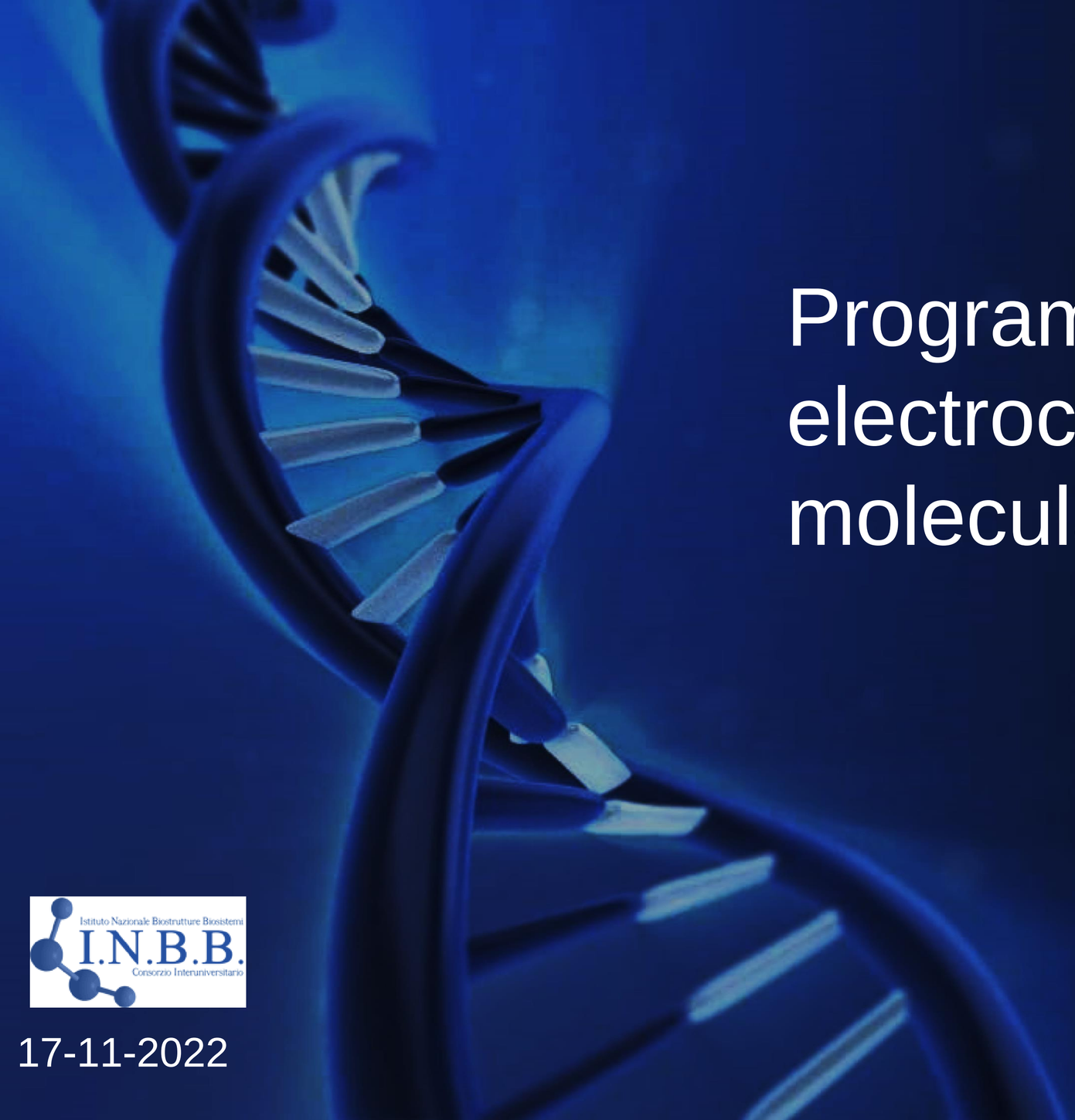


# Programmable DNA-based electrochemical sensors for molecular diagnostics

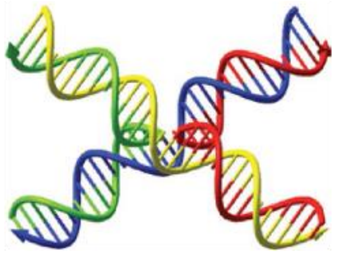
Istituto Nazionale Biostrutture Biosistemi
I.N.B.B.
Consorzio Interuniversitario

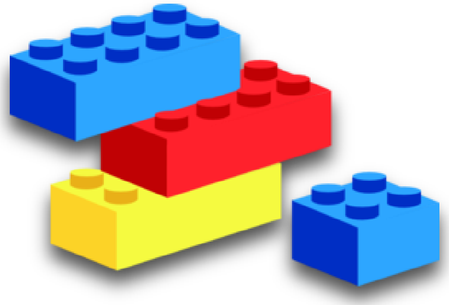
17-11-2022

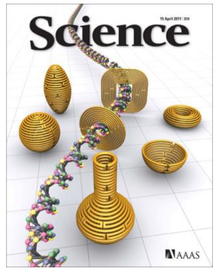
UNIVERSITÀ
DI PARMA

Alessandro Bertucci

# DNA nanotechnology uses DNA as an engineering material





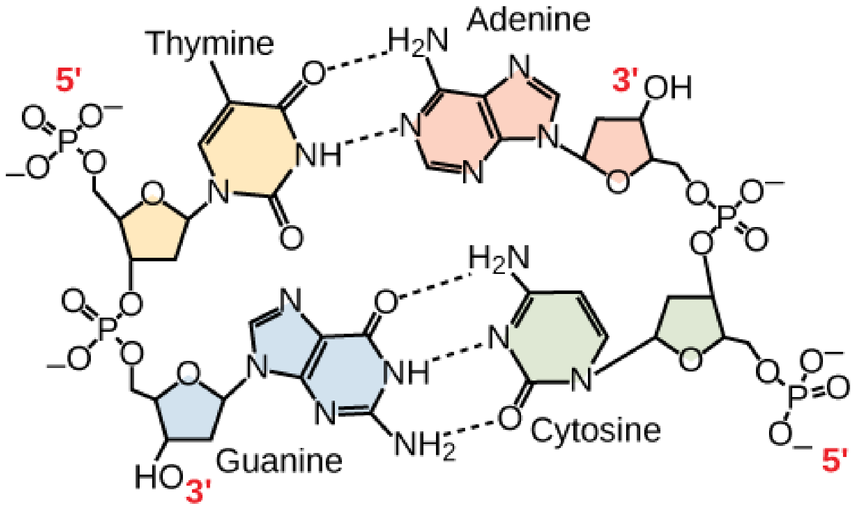

Programmable and controllable

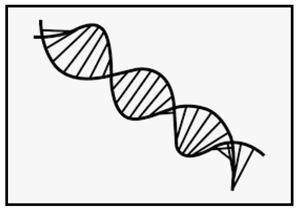
Nanodevices

Nanomachines

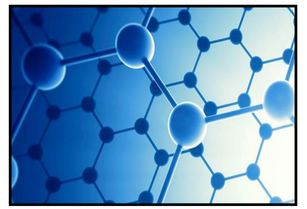
Dynamic structures

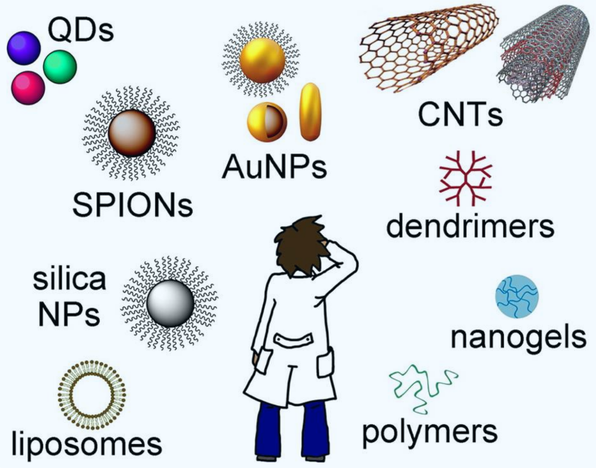
Origami



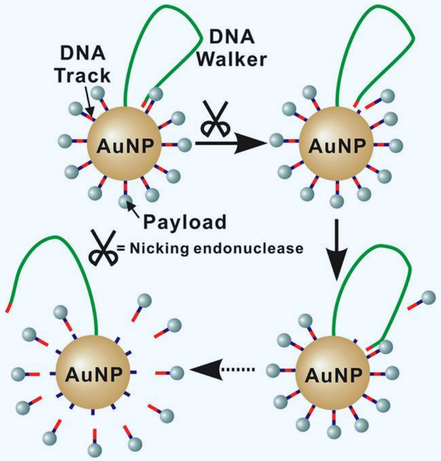
**DNA nanotechnologies can be combined with materials**

