PEN-DNA circuits: from particles programming to biosensing

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Molecular programming is a thriving discipline that deals with the design of artificial biomolecular circuits to perform information-processing tasks. These synthetic circuits can perform computations, store information, display dynamical behaviors, self-assemble into large supra-structures or act as biosensors. The predictable Watson and Crick base-pairing confers to DNA a unique programmability enabling the rational design of molecular circuits.

A few years ago, it has been developed a simple and versatile molecular programming language, named PEN-DNA toolbox (Polymerase Exonuclease Nickase-Dynamic Network Assembly) [1-2]. The topology of the networks is defined by a set of short synthetic DNA strands (templates) used as substrates by an enzymatic machinery to produce and degrade DNA strands. All of these reactions govern the dynamics and control the behavior of the system.

Here, we review the recent applications of these DNA circuits: we showed that we can trigger collective behaviors within microparticles populations encoded with DNA circuits [3]; these chemical reaction networks can be used to trigger the self-assembly of nano/microparticles; more recently, we conceived specific molecular programs dedicated to the ultrasensitive detection of biomolecules (manuscript under preparation).

[1] K. Montagne, R. Plasson, Y. Sakai, T. Fujii, and Y. Rondelez, "Programming an in vitro DNA oscillator using a molecular networking strategy," *Mol. Syst. Biol.*, vol. 7, p. 466, Feb. 2011.
[2] A. Baccouche, K. Montagne, A. Padirac, T. Fujii, and Y. Rondelez, "Dynamic DNA-toolbox reaction circuits: A walkthrough," *Methods*, vol. 67, no. 2, pp. 234–249, May 2014.
[3] G. Gines, A. S. Zadorin, J.-C. Galas, T. Fujii, A. Estevez-Torres, and Y. Rondelez, "Microscopic agents programmed by DNA circuits," *Nat. Nanotechnol.*, vol. 12, no. 4, pp. 351–359, May 2017.

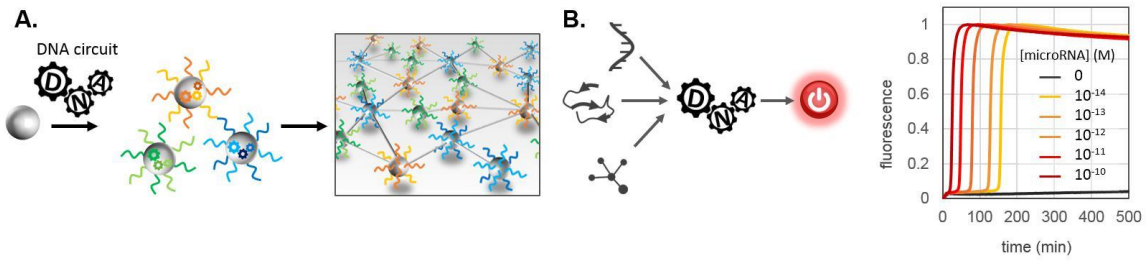

Figure: A. Microparticles programmed with DNA circuits exhibit collective behaviors. B. Specific molecular programs have been developed for the ultrasensitive detection of nucleic acids, protein or other analytes.