Raising the bar in undergraduate teaching: discovery and characterization of phages infecting Corynebacterium glutamicum by Bachelor students at Paris-Saclay University

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Résumé

Inspired by the SEA-PHAGES program established for 14 years in many American universities (1), two undergraduate teaching units (40 h each) were created at the University Paris-Saclay in 2021-2022 to isolate and characterize phages infecting *Corynebacterium glutamicum*. *C. glutamicum* belongs to the Gram positive but didermic Actinobacteria for which few phages have been characterized compared to Mycobacteria. In the first teaching unit called "Phage Discovery", thirteen 2nd-year Bachelor students* collected environmental soil and water samples. Using a strain of *C. glutamicum* devoid of prophages for enrichment and purification steps, the students isolated two distinct bacteriophages, observed their morphology by electron microscopy and analyzed their DNA by restriction digests. In preparation for the second teaching unit "Phage DNA explorer", viral DNA was sequenced. Then, 23 3rd-year Bachelor students* analyzed the assembled viral genomes using GLIMMER, BLAST, HHblits and InterPro.
The first isolated phage, named CyranoPS, exhibited a 90-nm long flexible tail twice as long as its capsid diameter. Analysis of its 15-kb genome revealed 22 protein coding sequences (CDS) of which 64 % were assigned a function (virion assembly, host cell lysis, transcriptional regulation, lysogeny). Consistent with the production of turbid lysis plaques, its genome encoded a predicted integrase, suggesting a lysogenic lifecycle.

The second phage JeanGrey presented a large capsid diameter (96 nm), a 91-nm contractile tail and a large genome (106 kb). Functions were predicted for 37% of the 155 CDS. Besides virion assembly and host cell lysis, the function of 18 % of CDS was ascribed to DNA metabolism, including a DNA polymerase and a deazaguanine DNA modification system. Production of small clear lysis plaques and the absence of integrase indicated that JeanGrey is a virulent phage.

Taken together, our results show the successful creation of an undergraduate classroom

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research experience at a French university. Further implementation in France and Europe could be developed in a network of higher education institutions in partnership with research labs interested in phage ecology, genomics and evolution.

(1) Jordan et al. 2014. mBio 5(1):e01051-13. doi:10.1128/mBio.01051-13.
* Bachelor students : K Barhaoui, R Bourgeois, T Brun, M Fabregues, A Srimoorthy, A Barkim, A Batsché, F Bernigole, SL Blanchard, C Brives, E Charousset, M Cohendy, C Conort, A Correia, H Croizet, A Fellah, I Gueguen, M Ibrelisle, A Mach, M Manuaud, K Muratoglu, F Naulin, A Nimser, B Ortheau, C Pierre, C Samson, M Temperville, R Vatin

Mots-Clés: Undergraduate classroom research experience, Corynebacterium, Genome annotation