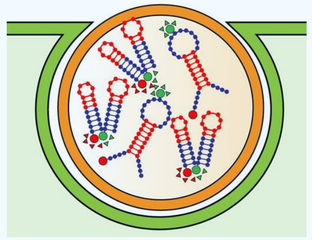





# Nanoparticles as delivery and materials platforms

# Nanomedicine



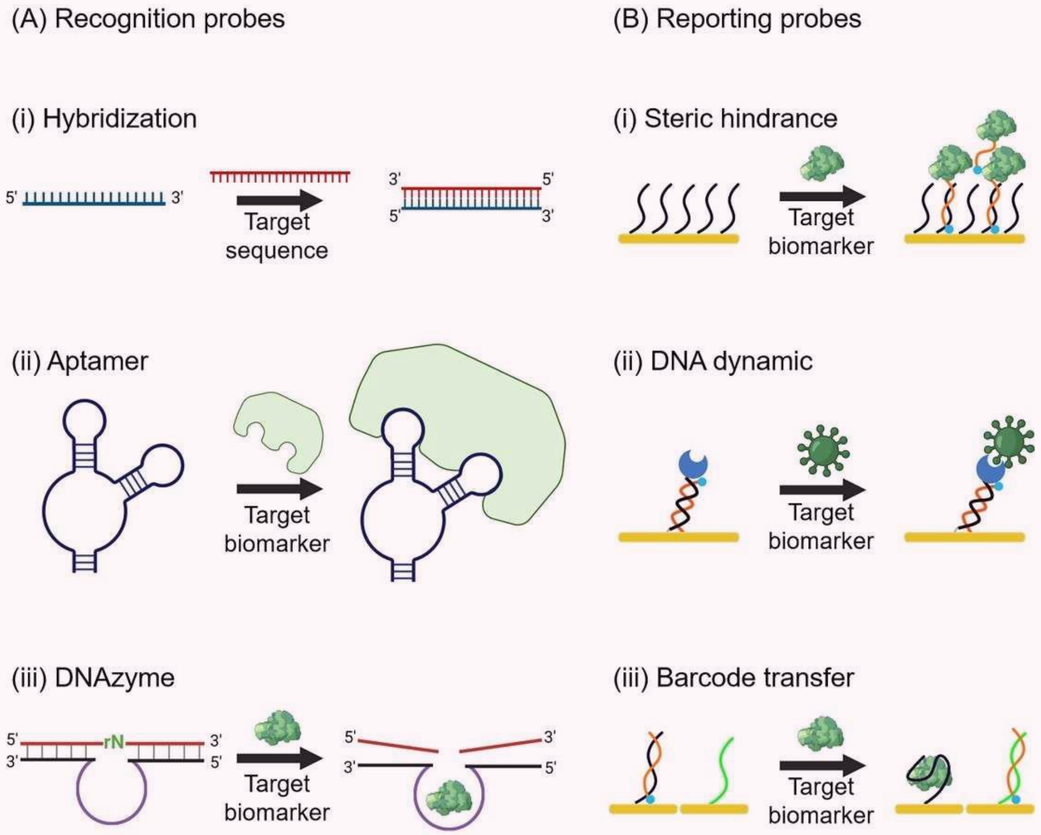



## Biointerfaces for sensor design

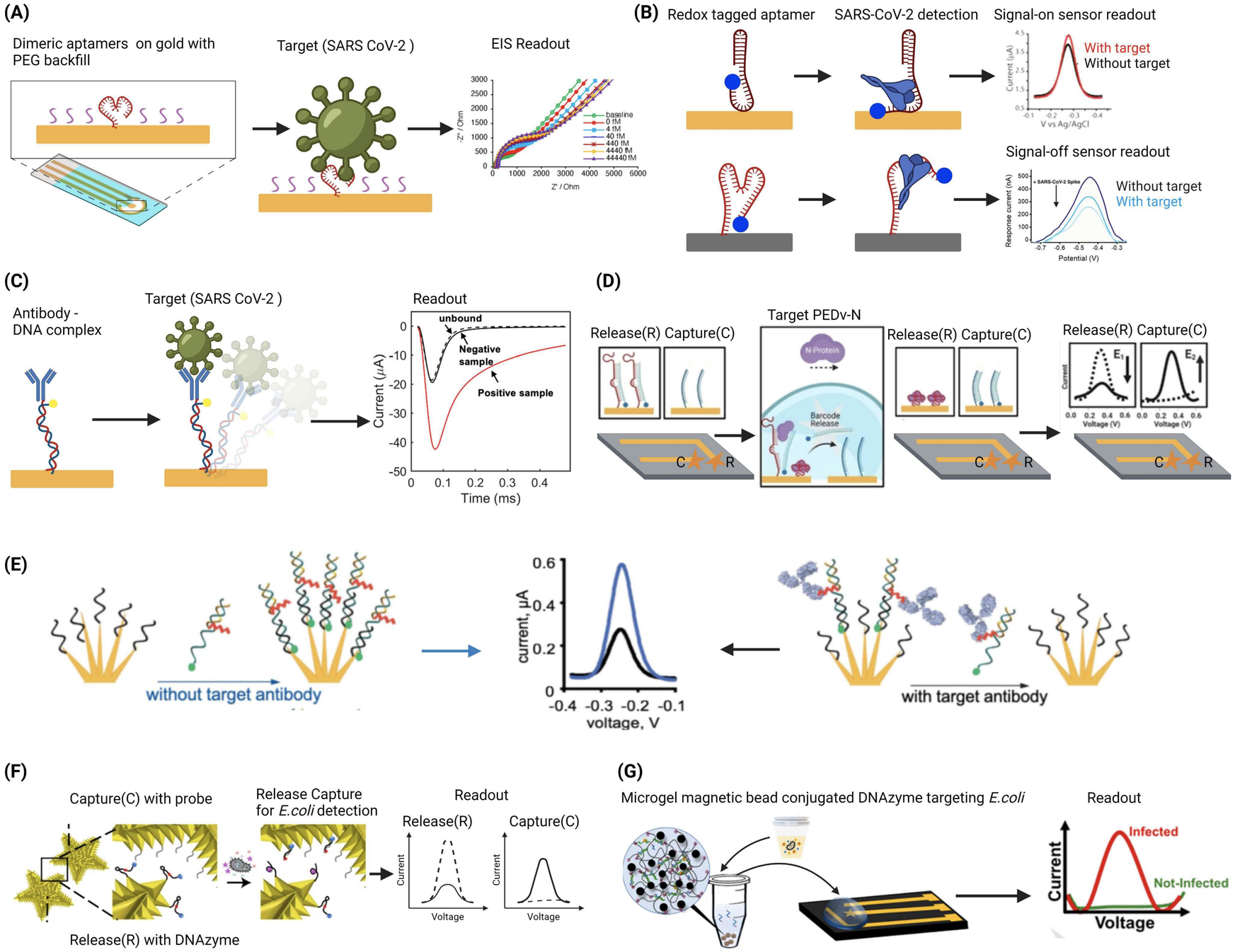
Synthetic receptors

Molecular processor layers

Dynamic probes/transducers

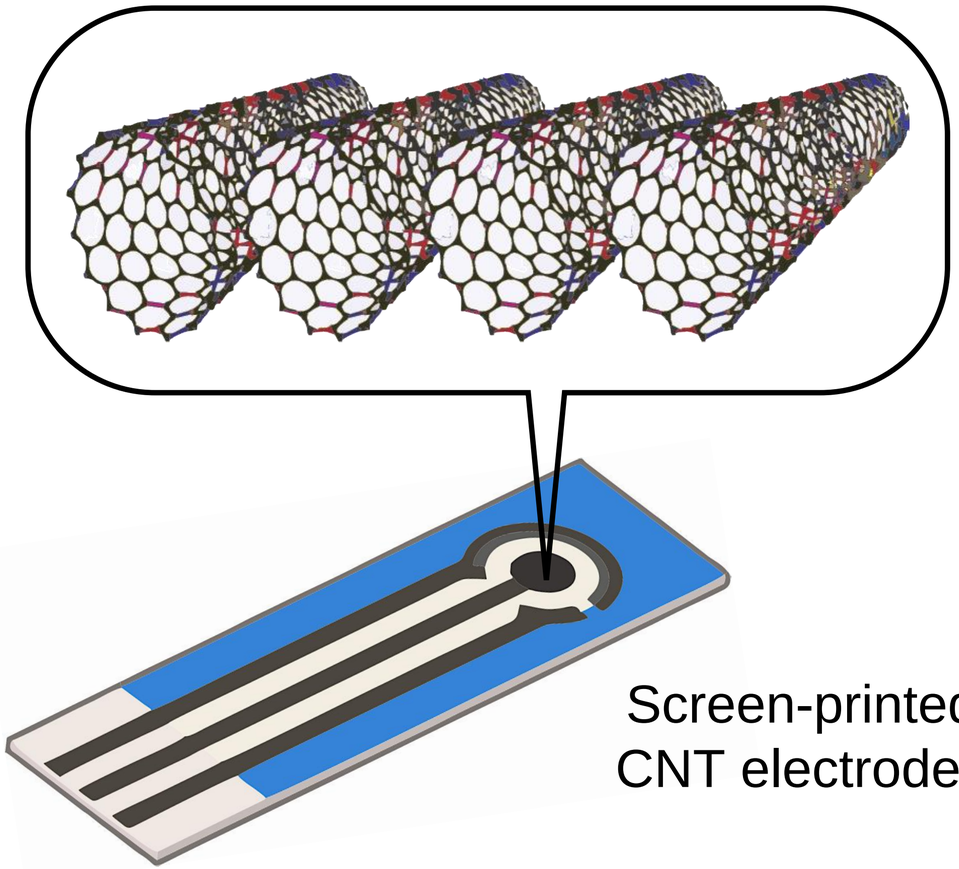



Fortunati, Bertucci, Anal Sens 2022
Chao, Fan, Biosensors Bioelectron 2016
Xe, Fan, Annu Rev Anal Chem 2018
Wang, Zu, Chem Soc Rev 2019




Zhang, Zijie, et al. "Development of Nucleic Acid-based Electrochemical Biosensors for Clinical Applications." *Angewandte Chemie* (2022).

