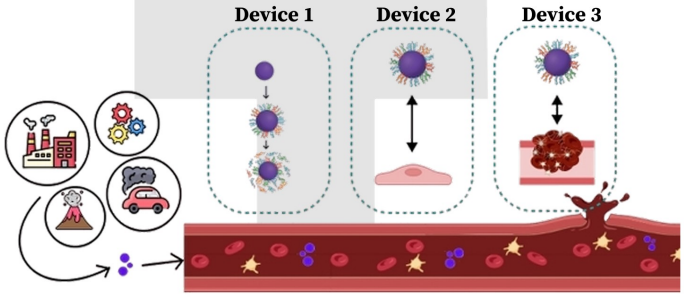
Nano-pollutants in blood: from protein corona formation to endothelial and haemostatic response in a microphysiological system

*S. Buis ¤, T. Leblois ¤, V. Humblot ¤, L. Maurizi °, E. De Maistre *, F. Chollet ¤ and A. Figarol ¤*

¤Université Marie et Louis Pasteur, CNRS, institut FEMTO-ST, F-25000 Besançon, France
°IS2M, CNRS, Université de Haute-Alsace, Mulhouse, France
*Haemophilia Treatment Centre, University Hospital of Dijon Bourgogne, Dijon, France

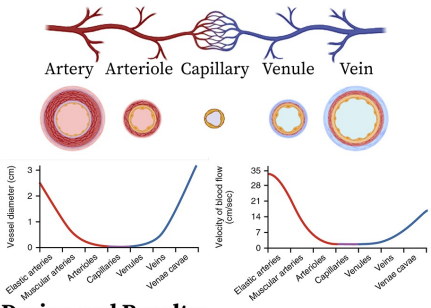
Introduction

Airborne nanopollutants (NPs) emitted by combustion or industrial activities, are increasingly recognized for their potential impact on health [1-2]. Due to their small size and high surface reactivity, NPs can translocate from the lungs into the bloodstream [2]. Once in the blood, a **protein corona** forms, alters their surface properties and governs interactions with the **vascular endothelium** and **haemostasis mechanisms**. The biological effects of NPs remain elusive due to the complexity of the protein corona and the lack of standardized models. To address these challenges, **a microphysiological platform is being developed** to form NPs coronas (device 1), monitor endothelial responses (device 2), and assess effects on primary and global haemostasis (device 3).

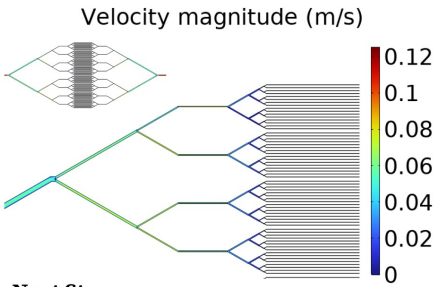


Device 1: Protein Corona Formation

Purpose:
Simulate the human circulatory system to form physiologically relevant NP coronas.



Design and Results:
Validation of flow velocities in the first device design using COMSOL multiphysics.

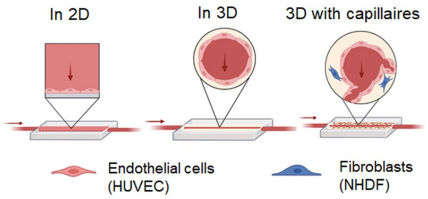


Next Steps:
- Fabrication of the device
- Test using model NPs in simple biofluids

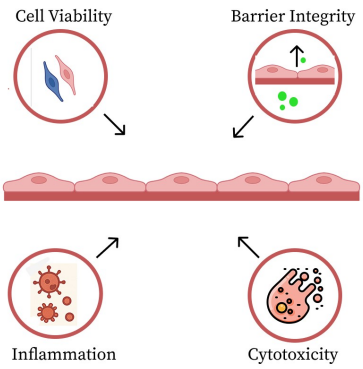
Device 2: Endothelium-on-Chip

Purpose:
Investigate endothelial responses to exposure of NPs with protein corona.

Design:
A microfluidic device lined with endothelial cells, developed in 3 levels of complexity:

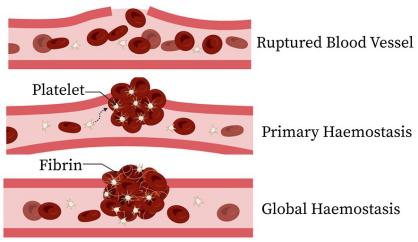


Planned Analysis:
Different tests to indicate endothelial response to NPs with protein corona.

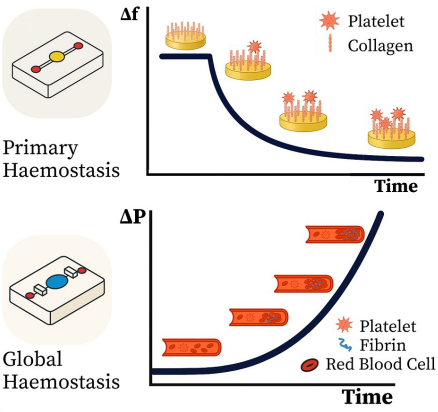


Device 3: Heamostasis-on-Chip

Purpose:
Evaluate the impact of NPs on primary and global heamostasis.



Design:
Based on previous work from ANR projects BLOOD and GHOST.

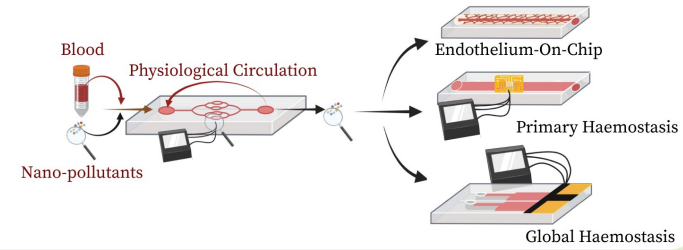


Integration of components

The three modules —protein corona formation, endothelium-on-chip, and haemostasis— will be integrated to simulate the biological interactions of NPs.

Incorporation of **in-flow sensing**:
- Particle Size
- Zeta Potential
- pH

Testing different **Nano-pollutants**:
- Silica (SiO_2) NPs
- Carbon based NPs
- Metal oxide NPs



References

[1] European Environment Agency (n.d.). [2] H.-S. Kwon, M. H. Ryu, and C. Carlsten, Exp. Mol. Med. 52, 318 (2020). [3] J. G. Betts et al., (2022).

Contact
Sieka BUIS
sieka.buis@femto-st.fr
+33 (0)3 63 08 23 79
FEMTO-ST - MN2S - BIND team
15b avenue des Montboucons
25030 Besançon France

Acknowledgments
This work is funded by ANR ModernIt (ANR-24-CE19-2093), partly supported by the French RENATECH network and its FEMTO-ST facilities. BioRender was used to create some of the figures.