Virus uses 'Swiss Army knife' protein to cause infection

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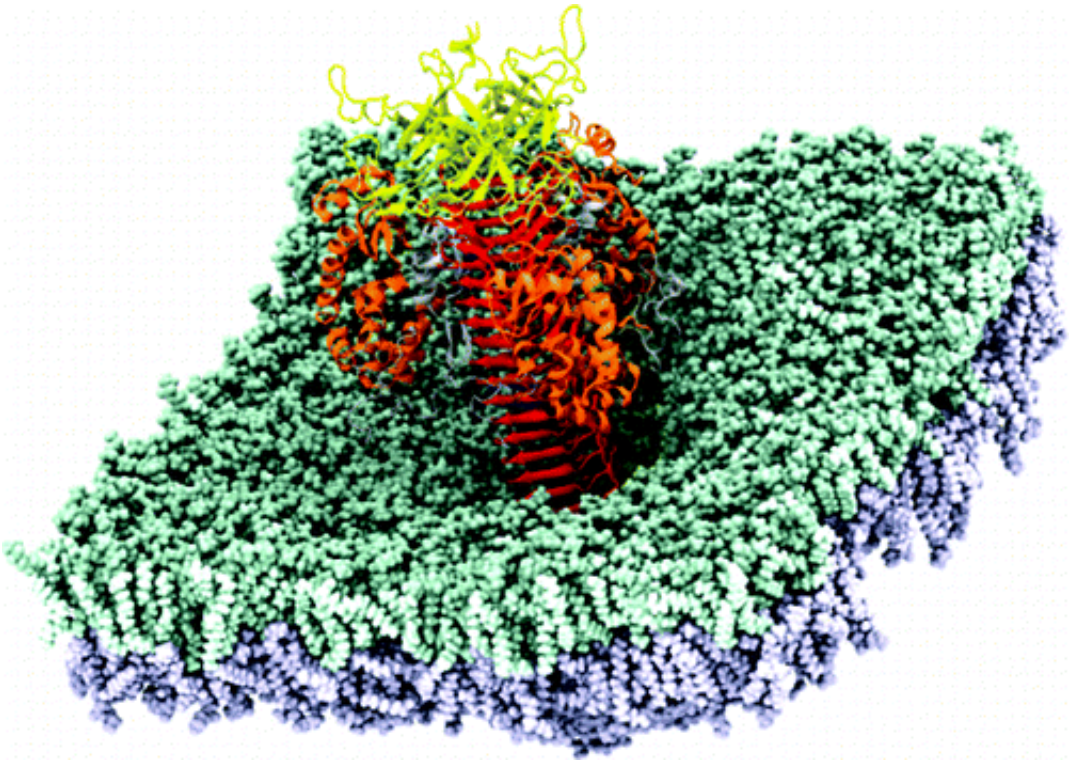

In an advance in understanding Mother Nature's copy machines, motors, assembly lines and other biological nano-machines, scientists are describing how a multipurpose protein on the tail of a virus bores into bacteria like a drill bit, clears the shavings out of the hole and enlarges the hole. They report on the "Swiss Army Knife" protein, which enables

the virus to pump its genetic material into and thus infect bacteria, in the *Journal of the American Chemical Society*.

Akio Kitao and colleagues focus on a group of viruses termed "bacteriophages," which literally means "bacteria eaters." These viruses infect bacteria like E. coli and usually make the bacteria dissolve. Infection involves injecting their own DNA or RNA into the bacteria, so that the viral genetic material takes over control of the bacteria. The tools for doing so are among numerous invisible nanomachines — so small that 50,000 would fit across the width of a human hair —that work unnoticed in organisms ranging from microbes to people.

The scientists recreated intricate details of the protein's work as it helps the tail of the virus infect E. coli bacteria. Their computer models show that the protein performs tasks in a regular sequence, starting with a screw-like motion as it begins to penetrate the outer membrane of E. coli. The protein acts as a cell-puncturing bit, a pipe to draw away membrane debris and a tool to enlarge the puncture hole, among other functions. The infection process demonstrates "a case where a single-function protein acquired multiple chemical functions" as different parts of its structure come in contact with bacterial membrane proteins.

More information: “Screw motion regulates multiple functions of T4 phage protein gp5 during cell puncturing” J. Am. Chem. Soc., Article ASAP
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Abstract
Bacteriophage T4 penetrates the outer membrane of Escherichia coli using a multifunctional device composed of a gene product 5 (gp5) protein trimer. We report that gp5 sequentially exerts distinct functions along the course of penetration stages induced by screw motion. A triple-stranded β-helix of gp5 acts as a cell-puncturing drill bit to make a hole

on the membrane and then send the lipids upward efficiently by strong charge interactions. The gp5 lysozyme domains, which degrade the peptidoglycan layer later, are shown to play novel roles to enlarge the hole and control the release of the β-helix. The lysozyme active site is protected from lipid binding during the penetration and is exposed after the β-helix release. Intrinsic multiple functions of gp5 are shown to be served in turn regulated by gradual change of interdomain interactions, which enables the initial infection process with single protein trimer by continuous screw motion. The results of lysozyme domain should be understood as the case where a single-function protein acquired multiple chemical functions through interplay with other domains in a multidomain protein.

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