

# Jeffrey Mc Hugh

Centre for Interdisciplinary Research in Biology  
Collège de France, Paris 75013  
Citizenship: Irish

Telephone: +353872530046  
Email: jeffrey.mc-hugh@college-de-france.fr  
Title: Dr

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## Current status

**Postdoctoral Research Fellow, Neuroglial interactions in cerebral physiology and pathologies, Collège de France, October 2020 - Present**

*Studying excitability in astrocytes at the perisynaptic interface*

Development of nanopipette electrophysiology to study voltage dynamics in fine processes of astrocytes, ultimately to target the perisynaptic processes. Use in combination with conventional electrophysiology techniques, 2 photon microscopy and super-resolution STED microscopy in cell culture and ex-vivo tissue slices.

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## Research career

I am fascinated by the form and function of cellular systems. I studied physics to obtain a framework with which to understand our universe and discovered I most enjoy developing an understanding of the living world, from the cellular level down to the single molecule. I apply knowledge of nanoscience to contribute to our understanding of neurobiology. My experience studying the mechanical and electrical behaviour of neurons awakened me to the number of unanswered questions in the function and behaviour of our cerebral information processing systems that I can help to answer using my skillset.

## Experience

**PhD Physics, Cavendish Laboratory, Keyserlab, University of Cambridge, Jan 2017 - July 2020**

*Ion flow and membrane tension studies with optical tweezers and nanopipettes*

Development of combined optical tweezers, nanopipette and fluorescence apparatus to study the physics of cells, supervised by Prof Ulrich Keyser. Used optical tweezers as a force probe to investigate the effect of ion species on voltage driven flow in glass nanopipettes. Collaborated with Dr. Kristian Franze (*Physiology, Cambridge*) to determine the effect of substrate stiffness on the surface tension of Xenopus retinal ganglion cells and 3T3 fibroblasts. Used optical tweezers to pull lipid tethers from cells, measured force using particle tracking techniques and imaged tethers with fluorescence. Collaborated with Dr. Nathalie Rouach (*CIRB, Collège de France*), Dr. Gabriele Kaminski Schierle (*Chemical Engineering and Biotechnology, Cambridge*) and Dr. Clemens Kaminski (*CEB, Cambridge*) to establish electrophysiology work with nanopipettes. Utilised nanopipettes previously developed for single-molecule sensing to record spontaneous activity from dendrites of primary neurons.

**Full-time research assistant, Cambridge Graphene Centre, Electronic engineering, University of Cambridge, Oct 2015 - Dec 2016**

Supervised by Prof Andrea Ferrari. Formulated graphene and other 2D material liquid phase inks using a microfluidic shearing system to create novel devices. Characterised inks with AFM, Raman and UV/Vis spectroscopy, and rheometry. Fabricated capacitors and transistors by printing inks, produced flame retardant aerogels by freeze drying of inks.

**Final year undergraduate research project, Nanomechanics Group, School of Physics, TCD, Sep 2014 - Jan 2015**

Full-time research project as part of the fourth year of my degree. Used single molecule techniques to measure the persistence length of DNA under the supervision of Prof Martin Hegner. Prepared DNA samples with PCR, UV spectroscopy and agarose gel electrophoresis. Performed force-extension experiments with DNA using optical tweezers and imaged DNA on mica with atomic force microscopy (AFM).

**Full-time research assistant, Chemical Physics of Low-Dimensional Nanostructures Group, School of Physics, TCD, June - Sep 2014**

Worked on liquid phase exfoliation of graphene and transition metal dichalcogenide materials with the research team of Prof Jonathan Coleman. Initiated research into using foetal bovine serum to exfoliate materials. Characterised material solutions with AFM, Raman and UV/Vis spectroscopy.

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## Education

**PhD Physics**, St Catharine's College, University of Cambridge, Jan 2017 - July 2020

**BA (Mod) Nanoscience Physics and Chemistry of Advanced Materials**, 1st Class, Trinity College, University of Dublin, Oct 2011 - June 2015

## Funding awards, prizes and distinctions

Postdoctoral Fellowship, 36 months at Collège de France - **Fondation pour la Recherche Médicale**

Postdoctoral Fellowship, 12 months at Collège de France - **Labex Memolife Consortium**

Postdoctoral Fellowship, 12 months at Collège de France - **CIRB Internal Award**, Declined

**St Catharine's Prize for Distinction in Research** awarded for my PhD work 2020

PhD Scholarship, 48 months at Trinity College Dublin - **Irish Research Council** Declined

Gold Medal for "exceptional merit" in Trinity College BA Moderatorship exams 2015  
Best Presentation in School of Chemistry Broad Curriculum Module 2013  
Best Presentation in School of Physics Poster Competition 2013  
Dean of Students' Roll of Honour for teaching work with the TCD Voluntary Tuition Program 2013  
Entrance Exhibition Award for outstanding performance in Irish State Exams, TCD 2011

