Joseph Webber

Research Fellow, Warwick Mathematics Institute

joe.webber@warwick.ac.uk
jwebber.github.io
Google Scholar
orcID

I'm an applied mathematician working at the interface between fluid mechanics and soft matter, specifically studying poroelasticity (the behaviour of porous, deformable media). I have a particular interest in hydrogels, soft elastic solids formed of a polymer matrix surrounded by water molecules, and their swelling and drying behaviour.

Apr 2024 – **Mathematics Institute, University of Warwick**
Postdoctoral research fellow
'Shape–Transforming Active Matter', Leverhulme Trust-funded project led by Professor Tom Montenegro-Johnson.

Education

2020 – 2024 **Department of Applied Mathematics and Theoretical Physics, University of Cambridge**
PhD Applied Mathematics (fluid mechanics)
PhD thesis title 'Dynamics of super-absorbent hydrogels', supervised by Professor Grae Worster.
full-text link for thesis

2019 – 2020 **Trinity College, University of Cambridge**
Part III Mathematics (MMath)
Exams not held due to COVID-19 pandemic. Part III Essay 'Viscous fingering instabilities', supervised by Dr Katarzyna Kowal

2016 – 2019 **Trinity College, University of Cambridge**
MA (Cantab.) Mathematics, 2.i
Undergraduate summer research with Prof Herbert Huppert FRS (2018, 2019)

Awards and prizes

2025 **Finalist: IMA Lighthill-Thwaites Prize**
Pending awards ceremony, for 'Cryosuction and freezing hydrogels' (7)

2022 **Smith-Knight and Rayleigh-Knight Prize, University of Cambridge**
Awarded Group 1 (highest category) – joint top result in my cohort

2022 **DAMTP Friday Fluids second year talks, University of Cambridge**
First prize talk 'Dynamics of super-absorbent hydrogels'

2019 **STEM for Britain**
Shortlisted finalist in UK Parliament for 'Stokes drift through corals'

Publications

Links are DOI references to the full text, preprints (in grey) available on request

10 **Surfing on chemical waves: a simple yet dynamically rich two-sphere responsive gel swimmer**
Webber, J. J. and Montenegro-Johnson, T. D. **2025**
in prep.

9 **Oscillating chemical reactions enable communication between responsive hydrogels**
Webber, J. J. and Montenegro-Johnson, T. D. **2025**
under review

8 **Poromechanical modelling of responsive hydrogel pumps**
Webber, J. J. and Montenegro-Johnson, T. D. **2025**
Journal of Fluid Mechanics, in press
10.1017/jfm.2025.249

7 **Cryosuction and freezing hydrogels**
Webber, J. J. and Worster, M. G. **2025**
Proceedings of the Royal Society A *481:20240721*
10.1098/rspa.2024.0721

6 **Wrinkling instabilities of swelling hydrogels**
Webber, J. J. and Worster, M. G. **2024**
Physical Review E *109:044602*
10.1103/PhysRevE.109.044602

5 **A linear-elastic-nonlinear-swelling theory for hydrogels. Part 2. Displacement formulation**
Webber, J. J., Etzold, M. A. and Worster, M. G. **2023**
Journal of Fluid Mechanics *960:A38*
10.1017/jfm.2023.201

4 **A linear-elastic-nonlinear-swelling theory for hydrogels. Part 1. Modelling of super-absorbent gels**
Webber, J. J. and Worster, M. G. **2023**
Journal of Fluid Mechanics *960:A37*
10.1017/jfm.2023.200

3 **Stokes drift through corals**
Webber, J. J. and Huppert, H. E. **2021**
Environmental Fluid Mechanics *21:1119-1135*
10.1007/s10652-021-09811-8

2 **Stokes drift in coral reefs with depth-varying permeability**
Webber, J. J. and Huppert, H. E. **2020**
Philosophical Transactions of the Royal Society A *20190531*
10.1098/rsta.2019.0531

1 **Time to approach similarity**
Webber, J. J. and Huppert, H. E. **2020**
Quarterly Journal of Mechanics and Applied Mathematics *72:1-23*
10.1093/qjmam/hbz019

Supervision

2024- **Xietao Wang Lin** (MSc+PhD, University of Warwick)
Informal co-advisor with T. D. Montenegro-Johnson

2024-2025 **Usmaan Mirza** (MMath research project, University of Warwick)
Co-advisor with T. D. Montenegro-Johnson, 'An analytical and numerical framework for modelling self-oscillating hydrogels'

2024 **Warwick Summer Research Programme for Undergraduates from Underrepresented Groups**, University of Warwick
Co-supervisor with T. D. Montenegro-Johnson for a group of three undergraduate students

Teaching

Undergraduate module teaching

- **MA256 Introduction to Mathematical Biology, University of Warwick**
Autumn 2024, 6/30 lectures in course, cohort size $\sim$ 120
- **Part IA Introduction to Mechanics, University of Cambridge**
Michaelmas 2022, 5/9 lectures in course, cohort size $\sim$ 30

Workshops

- **'How to make a poster: ...also how you shouldn't, why you should care, and why they matter", University of Warwick**
Summer 2024
Talk for summer undergraduate research students with interactive element designing their own research posters.
- **Part III Preparatory Workshops, University of Cambridge**
Michaelmas 2023, 2 hours (content later reused by other instructors in Michaelmas 2024)

Designed and delivered revision content for incoming Part III (masters) students covering all aspects of continuum mechanics, including a series of 10 introductory videos (tinyurl.com/partiiivideos) which have been reused in subsequent years.

