# Remote-controlled synthetic cells for biology and medicine

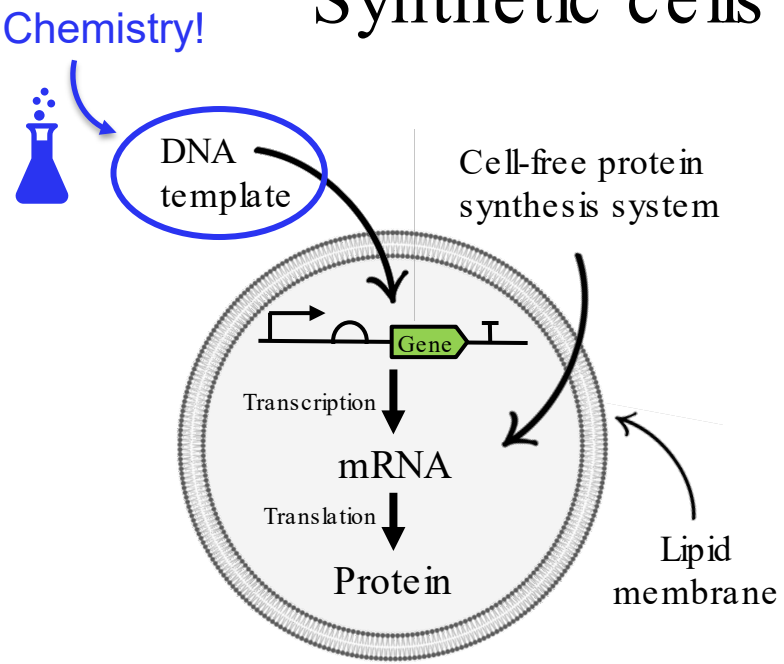
Michael J. Booth
Royal Society University Research Fellow
Associate Professor of Chemical Biology and Organic Chemistry
University College London, UK

Frontiers of Synthetic Cells: Applications, Insights, and Implications
NASEM webinar
22nd July 2025


@DrMikeBooth
boothlab.uk

THE ROYAL SOCIETY

# Synthetic cells for biology and medicine




In-situ protein synthesis inside a cell-like compartment according to an encapsulated DNA template

***Cellular function in a minimal environment***

- Customisable (synthetic + bio parts)
- Not alive!

***Applications:***

- Studying/manipulating living processes
- Smart therapeutics
- Biosensing
- Bioreactors

(Niche between living cells and individual molecules)

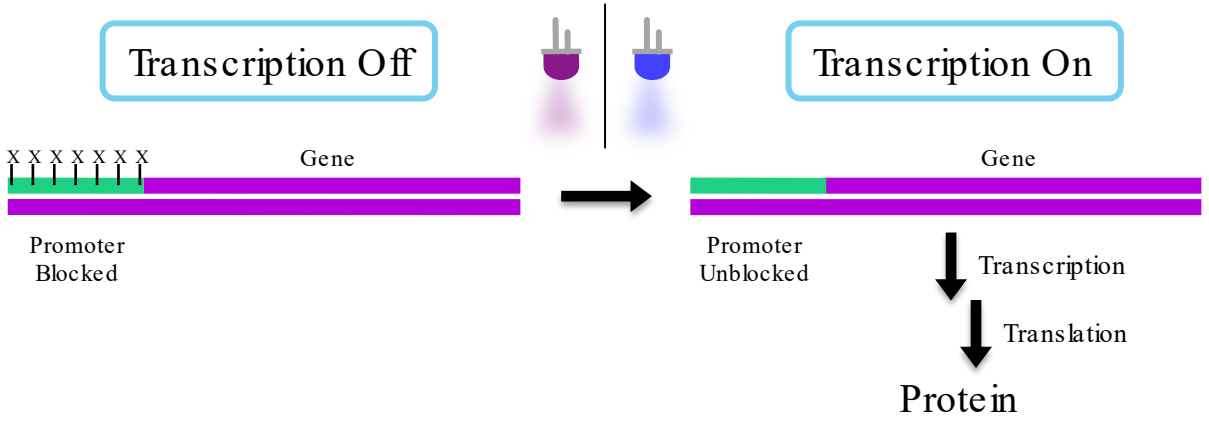
Need methods of control

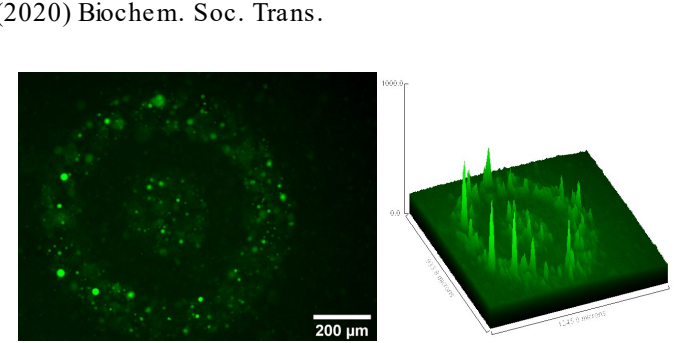
Smith, J., Chowdhry, R., et al. (2021) Front. Mol. Biosci.

