Tuning the Dynamics of Life: One Chemical Moiety at a Time

J.G. Vilhena[1,2]
[1] Universidad Autónoma de Madrid
[2]IFIMAC - Condensed Matter Physics Center
guilhermevilhena@gmail.com

Life is inherently a non-equilibrium process whereby *the jiggling and wiggling of atoms*, functional building blocks (nucleic-acids and proteins) realize complex tasks in a synchronized manner far exceeding the ones anticipated from their structure alone. In this talk, I selected two examples that portray how bio-molecular vibrations can be harnessed in different biological processes. Firstly we show how a single oxygen atom differentiating dsDNA from dsRNA can completely alter their unwinding dynamics (pivotal in DNA/cell replication). Then, we unveil how DNA sequence is not only a chemical code but also a physical one, thus capable regulating different biological processes. [1, 2, 3, 4, 5, 6] In the second part of the talk, we focus on electron-transport processes occurring in proteins [8, 9, 10, 11, 12, 13] pivotal in several biological processes (photosynthesis, respiration,). In particular, we show how single point mutations provide the means to finely regulate molecular vibrations of the protein matrix surrounding the active redox-active site, thus giving the means to control/regulate charge-transport processes at single-protein level. Overall, these results showcase how vibrations at the molecular level are inextricably connected to different biological functions and conversely how such processes may be tuned/regulated through carefully designed molecular substitutions.

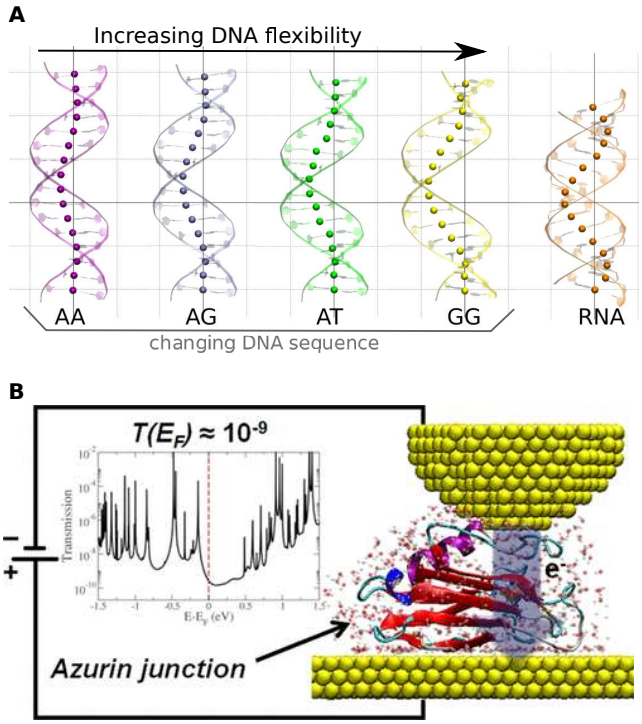

Fig. 1. Tuning the mechanics of DNA and single proteins. **A)** Schematic representation of how DNA sequence modulates structure and consequently its flexibility. **B)** Model of a bio-molecular junctions whose conductance properties can be tweaked via single point mutations.

[1] Proceedings of the National Academy of Sciences **114** (27), 7049 (2017).

[2] Physical Review Letters **122** (4), 048102 (2019).

[3] Nanoscale **11**, 21471 (2019).

[4] Nucleic Acids Research **48** (9), 5024 (2020).

[5] Nucleic Acids Research **48** (22), 12917 (2020).

[6] ACS Sensors **6** (2), 553 (2021).

[7] Quarterly Reviews of Biophysics **54**, E8 (2021).

[8] Journal of the American Chemical Society **139**, 15337 (2017).

[9] Physical Chemistry Chemical Physics **20**, 30392 (2018).

[10] Biomolecules **9**, 506 (2019).

[11] Biomolecules **9**, 611(2019).

[12] Journal of Physical Chemistry C **125** , 1693 (2021)

[13] Applied Sciences **11**, 3732 (2021)