Mechanism of bacteriophage λUr infection and post-infection decision making

Qiuyan Shao[1], Jimmy T. Trinh[1], and Lanying Zeng[1]

***Short Abstract* — λUr phage have side tail fibers absent in the common laboratory strain of bacteriophage λ (λWT). As a result, λUr adsorbs faster to the *E.coli* cell surface. Our data show that DNA ejection of λUr occurs earlier and in a more synchronized manner when observed at the single virus level. Meanwhile, the lysogenic response of λUr infection to different multiplicities of infection (MOIs) is different from that of λWT. Moreover, compared to λWT, the decision making of λUr is less affected by the host cell size. These together shed light on the modeling of phage infection and post-infection decision making.**

***Keywords* — Ur, adsorption, DNA ejection, decision making.**

I. Introduction

Upon infection of *E.coli*, bacteriophage λ ejects its DNA into the host cell. And subsequently, a decision between lysis and lysogeny is then made following the expression of λ proteins[1]. This simple paradigm has been extensively studied to allow for modeling of decision making between alternative fates during cellular development[1, 2].

Unlike λWT, the commonly used laboratory strain, λUr have side tail fibers, resulting in faster adsorption to *E.coli* cell surface[3, 4]. Additional differences between λUr and λWT, such as the timing and kinetics of DNA ejection and the effects on cellular decision making remain unknown.

We have been able to visualize phage DNA injection by labeling phage virions and phage DNA. Moreover, λUr infection and post-infection cell fate selection are observed at the single cell level, allowing for the modeling of decision making at higher resolutions.

II. Results

A. λUr adsorption

Studies of λWT have revealed that phages initially land on the host cell surface at random locations, and then move along the cell surface until it reaches its 'destination', mostly at cell poles[5, 6]. Our experiments show that λUr also reach the cell pole as their preferable "destination". Interestingly, when utilizing antibiotics to inhibit host cell division, λUr prefer to locate to also potential cell division sites, however, the underlying mechanism is still under investigation.

[1]Center for Phage Technology, Department of Biochemistry and Biophysics, Texas A&M University, College Station, TX 77843-2128. E-mail: lzeng@tamu.edu

B. λUr DNA ejection

Methylated phage DNA can be visualized by introducing SeqA-CFP inside the cell, taking advantage of the SeqA binding activity to hemi-methylated or fully-methylated DNA[7]. We are able to monitor the timing of the phage DNA ejection with SeqA-CFP. Our results indicate that λUr ejects DNA earlier and in a more synchronized manner compared to λWT. The kinetic details of λUr DNA injection process are still under investigation.

C. λUr decision making

The post-infection decision making of λUr infecting *E.coli* strain MG1655 is recorded using fluorescence microscopy. Compared to λWT, λUr has a higher lysogenization frequency at MOI=1, whereas at MOI>1, its frequency is lower, indicating influence of the side tail fibers on decision making. Previous research has shown that the host cell size affects decision making for λWT infection, with smaller cells having higher lysogenization frequency[2, 8]. However for λUr, this dependence of lysogenization frequency on cell size has been greatly decreased.

III. Conclusion

Compared to λWT, the side tail fibers allow λUr to adsorb faster to the host cell surface and eject its DNA earlier and in a more synchronized manner. Taken together, these differences deviate the λUr infection outcome from that of λWT. In summary, this study has enabled a more detailed modeling of λ decision making by combining adsorption and DNA ejection to post-infection cell fate selection.

References

[1] Oppenheim, A.B., et al, Switches in bacteriophage lambda development. *Annual Review of Genetics*, 2005. **39**: p. 409-429.

[2] Zeng, L.Y., Et al., Decision making at a subcellular level determines the outcome of bacteriophage infection. *Cell*, 2010. **141**(4): p.682-691.

[3] Hendrix, R. and R. Duda, Bacteriophage lambda PaPa: not the mother of all lambda phages. *Science*, 1992. **258**(5085): p. 1145-1148.

[4] Shao, Y.P. and I.N. Wang, Bacteriophage adsorption rate and optimal lysis time. *Genetics*, 2008. **180**(1): p. 471-482.

[5] Rothenberg, E., et al., Single-virus tracking reveals a spatial receptor-dependent search mechanism. *Biophys J*, 2011. **100**(12): p. 2875-82.

[6] Edgar, R., et al., Bacteriophage infection is targeted to cellular poles. *Molecular Microbiology*, 2008. **68**(5): p. 1107-1116

[7] Casadesus, J. and D. Low, Epigenetic gene regulation in the bacterial world. *Microbiol. Mol. Biol. Rev*, 2006. **70**(3): p. 830-+.

[8] St-Pierre, F. and D. Endy, Determination of cell fate selection during phage lambda infection. *PNAS*, 2008. **105**(52): p. 20705-20710.