Institute: Institute of Environmental Sciences

Topic: Evolution of the optimal level of gene expression

Name of supervisor: Katarzyna Tomala
katarzyna.tomala@uj.edu.pl

Background information:
The project tests assumptions of two related hypotheses regarding the evolution of dominance: safety margin and optimal expression. The increased safety margin hypothesis proposes that the expression level of enzymes in the standard conditions is too-high to ensure proper organism function in a harsh or frequently changing environment. The optimal expression model proposes that the wild-type protein doses are optimal, but the fitness decreases very slowly for the vast range of protein doses, including the halved one.

The essential assumption of these hypotheses of dominance is that natural selection efficiently shapes the expression of individual genes. The expression pattern observed in a frequently encountered environment should be a well-adapted organism's characteristic. Furthermore, the longstanding selection for the new environment should lead to expression adjustments. Indeed, laboratory evolution experiments with bacteria have shown that expression of the LacZ gene approached its predicted optimal value (different for different lactose concentrations). However, other studies have found that the selection coefficients of mutations changing expression are extremely small or even suggest that divergence in expression patterns observed between closely related species can be effectively neutral – gene expression follows phylogeny and not the environments.

The main question to be addressed in the project:
How likely selection is to fine-tune the expression level to the optimal value and whether the expression safety margin will emerge in the changing environment?

Information on the methods/description of work:
Laboratory evolution of the yeast strains with an engineered suboptimal (too-low or too-high) and native (control) expression level of the *TDH3* gene. Two growth regimes will be applied: with constant and changing glucose concentrations. Investigation of the evolved lines and evaluation:
- how often *TDH3* expression changes (increase in case of too-low and decrease for too-high expression strains) explains the increase in strains' growth rate;
- whether evolved *TDH3* expression is, on average, higher for strains evolved in the variable glucose regime (test of the safety-margin hypothesis).

Additional information (e.g Special requirements from the student):
- MSc in biology or related fields
- ability to work with microorganisms
- experience with flow cytometry would be advantageous.

Place/name of potential foreign collaborator:
-

References (max.3**):**
[1] D. Bourguet, "The evolution of dominance," Heredity, vol. 83, no. 1, Art. no. 1, Jul. 1999, doi: 10.1038/sj.hdy.6885600.

[2] L. D. Hurst and J. P. Randerson, "Dosage, Deletions and Dominance: Simple Models of the Evolution of Gene Expression," J. Theor. Biol., vol. 205, no. 4, pp. 641–647, Aug. 2000, doi: 10.1006/jtbi.2000.2095.

[3] F. Duveau et al., "Fitness effects of altering gene expression noise in Saccharomyces cerevisiae," eLife, vol. 7, p. e37272, Aug. 2018, doi: 10.7554/eLife.37272.