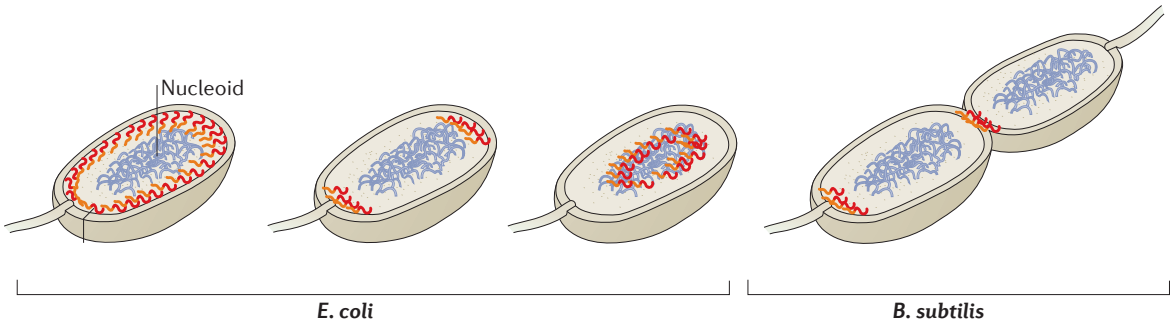
Effect of mRNA localization on protein synthesis

Protein synthesis is of fundamental importance for life. The molecular components involved in this process are messenger RNAs (mRNAs) and ribosomes. In the model bacterium *Escherichia coli*, the strongly condensed DNA nucleoid located at midcell causes strong excluded-volume effects, pushing both ribosomes and mRNAs a to the cell poles. Concurrently, mRNAs that are indpendently localized to different cellular localizations will be translated at different rates than mRNAs that are localized randomly.



mRNA localization at different intracellular locations in bacteria. From left to right, the Escherichia coli mRNAs which encode transmembrane proteins localize to the plasma membrane, while other mRNAs are observed to localize to the cell poles, or in the cytoplasm. In Bacillus subtilis, mRNAs may localize to the nascent septum that separates daughter cells and to the cell poles. Image from [1].

We will synthetically alter native mRNA localization to test their effects on translation rate, monitoring localization and translation efficiency by fluorescence microscopy in single cells. To that end we will use green fluorescent protein as a marker of mRNA localization [2] and abundance [3], and a second fluorescent protein as marker of the total rate of translation.

These results will be tested with established theoretical models, where we will use reaction-diffusion equations to predict the rate of protein synthesis associated with any given spatial distribution of mRNAs, thus showing how the protein-synthesis rate can be regulated by controlling mRNA localization patterns.

Overall, this analysis would demonstrate how mRNA localization constitutes a novel, finely tunable mechanism for controlling protein-synthesis rate which is alternative to gene regulation.

This project is suitable for physicists and biologists. However, it requires solid expertise in computational data analysis and programming in the first place. In addition, the student will be welcome to participate to the model development to any desired degree.

References

[1] A. R. Buxbaum, G. Haimovich, and R. H. Singer. In the right place at the right time: visualizing and understanding mRNA localization. *Nat. Rev. Mol. Cell Bio.*, 16(2):95, 2014.

[2] K. Nevo-Dinur, A. Nussbaum-Shochat, S. Ben-Yehuda, and O. Amster-Choder. Translation-independent localization of mRNA in *E. coli*. *Science*, 331(6020):1081, 2011.

[3] C. C. Guet, L. Bruneaux, T. L. Min, D. Siegal-Gaskins, I. Figueroa, T. Emonet, and P. Cluzel. Minimally invasive determination of mRNA concentration in single living bacteria. *Nucleic acids research*, 36(12):e73, 2008.