Small group teaching

Over 300 hours of supervisions in the Cambridge Mathematical Tripos (undergraduate course), mostly covering undergraduates from Trinity College.

- **Part II (3rd year) Fluid Dynamics** (Michaelmas 2020)
- **Part IB (2nd year) Fluid Dynamics** (Lent 2021, 2022, 2023, 2024 + revision in Easter 2021, 2022, 2023)
- **Part IB Methods** (Michaelmas 2021, 2022, 2023 + revision in Easter 2023)
- **Part IB Variational Principles** (Michaelmas 2021, 2022, 2023 + revision in Easter 2023)

Research leadership & academic service

2024- **UK Hydrogels Network**
I co-organise and coordinate a mailing list and network of UK hydrogels researchers from across universities and disciplines, sending a regular bulletin and running events.

2024- **Soft Matter Lunches, University of Warwick**
Seminar series organised jointly with collaborators in Warwick Physics.

Dec 2024 **Modelling hydrogels: building networks in the Mathematical Sciences**
I planned and ran a one-day meeting at the University of Warwick to launch the new UK Hydrogels Network.

Dec 2022 & Dec 2023 **Undergraduate admissions interviews, Trinity College, Cambridge**
Devised questions for the admissions tests and carried out admissions interviews for mathematics applicants.

2022-2024 **Institute of Theoretical Geophysics lunches, University of Cambridge**
Organised the weekly informal seminar series during term time.

Open-source tools

- **pgfcet**
A `tikz` libary to allow the use of the `colorcet` colour maps with `pgfplots`
- **texnically**
A LaTeX-to-SVG tool that embeds the original source into the SVG metadata for easy future editing
- **fix-matlab-eps**
A utility to fix the vector output of Matlab's `contourf`, removing white line artefacts from the EPS output

Outreach

2025 **Collaboration with origami artist Coco Sato**
An origami artwork based on the results of 'Poromechanical modelling of responsive hydrogel pumps' (8) was designed and created by our research group in collaboration with Coco Sato.

2021 **Cambridge Festival**
Produced a video (link) on poroelasticity and coffee makers for an online Cambridge Festival outreach event.

2019-2020 **BBC *University Challenge***
Captained the semi-finalist team for Trinity College, Cambridge.

Talks

Ⓘ = invited, Ⓒ = contributed

2025 Ⓘ **2nd European Fluid Dynamics Conference, Dublin, Ireland**
Poromechanical modelling of pumping with responsive hydrogels (08/25)

Ⓘ **British Applied Mathematics Colloquium, Exeter, UK**
Getting stressed about frozen gels (25/06/25)

2024 **Modelling hydrogels: building networks in the Mathematical Sciences, University of Warwick, UK**
Deswelling response to temperature changes (09/12/24)

Ⓒ **77th Annual Meeting of the Division of Fluid Dynamics (APS), Salt Lake City, USA**
XOXO, Gossip Gel: oscillating chemical reactions facilitate communication between responsive hydrogels (25/11/24)

Ⓘ **Mathematical Biology Meeting, University College London, UK**
Smart responsive gels: designing the building blocks of squishy bio-inspired devices (30/10/24)

Soft Matter Lunch, University of Warwick, UK
Tubular hydrogel pumps through a responsive LENS (30/09/24)

Ⓘ **Soft Lab Seminar, Bristol Robotics Laboratory, University of Bristol, UK**
A linear-elastic-nonlinear-swelling model for hydrogels (03/07/24)

Ⓒ **UKFN BioActive & Non-Newtonian Fluids SIG Meeting, University College London, UK**
Buckling and swelling instabilities of super-absorbent gels (18/06/24)

Ⓘ **Physics of Fluids and Soft Matter seminar, University of Manchester, UK**
A linear-elastic-nonlinear-swelling model for hydrogels (17/05/24)

Ⓒ **Warwick–Cambridge Quantitative Cell Biology Symposium, University of Warwick, UK**
Freezing soft porous gels (16/05/24)

Ⓘ **Warwick Applied Maths seminar, University of Warwick, UK**
A linear-elastic-nonlinear-swelling theory for hydrogels (03/05/24)

2023 Ⓘ **Squishy Journal Club, University of Oxford, UK**
Buckling and swelling instabilities of super-absorbent hydrogels (28/11/23)

Ⓒ **76th Annual Meeting of the Division of Fluid Dynamics (APS), Washington DC, USA**
Wrinkling instabilities of swelling hydrogels (21/11/23)

Ⓒ **15th Annual InterPore Meeting, Edinburgh, UK**
Linear stability analysis for the formation of wrinkles on confined swelling hydrogels (24/05/23)

2022 Ⓒ **75th Annual Meeting of the Division of Fluid Dynamics (APS), Indianapolis, USA**
A linear-elastic-nonlinear-swelling theory for hydrogels: displacements and differential swelling (20/11/22)

Ⓒ **14th Annual InterPore Meeting, online**
Multidirectional gel swelling and drying: a linear-elastic-nonlinear swelling theory for hydrogels (02/05/22)

DAMTP Friday Fluids second year talks, University of Cambridge, UK
Dynamics of super-absorbent hydrogels (27/05/22)

2020 Ⓘ **Pure & Applied Maths colloquium, Open University, UK**
Stokes drift through coral reefs (04/02/20)

2019 Ⓒ **Stokes200 Symposium, University of Cambridge, UK**
Stokes drift through corals (17/09/19)