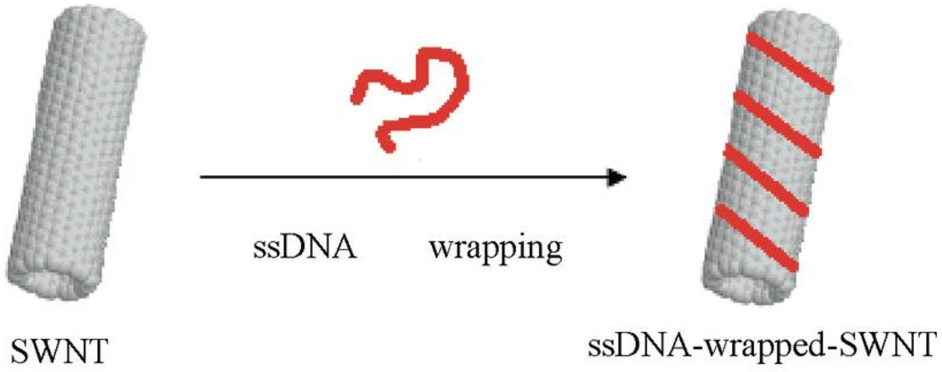
# Carbon nanotube (CNT) electrodes are desirable electrochemical platforms



Screen-printed
CNT electrodes

- Cheaper than gold
- Highly conductive
- Large surface area

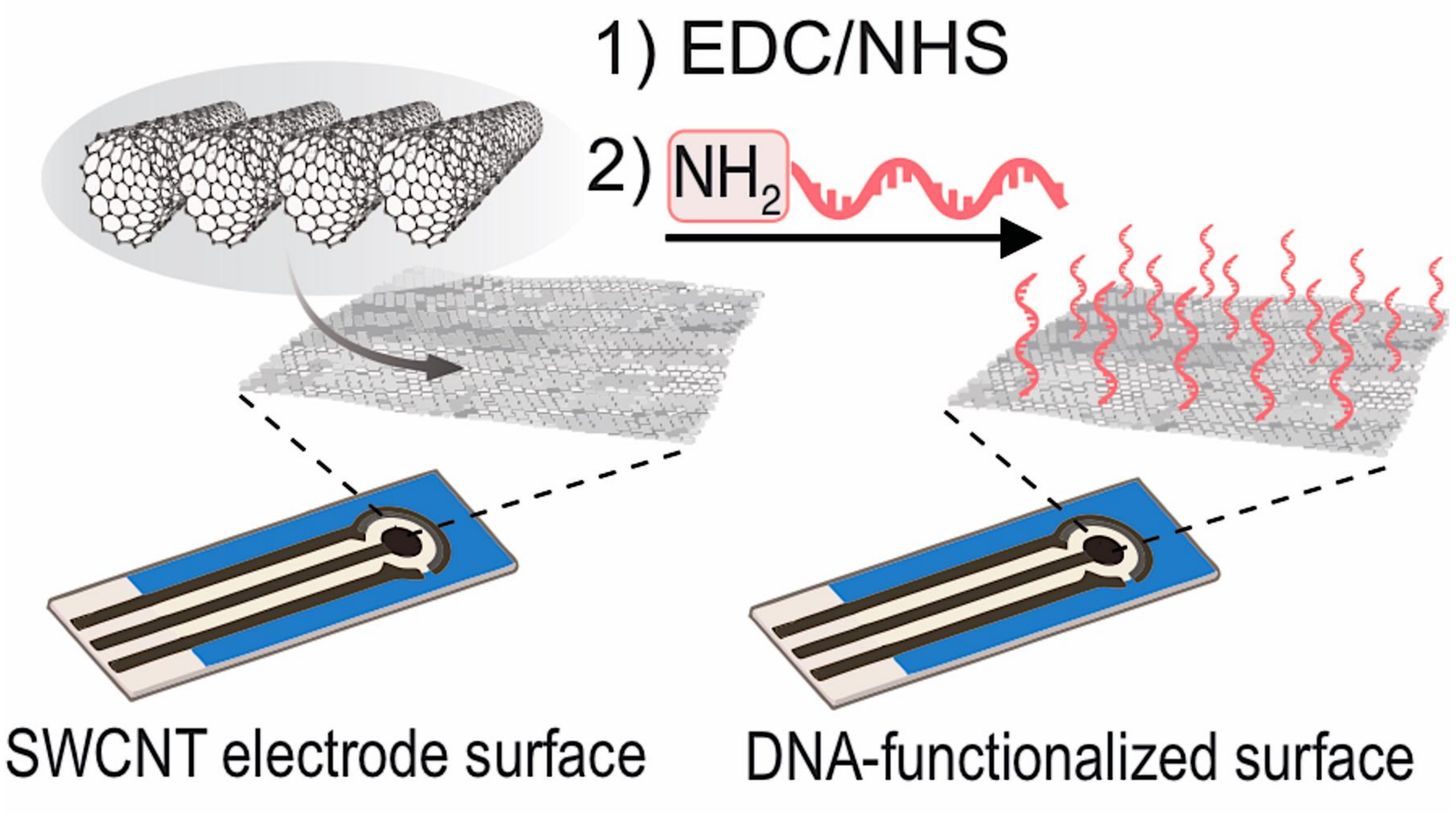
- Nonspecific DNA physisorption due to strong π-π



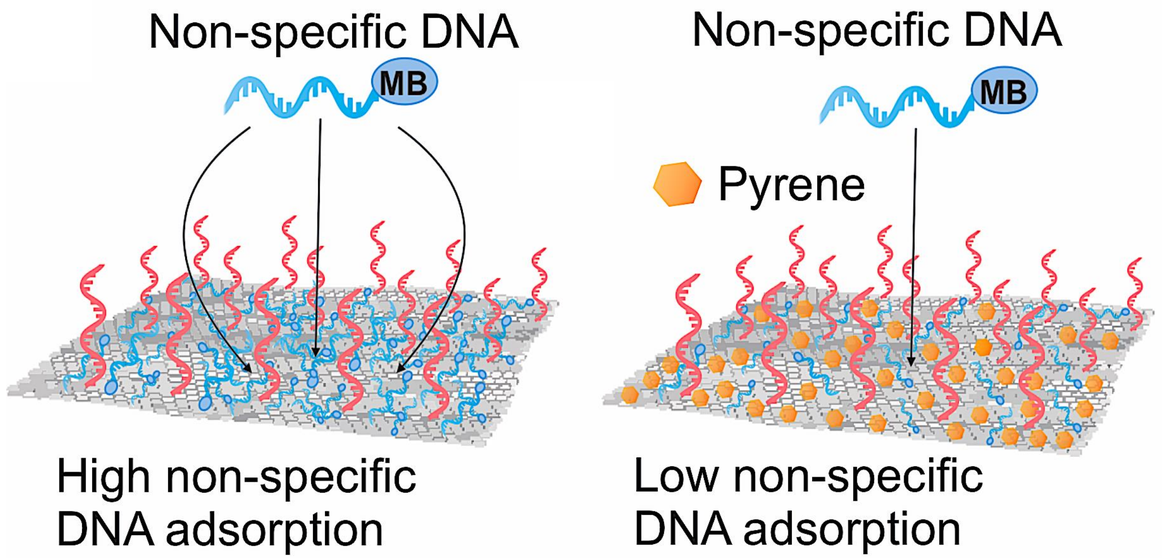

Zhang, Hu, Anal Chem 2009

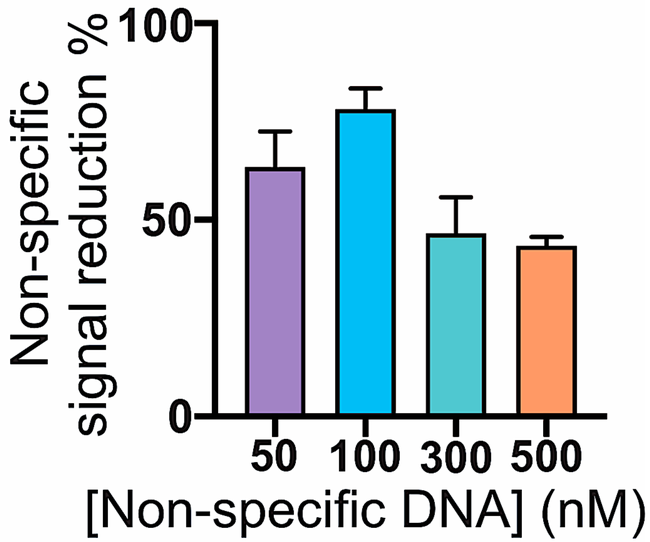
Programming and controlling dynamic and specific DNA-based interactions at the surface of single-walled carbon nanotubes electrodes can be challenging

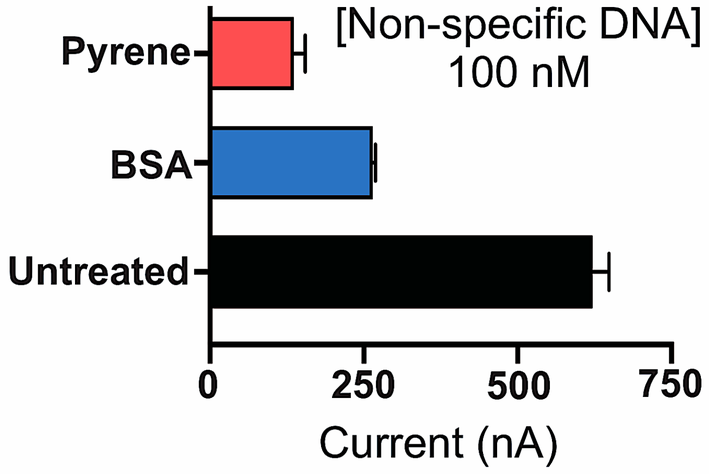
DNA probes can be efficiently attached to the CNT surface via covalent coupling