## Publications

1. **Mc Hugh J**, Andresen K, & Keyser U F Cation dependent electroosmotic flow in glass nanopores, *Appl Phys Lett*, 113702 (2019) <https://doi.org/10.1063/1.511676> [Editor's Pick]
  2. Xiao J, Liu Y, Steinmetz V, Caglar M, **Mc Hugh J**, Baikie T, Gauriot N, Nguyen M, Ruggeri E, Stranks S D, Legrand L, Barisien T, Friend R H, Greenham N C, Rao A, Pandya R Optical and Electronic Properties of Colloidal CdSe Quantum Rings *ACS Nano*, 14, 11, 14740–14760 (2020) 10.1021/acsnano.0c01752
  3. **Mc Hugh J**, A. L. Thorneywork, Andresen K, & Keyser U F Note: 3D flow-field measurements with nanopores *Rev Sci Instr* 93, 054106 (2022) <https://doi.org/10.1063/5.0083054>
  4. Knowles S F, Fletcher M, **Mc Hugh J**, Earle M, Keyser U F, Thorneywork A L, Observing capture with a colloidal model membrane channel *J. Phys.: Condens. Matter* 34 344001 (2022) 10.1088/1361-648X/ac7764
  5. **Mc Hugh J\***, Kreysing E\*, Foster S, Andresen K, Greenhalgh R, Pillai E, Dimitracopoulos A, Keyser U F & Franze K Global membrane tension is independent of polyacrylamide substrate stiffness *PNAS Nexus* (In review)
  6. **Mc Hugh J\***, Makarchuk S\*, Fernandez Villegas A, Kaminski Schierle G S, Keyser U F, Kaminski C F & Rouach N Nanopipettes for long-time recording from neuronal dendrites *Nanoscale* (In review)
  7. Pandya R, Valzania L, Dorchies F, Xia F, **Mc Hugh J**, Mathieson A, Hwee Tan J, Parton T G, De Volder M, Tarascon J, Gigan S, B de Aguiar H, Grimaud A Three-dimensional operando optical imaging of single particle and electrolyte heterogeneities inside Li-ion batteries *Nat Mater* (In review)
- \*Authors contributed equally to this work

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## Teaching and Outreach

- Supervised Part III research projects, University of Cambridge, Oct 2017 - Mar 2018, Oct 2018 - Mar 2019
- 40 hours of teaching time in small group supervisions of the Part II (3rd year) physics course, Soft Condensed Matter, University of Cambridge, Jan 2017 - May 2019
- Outreach event: Women in STEM residential programme, Cavendish Lab, University of Cambridge Jun 2018

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## Presentations

- *Life Under the Spotlight* - **Talk**: X-Sig Physics Colloquium, Gettysburg College, Mar 2019
- *Probing Nanopore Electroosmotic Flow with Optical Tweezers* - **Talk**: AML Nanotechnology Seminar, Trinity College Dublin, Dec 2018
- *Effect of Substrate Stiffness on Cell Membrane Tension* - **Poster**: BPS Annual Meeting 64, Feb 2020
- *Variation in Electroosmotic Flow Outside Glass Nanopores with Species of Monovalent Cation* - **Poster**: BPS Annual Meeting 63, Mar 2019
- *Controlled DNA Interactions with Graphene Nanopores* - **Poster**: Bremen Nanopore Meeting, Jul 2017

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## Research Skills

- Optical Tweezers
- Nanopipette fabrication
- Optical setup design, building and alignment
- Electrophysiology
- Particle Tracking
- Atomic Force Microscopy
- DNA Preparation
- Coding in Python, LabVIEW
- Teamwork and collaboration

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## Lab Visits and Collaborators

- Dr Meni Wanunu (Northeastern University, Boston, MA, USA - 2 week visit in Sept 2017)
- Dr Marija Drndic (University of Pennsylvania, Philadelphia, PA, USA - 1 week visit in Mar 2019)
- Dr Kurt Andresen (Gettysburg College, Gettysburg, PA, USA)
- Kristian Franze (University of Cambridge, Cambridge, UK)

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## Additional Skills and Interests

- Rowing and coaching with St Catharine's College Boat Club, University of Cambridge, Oct 2015 - Mar 2018
- Enterprise Tech entrepreneurship course at the Judge Business School, University of Cambridge, Oct 2015 - Mar 2016
- Competent with LaTeX, ImageJ, Office, OriginPro, Clampex, CAD, 3D printing, French (B1) Spanish (basic), Irish (basic)

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## Referees

**Dr. Nathalie Rouach**

CIRB, Collège de France, 75005 Paris, France  
nathalie.rouach@college-de-france.fr, +33144271449

**Dr. Ulrich Keyser** (PhD Supervisor)

Cavendish Laboratory, University of Cambridge, Cambridge  
CB3 0HE, UK, [ufk20@cam.ac.uk](mailto:ufk20@cam.ac.uk), +441223337272

**Dr. Kurt Andresen**

Department of Physics, Gettysburg College, Gettysburg, PA  
17325, USA, [kandrese@gettysburg.edu](mailto:kandrese@gettysburg.edu), +17173376056