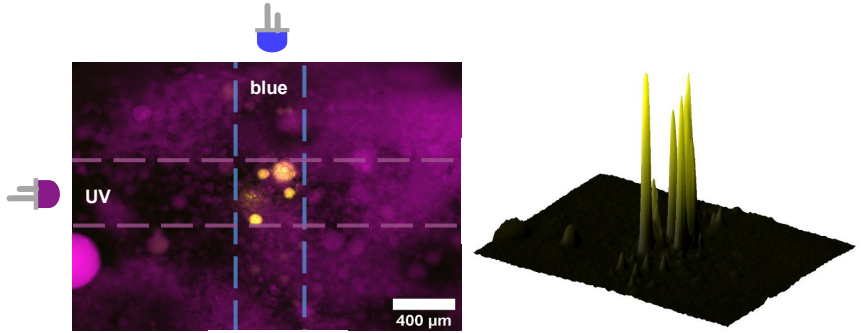
# Light-activated DNA

**Light as a stimulus:**
- Spatial precision (μm)
- Biocompatible
- Multiwavelength orthogonality
- Tissue penetration with longer wavelengths

Hartmann, D., Smith., J., et al. (2020) Biochem. Soc. Trans.

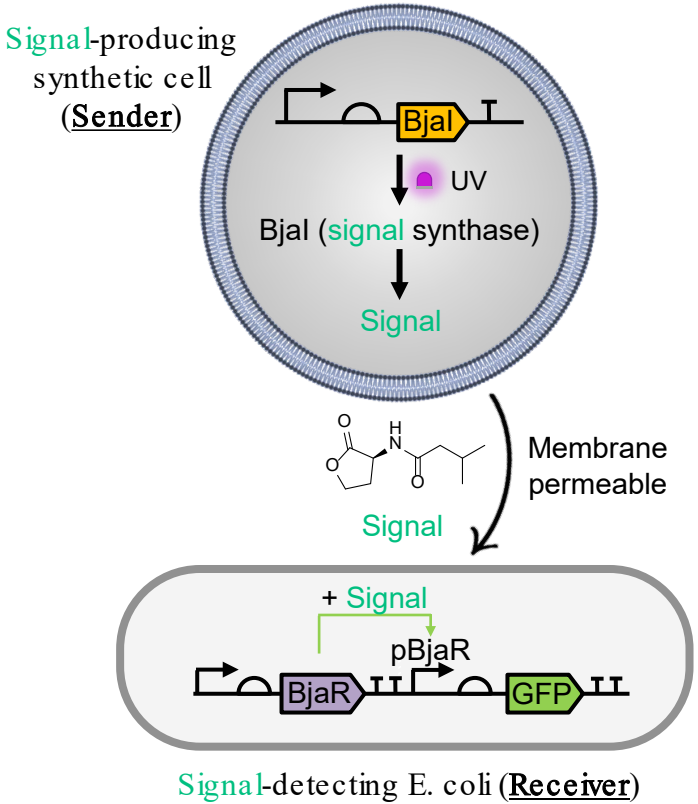


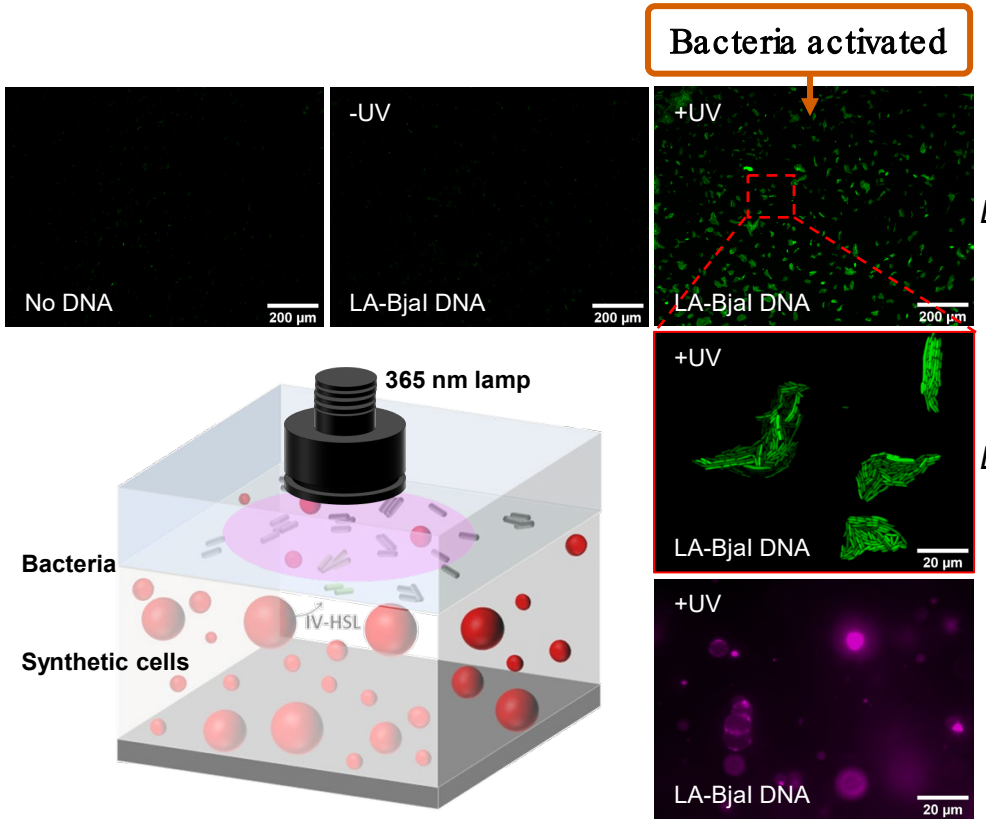




Booth, M., et al. (2016) Sci. Adv., Hartmann, D., et al. (2023) JACS, Smith, J. M., et al. (2023) Nat. Chem. Biol.

# Light-activated synthetic cell -> bacteria communication



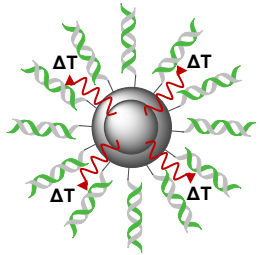




Smith, J. M., et al. (2023) Nat. Chem. Biol.