# Nonspecific adsorption is greatly reduced when using pyrene as a backfilling agent

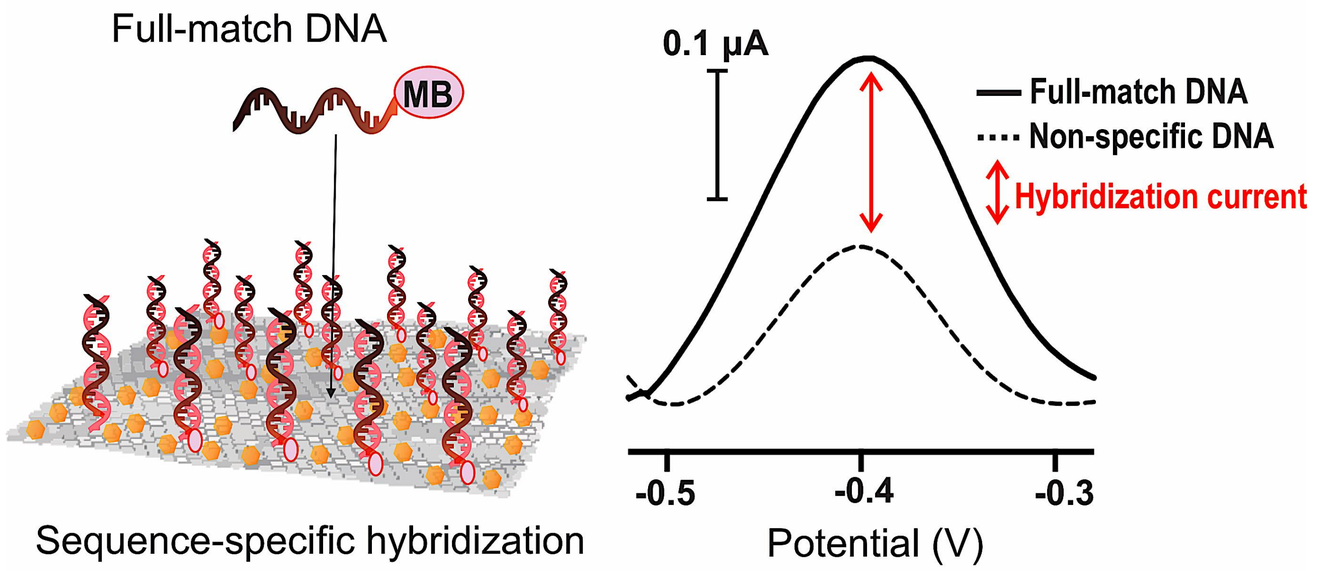


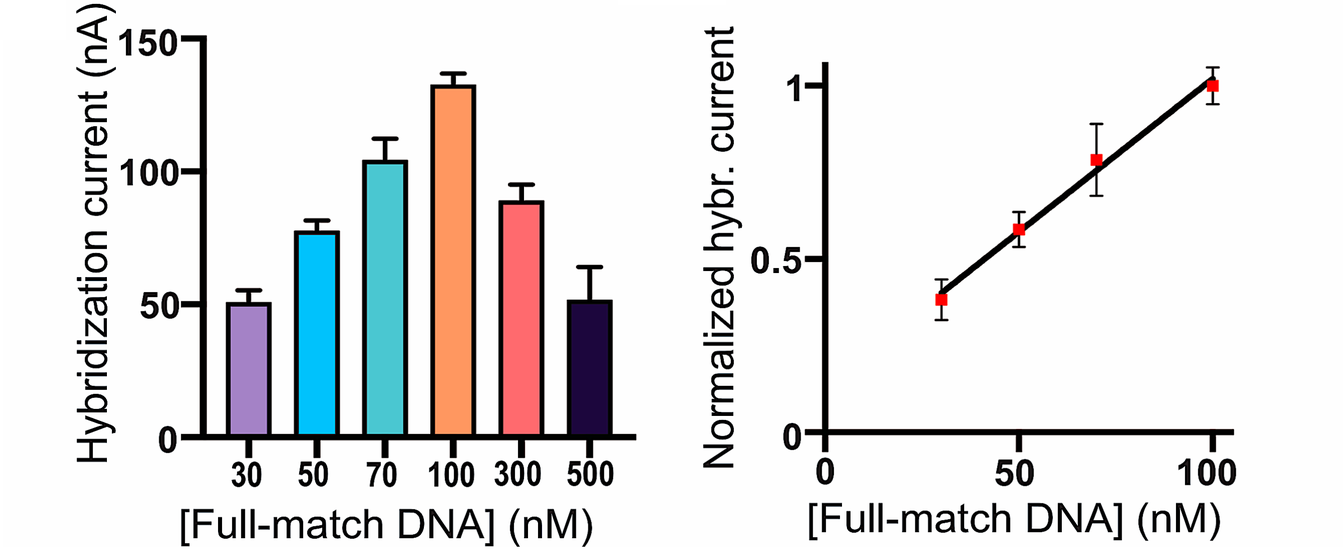




Fortunati, Bertucci, Careri, et al *Anal Chem* **2022,** 94, 5075

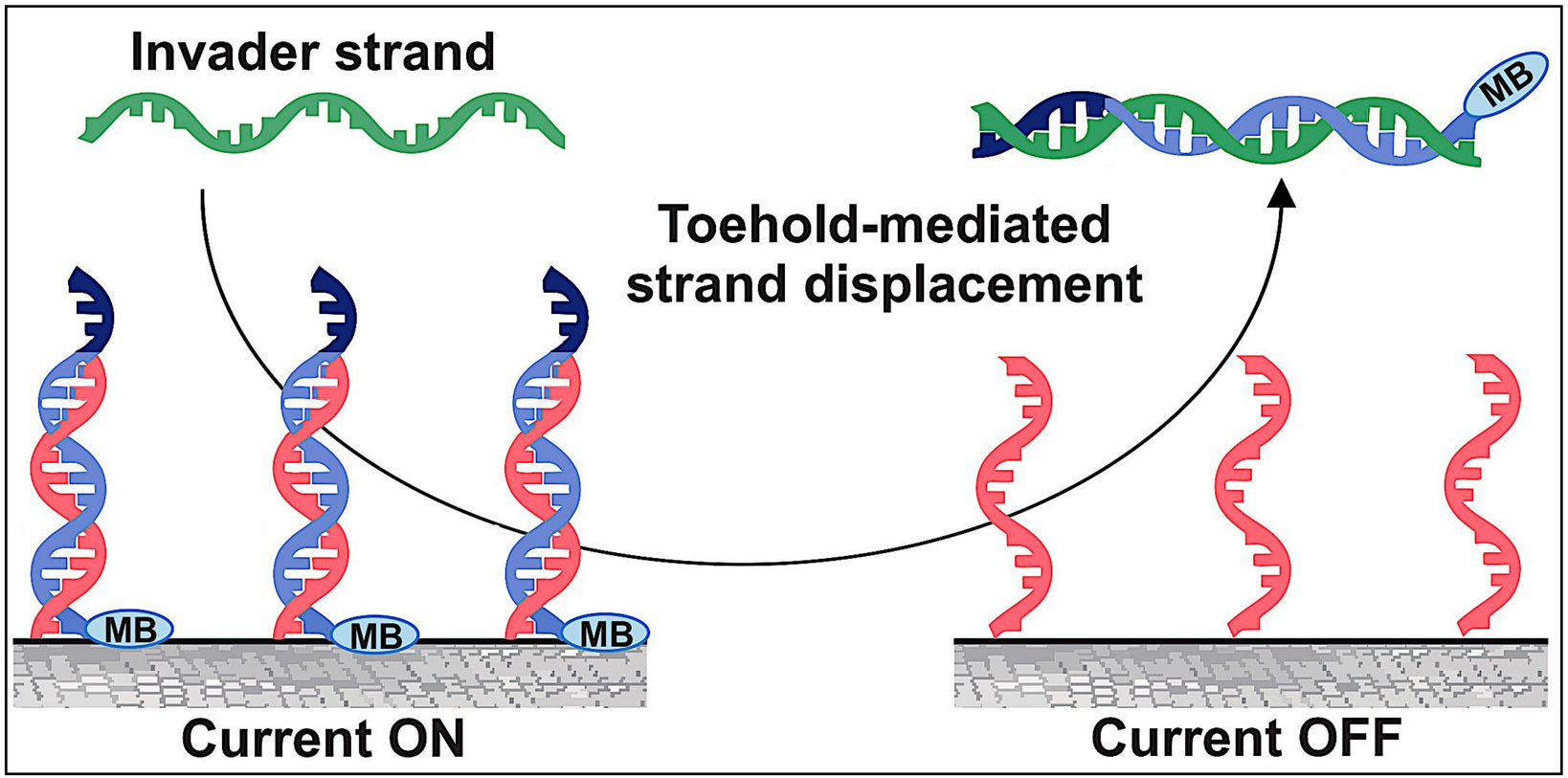
DNA duplexes can be formed in a controlled way on the CNT surface

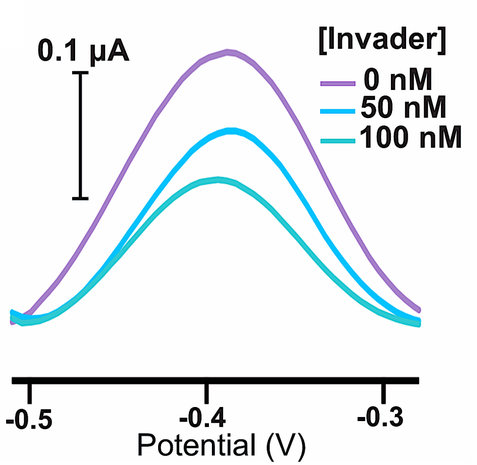


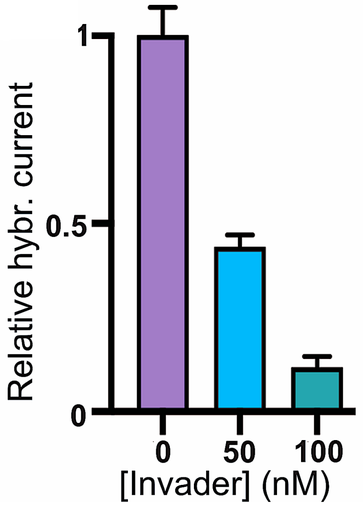

"**Hybridization current**" is introduced as a measure of specific DNA hybridization

