing bacteria's manganese substitution also helps it dodge immune system defense mechanisms. One such mechanism is that the body makes chemicals that inhibit the gut from absorbing iron and sending it into the bloodstream. That makes us anemic, which is why we feel tired and weak when we're sick. But it also effectively starves most pathogens of the iron they need to build enzymes.

But not *B. burgdorferi*. It can continue to make enzymes with manganese instead of iron. Some of these enzymes protect them against another immune defense. The body bombards bacteria with superoxide radicals. These highly reactive molecules damage most bacteria. But *B. burgdorferi* makes manganese enzymes that neutralize superoxides.

文獻引用 (REFERENCES)

萊姆病的病原體 *B. burgdorferi* 代表了在金屬生物學中一個新穎的生物，在螺旋體門中獨一無二地演化成不需要鐵就能生長的特性…*B. burgdorferi* 的致病性可能可以以開發 SodA 的特定特性來控制。

"The Lyme disease pathogen *Borrelia burgdorferi* represents a novel organism in which to study metalloprotein biology in that this spirochete has uniquely evolved with no requirement for iron. … *B. burgdorferi* pathogenicity may be controlled by exploiting the unusual properties of SodA."

J. Dafhne Aguirre, et al. 2013:8468
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