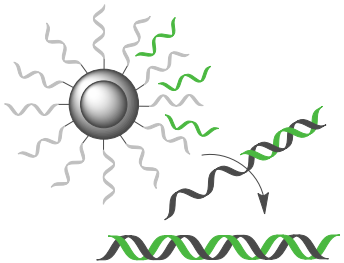
# Magnetically-activated nucleic acids

Promoter DNA attached to magnetic nanoparticle

Gene Expression OFF




Alternating magnetic field induces heat emission and DNA release



Active template formed

Gene Expression ON

mNeonGreen

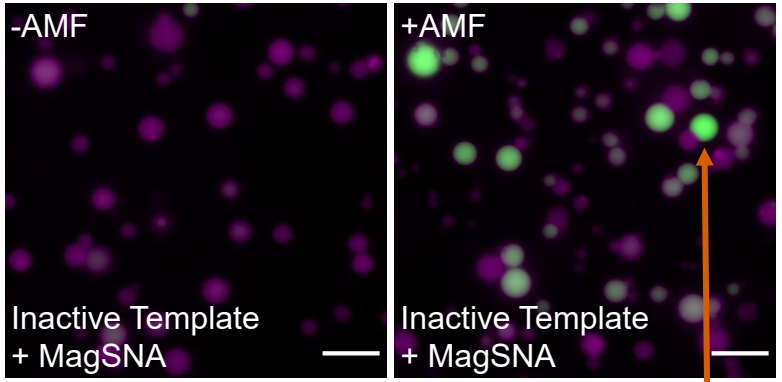
Cell-free protein synthesis

**Magnetism as a stimulus:**

- Deeply tissue penetrating
- Biocompatible

***with Iron Oxide Nanoparticles:***

- Clinically applied using alternating magnetic field
- Trackable by MRI

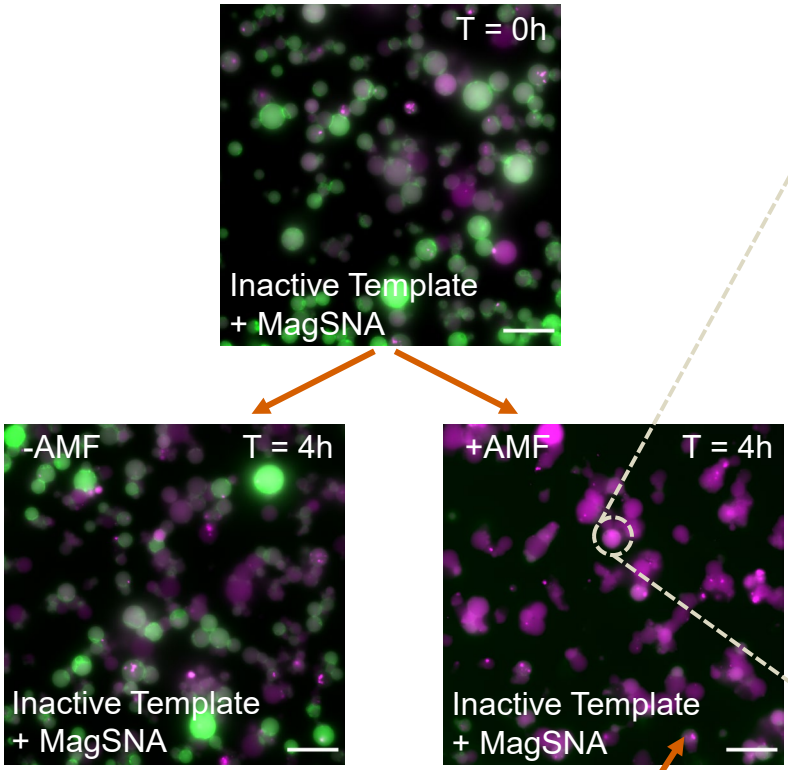


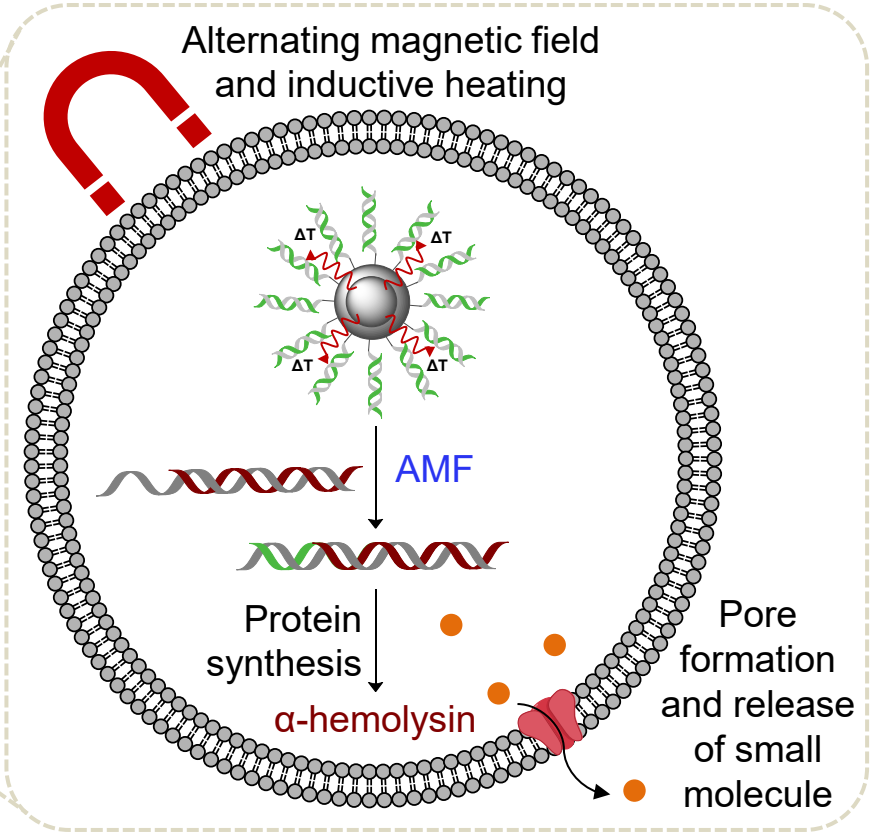