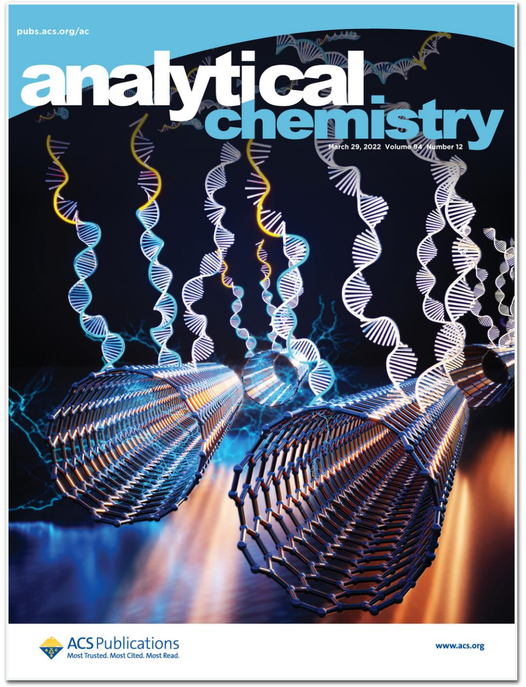


# Toehold-mediated strand displacement reactions can be carried out at the electrode surface



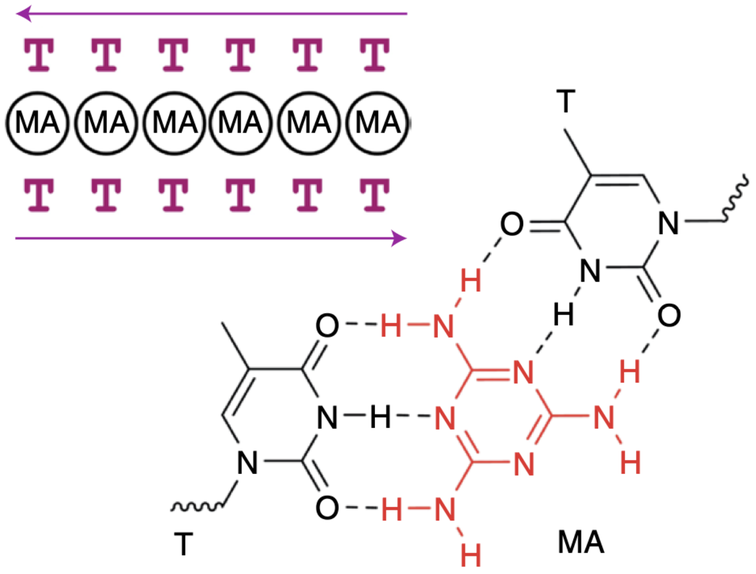



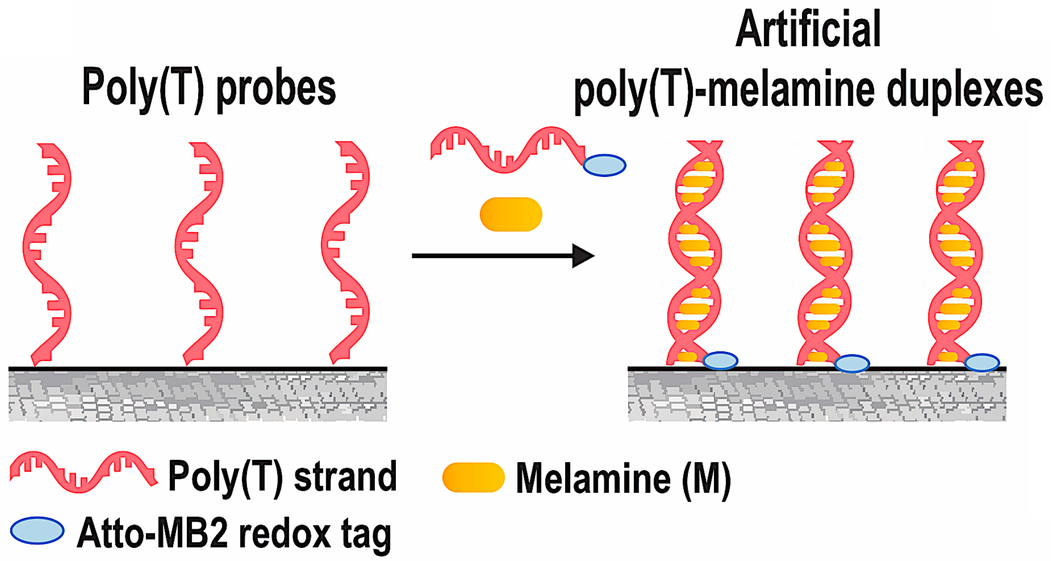



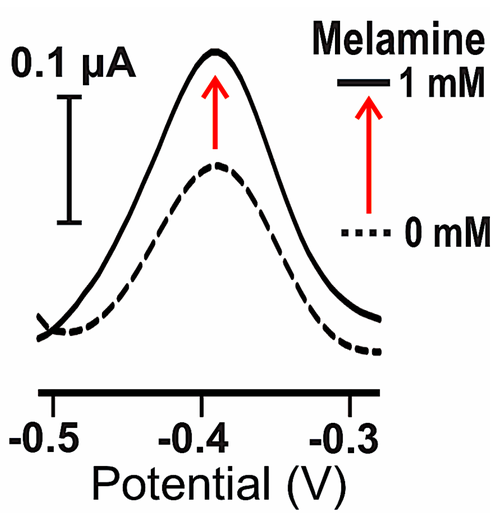




Fortunati, Bertucci, Careri, et al *Anal Chem* **2022,** 94, 5075

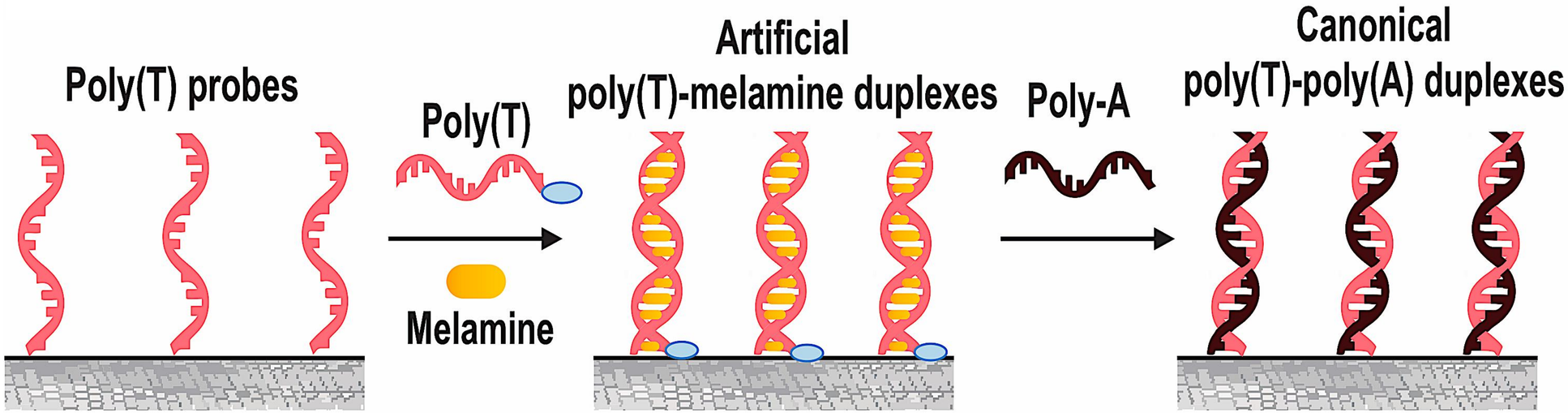
# Artificial poly(T)-melamine duplexes enable toehold-free DNA strand displacement

