## Paper-based sensors

Paper substrates are promising for development of cost-effective and efficient point-of-care biosensors, essential for public healthcare and environmental diagnostics in emergency situations. Most paper-based biosensors rely on the natural capillarity of paper to perform qualitative or semi-quantitative colorimetric detections (Figure 1). To achieve quantification and better sensitivity, technologies combining paper-based substrates and electrical detection are being developed.

In this work, we demonstrate the potential of electrical measurements by means of a simple, parallel-plate electrode setup towards the detection of whole-cell bacteria captured in nitrocellulose (NC) membranes. Unlike usual electrical sensors, which are mostly integrated, this plug and play system has reusable electrodes and enables simple and fast bacterial detection through impedance measurements (Figure 2). The characterized NC membrane was subjected to (i) a biofunctionalization, (ii) different saline solutions modelling real water samples, and (iii) bacterial suspensions of different concentrations. Bacterial detection was achieved in low conductivity buffers through both resistive and capacitive changes in the sensed medium. To capture Bacillus thuringiensis, the model microorganism used in this work, the endolysin cell-wall binding domain (CBD) of Deep-Blue, a bacteriophage targeting this bacterium, was integrated into the membranes as a recognition bio-interface. This experimental proof-of-concept illustrates the electrical detection of $10^7$ colony-forming units (CFU) $mL^{-1}$ bacteria in low-salinity buffers within 5 minutes, using a very simple setup. This offers perspectives for affordable pathogen sensors that can easily be reconfigured for different bacteria. Water quality testing is a particularly interesting application since it requires frequent testing, especially in emergency situations.


- G. Le Brun, J.-P. Raskin, "Life cycle approach for electronics eco-design: case study on paper-based water quality sensors", Procedia CIRP, vol. 90, 2020, pp. 344-349, https://doi.org/10.1016/j.procir.2020.02.041.
- G. Le Brun, M. Hauwaert, A. Leprince, K. Glinel, J. Mahillon and J.-P. Raskin, "Electrical characterization of cellulose-based membranes towards pathogen detection in water", *Biosensors*, 11, 57, February 2021, https://doi.org/10.3390/bios11020057.