**Synthetic cells activated by the magnetic field!**

Parkes, E., et al. (2025) Nat. Chem. (Accepted)

# Magnetically-activated small molecule release

Synthetic cell - Small molecule



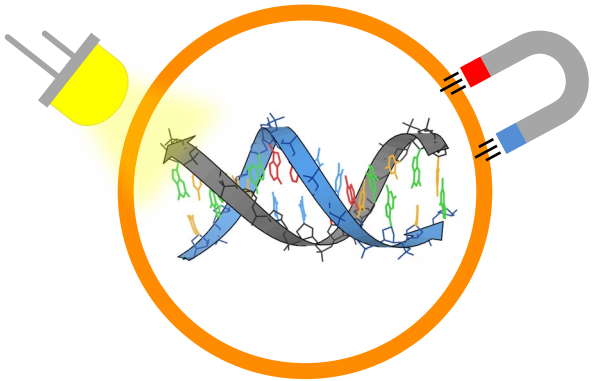

Release from synthetic cells only using the magnetic field!

# Remote-controlled synthetic cells for biology and medicine

@DrMikeBooth

boothlab.uk

Chemistry is vital to realise the potential of synthetic cells/synthetic biology for studying living organisms and treating diseases



*Acknowledgements*


EPSRC

BBSRC bioscience for the future

THE ROYAL SOCIETY