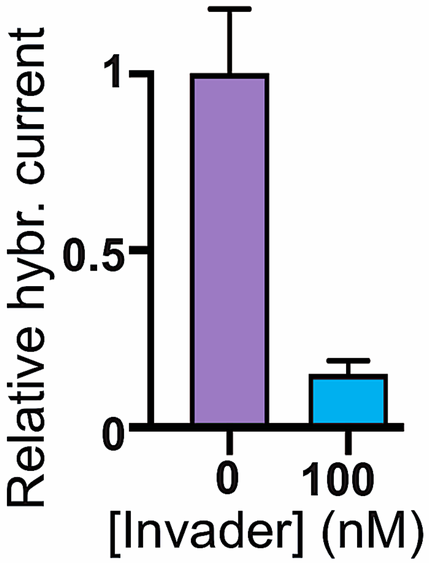


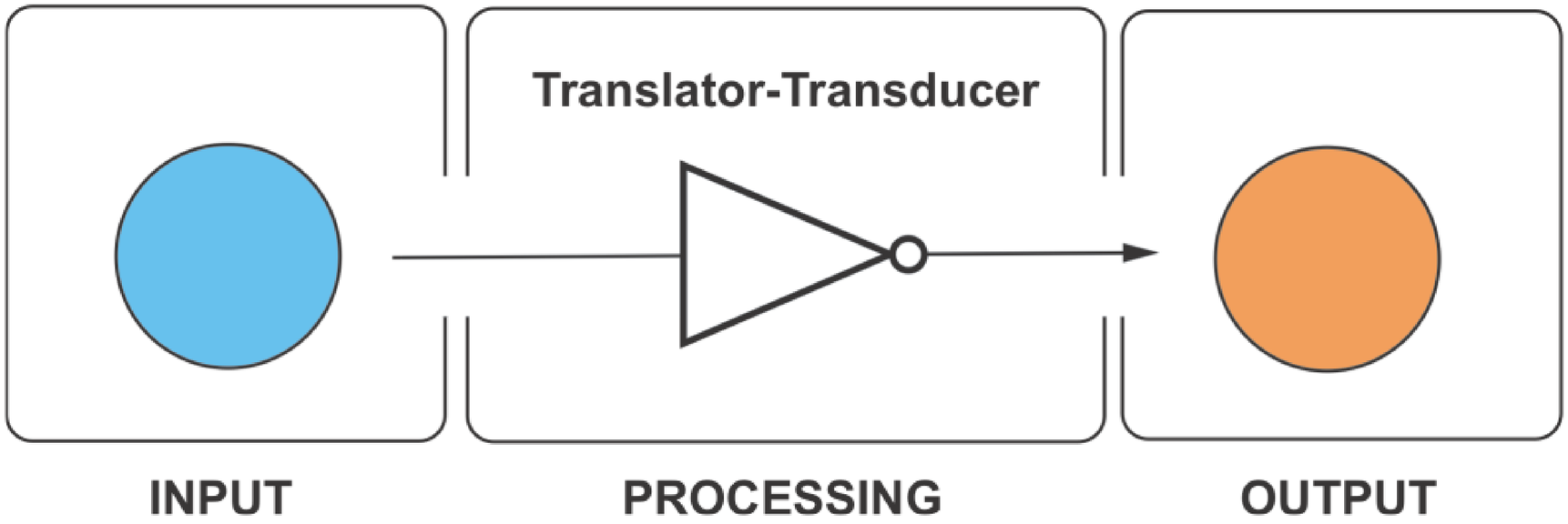



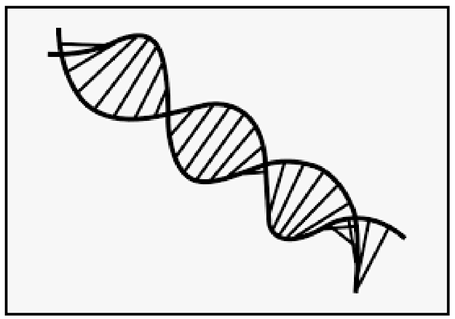

Li, Sleiman, Mao, Nat. Mater 2020



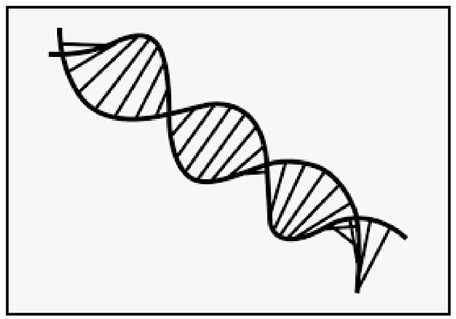



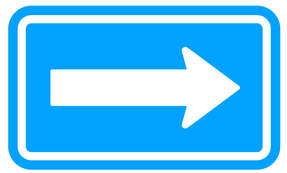



Nucleic acid input

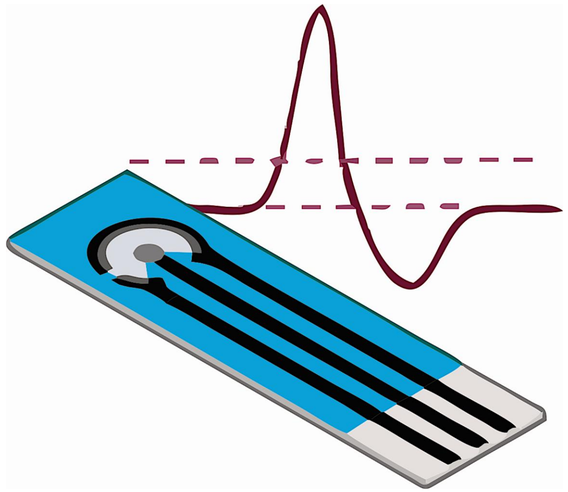


Nucleic acid probe





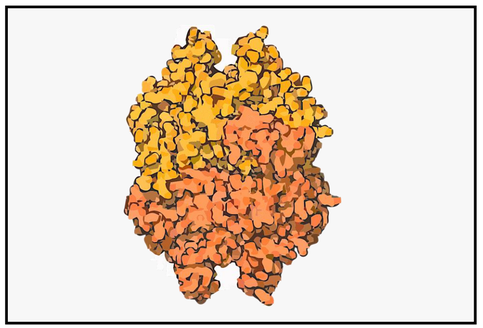
Electrochemical output

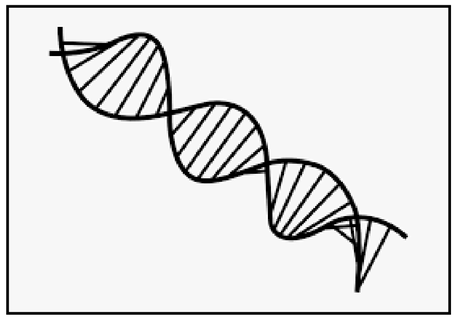


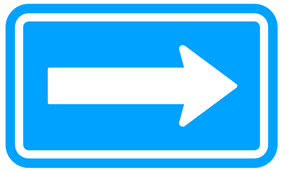
Protein input

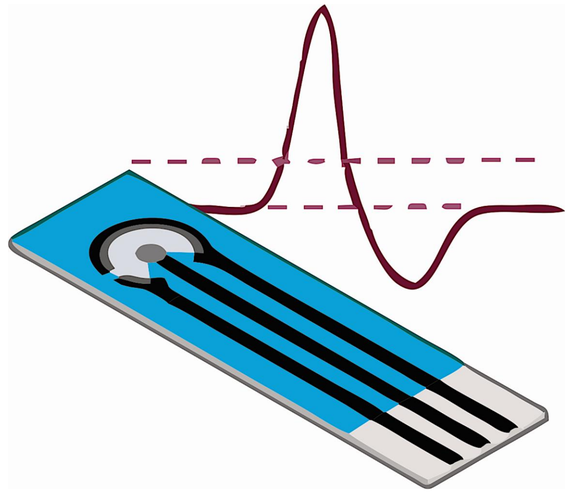
Nucleic acid probe

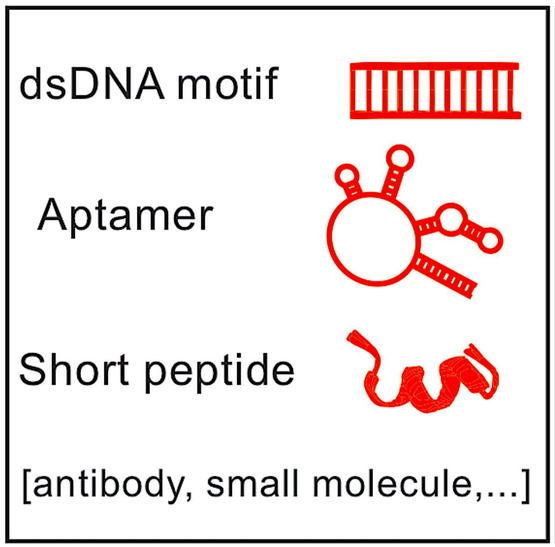
Electrochemical output

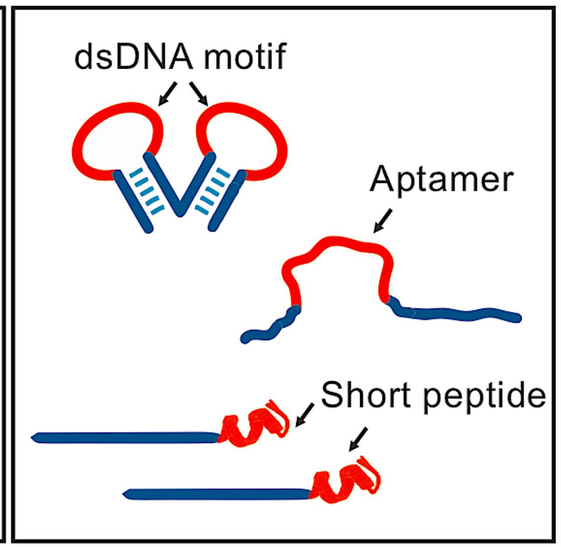


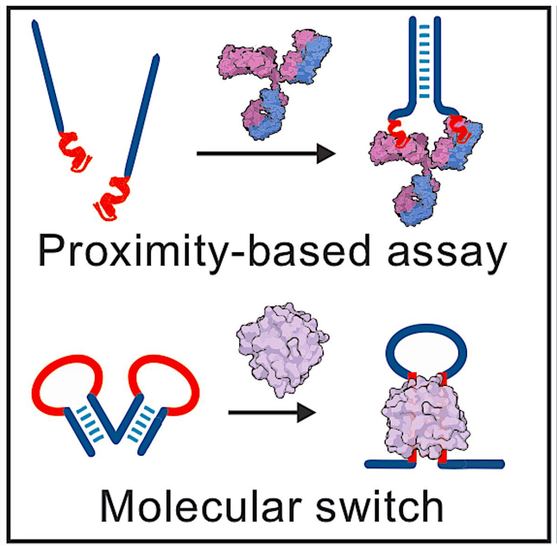


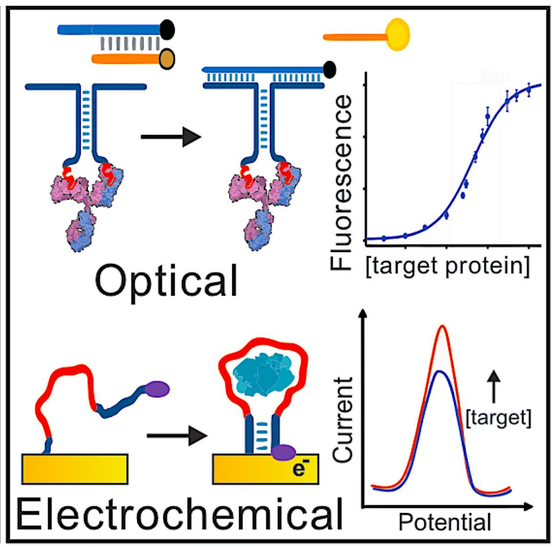







**1 - Select a specific recognition element**

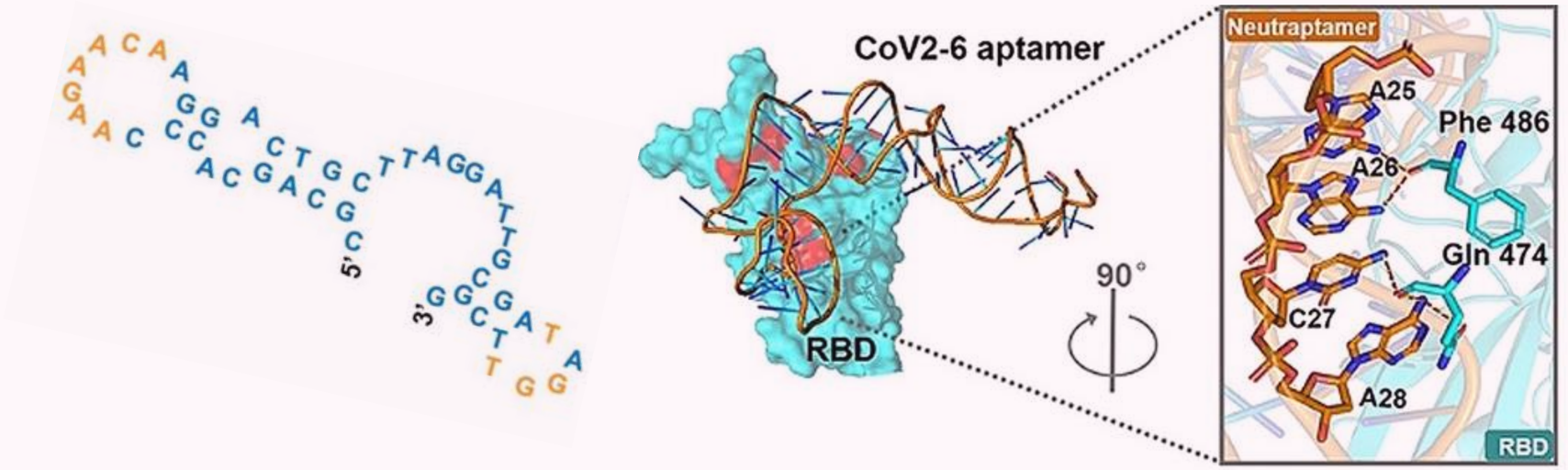
**2 - Design functional protein-interacting nucleic acid probes**