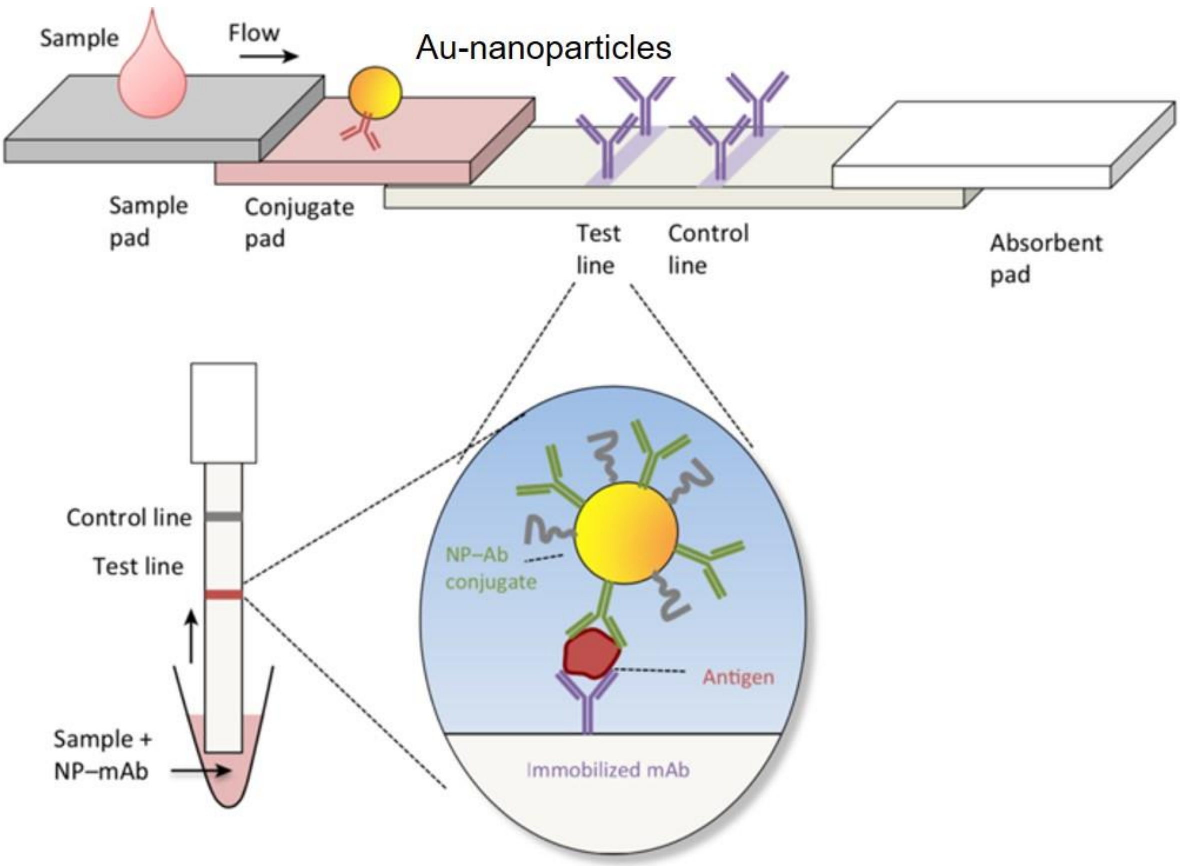


Figure 1. Classical lateral flow assay (LFA) based on semi-quantitative colorimetric detection.

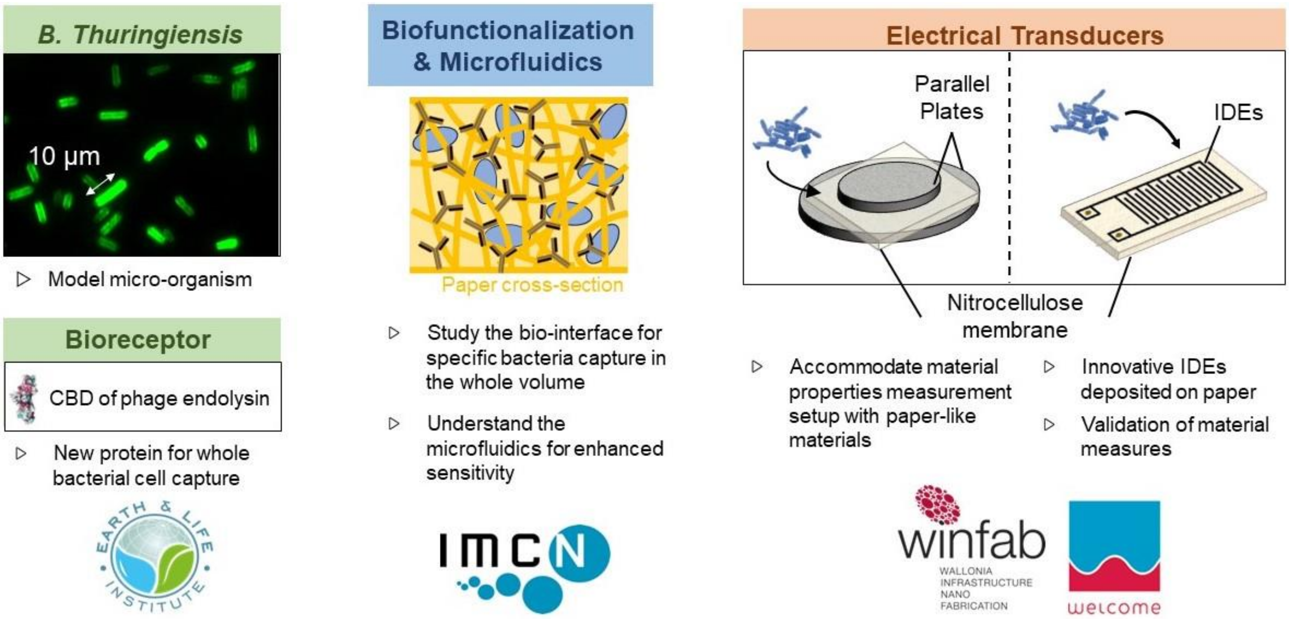


Figure 2. Attachment of bioreceptors onto nitrocellulose matrix and wideband electrical detection using either parallel plate or interdigitated electrodes.

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