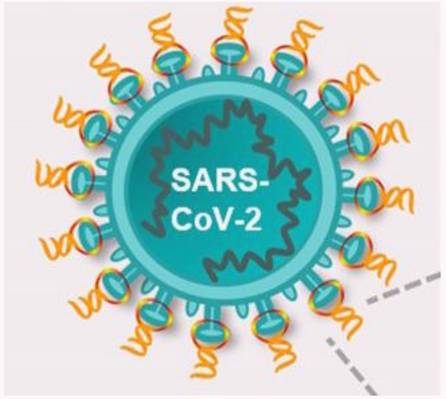
**3 - Engineer and optimize a binding-induced molecular mechanism**

**4 - Generate a measurable output**

S. Fortunati, F. Pedrini, E. Del Grosso, L. Baranda Pellejero, A. Bertucci, *Analysis & Sensing*, **2022**, e202200037.

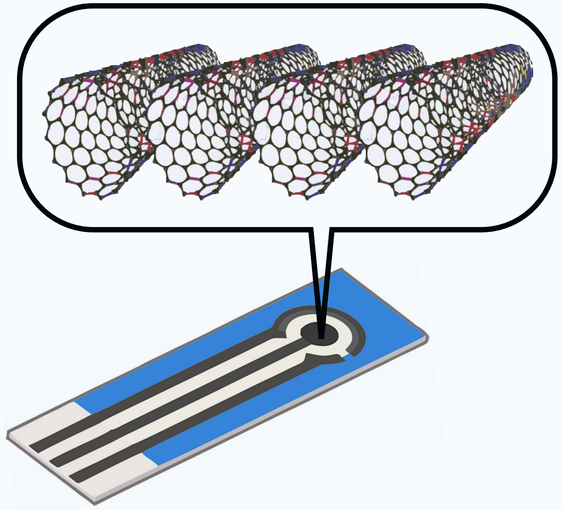
# A DNA aptamer as a dynamic electrochemical probe for the Spike protein



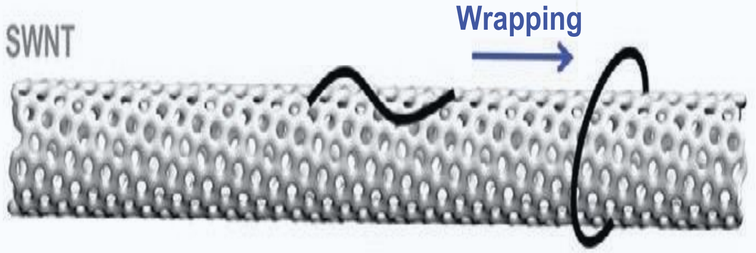




Sun, Song, Yang, Angew Chem 2021

Screen-printed carbon nanotube electrodes

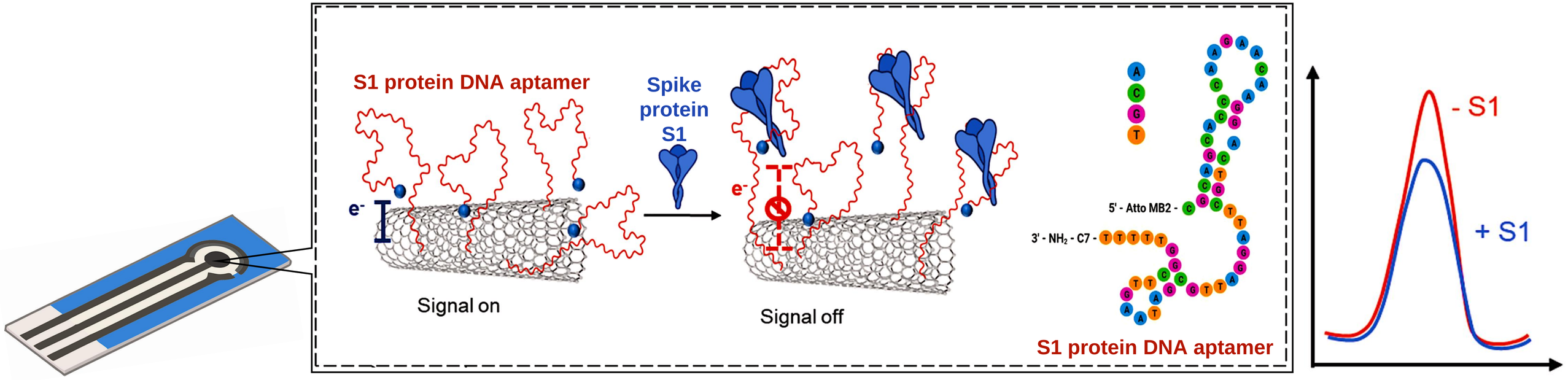


Strong π-π stacking



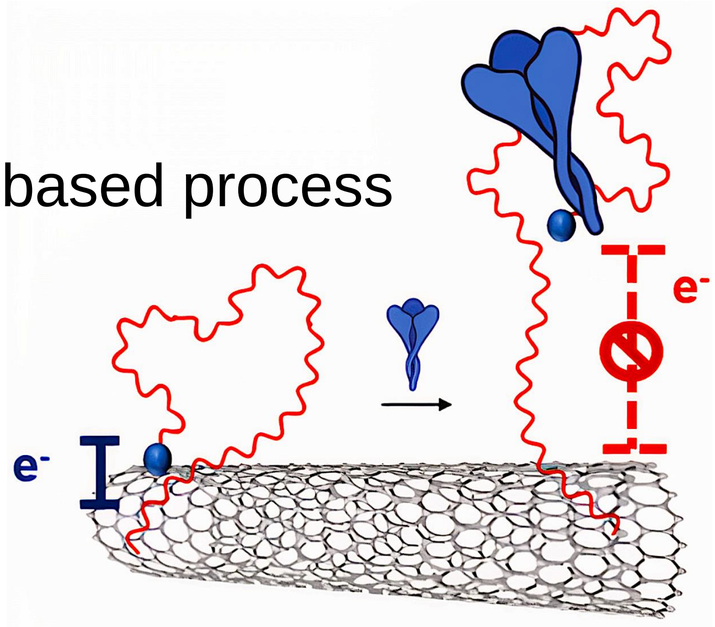

Landry, Vukovic, Adv Mater Interfaces 2020

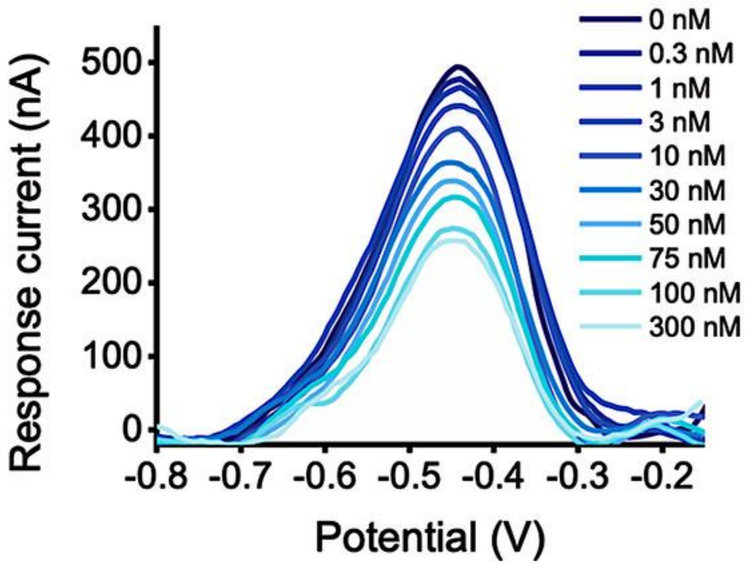
# A Folding-based electrochemical aptasensor



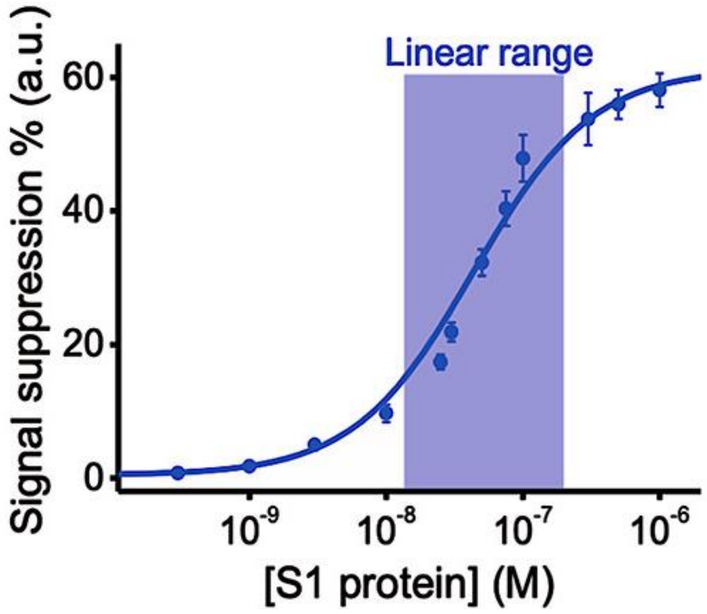

Curti, Bertucci, Careri, et al *ACS Appl Mater Interfaces* **2022,** 14, 19204

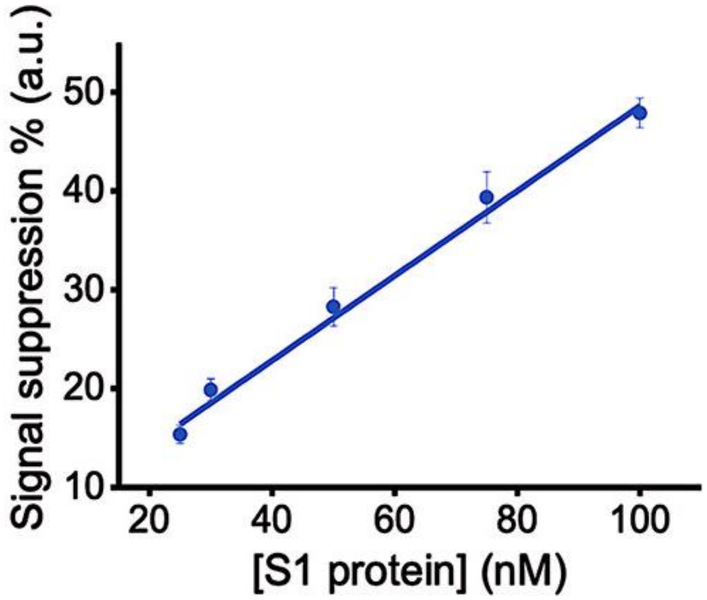
Folding-based process



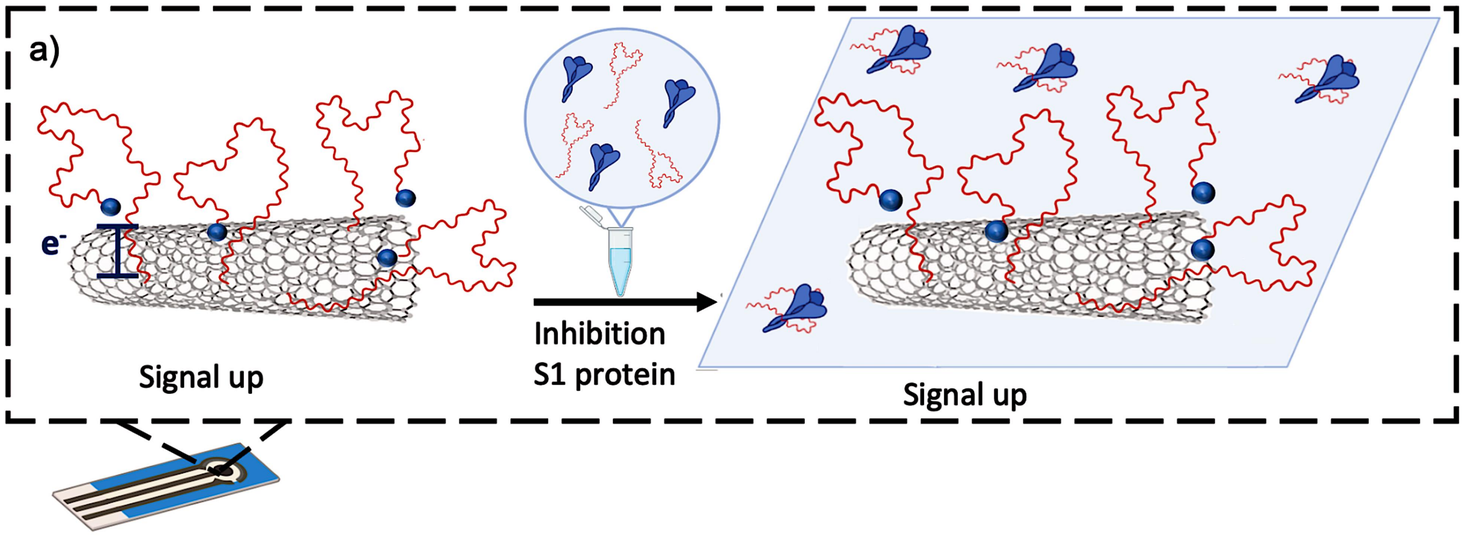



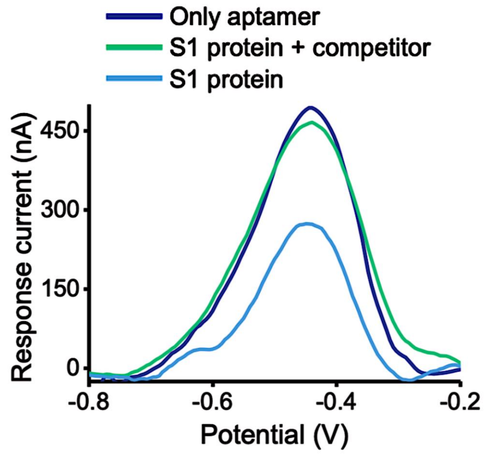

Single-step
Reagent-free
Rapid
Easy to use

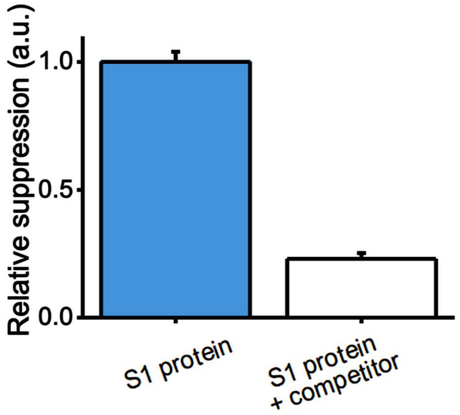


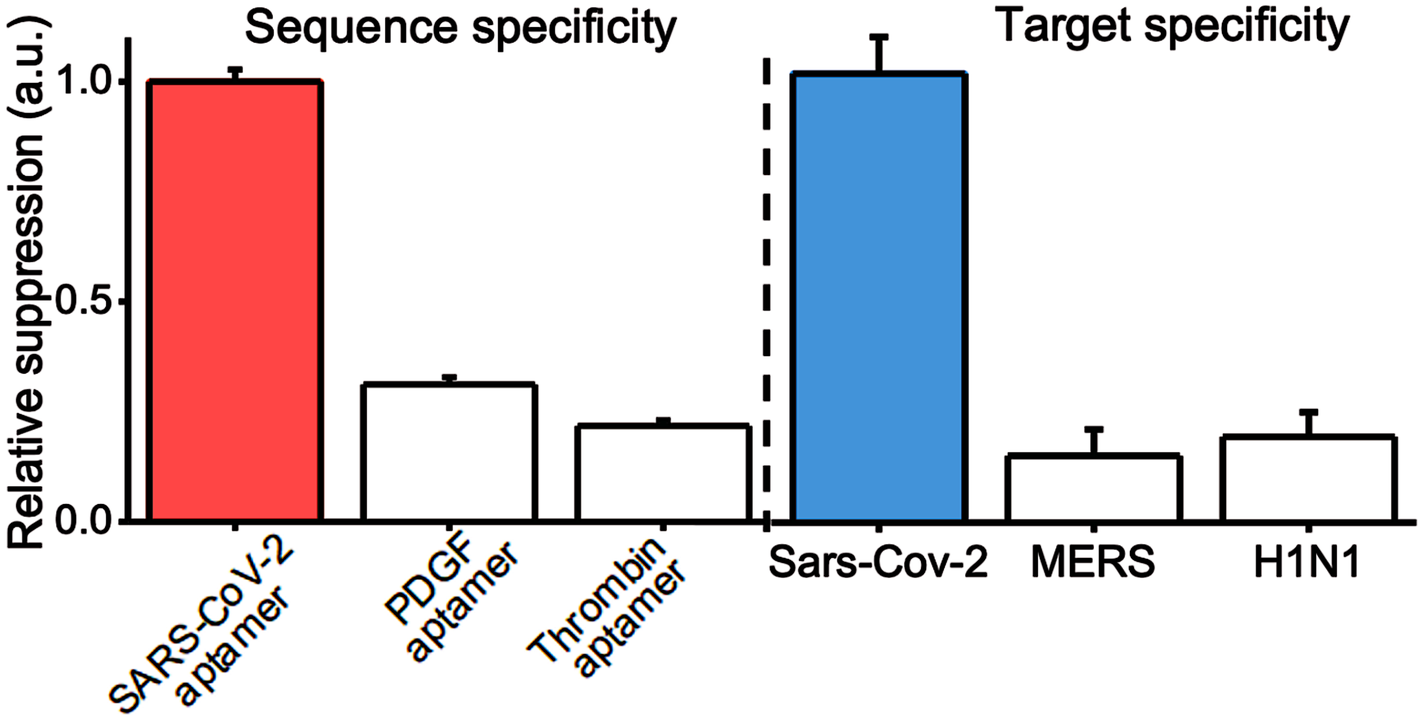




Curti, Bertucci, *ACS Appl Mater Interfaces* **2022,** 14, 19204




Curti, Bertucci, *ACS Appl Mater Interfaces* **2022,** 14, 19204

**University of Parma**

Dr. Simone Fortunati
Dr. Federica Curti
Ilaria Vasini
Prof. Marco Giannetto
Prof. Maria Careri
Prof. Monica Mattarozzi
Prof. Roberto Corradini

**University of Rome Tor Vergata**

Prof. Alessandro Porchetta

**Austrian Institute of Technology**

Prof. Wolfgang Knoll


## Laboratory of Bioartificial Systems and Programmable Nanotechnologies

Enrica Russo

Federica Pedrini

Luca Capelli

Dr. Pavlos Nikolaou


alessandro.bertucci@unipr.it

AleBertu



Fondazione Guido Berlucchi
Organizzazione Non Lucrativa di Utilità Sociale (ONLUS)

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