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

Education and prizes

2020 – 2024 PhD applied maths, **Department of Applied Mathematics and Theoretical Physics, Uni. of Cambridge**
Supervised by Professor Grae Worster, thesis available online: Dynamics of super-absorbent hydrogels

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

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

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

2022 Group 1, **Smith-Knight and Rayleigh-Knight Prize, Uni. of Cambridge** *joint top result in cohort*

2022 First prize, **DAMTP fluids second year talks, Uni. of Cambridge** *for 'Dynamics of super-absorbent hydrogels'*

2019 Shortlisted finalist, **STEM for Britain** *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. Phys. Rev. Fluids, *in press* **2025** 10.1103/52bv-vyb5 arXiv:2509.13850

9 **Oscillating chemical reactions enable communication between responsive hydrogels**
Webber, J. J. and Montenegro-Johnson, T. D. Phys. Rev. Research, *7:L032055* **2025** 10.1103/xbvn-5b59

8 **Poromechanical modelling of responsive hydrogel pumps**
Webber, J. J. and Montenegro-Johnson, T. D. J. Fluid Mech., *1009:A38* **2025** 10.1017/jfm.2025.249

7 **Cryosuction and freezing hydrogels**
Webber, J. J. and Worster, M. G. Proc. Roy. Soc. A *481:20240721* **2025** 10.1098/rspa.2024.0721

6 **Wrinkling instabilities of swelling hydrogels**
Webber, J. J. and Worster, M. G. Phys. Rev. E *109:044602* **2024** 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. J. Fluid Mech. *960:A38* **2023** 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. J. Fluid Mech. *960:A37* **2023** 10.1017/jfm.2023.200

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

2 **Stokes drift in coral reefs with depth-varying permeability**
Webber, J. J. and Huppert, H. E. Phil. Trans. Roy. Soc. A *378:20190531* **2020** 10.1098/rsta.2019.0531

1 **Time to approach similarity**
Webber, J. J. and Huppert, H. E. Q. J. Mech. Appl. Math. *72:1-23* **2020** 10.1093/qjmam/hbz019

Research leadership

2024- Coordinator, **UK Hydrogels Network** *founding organiser of cross-disciplinary network*

2024-2025 **Soft Matter Lunches, Uni. of Warwick** *seminar series organised jointly with Physics Department*

Dec 2024 Organiser, **Modelling hydrogels: building networks in the Mathematical Sciences** workshop

Dec 2022 & Dec 2023 Undergraduate admissions interviewer, **Trinity College, Cambridge** *devised questions and carried out admissions interviews in-person and online*

2022-2024 Organiser, **Institute of Theoretical Geophysics lunches, Uni. of Cambridge** *informal weekly seminar series*

- **Peer review** journals include J. Fluid Mech. and Phys. Chem. Chem. Phys.
- **Conference session chair** at EFDC2, Dublin 2025 – minisymposium on 'Poroelastic Flows'

- **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 artefacts from the EPS output

---

Research project supervision

2024- Informal co-advisor, **Xietao Wang Lin** (MSc+PhD, Uni. of Warwick) *with T. D. Montenegro-Johnson*
Machine-learning accelerated simulation of suspensions of elastic microfilaments

2024-2025 Co-advisor, **Usmaan Mirza** (MMath research project, Uni. of Warwick) *with T. D. M.-J.*
An analytical and numerical framework for modelling self-oscillating hydrogels

2024 Small group co-advisor, **Summer Research Programme for Undergraduates from Underrepresented Groups**, Uni. of Warwick *with T. D. M.-J.*
The digital epidemic

Teaching

- **MA4N4 Transport Processes in Mathematical Biology, Uni. of Warwick** (Autumn 2025) *30 lectures*
- **MA256 Introduction to Mathematical Biology, Uni. of Warwick** (Autumn 2024) *6/30 lectures, cohort size* $\sim$ 120
- **Part IA Introduction to Mechanics, Uni. of Cambridge** (Michaelmas 2022) *5/9 lectures, cohort size* $\sim$ 30

Part III Preparatory Workshops, Uni. of Cambridge (Michaelmas 2023, 2 hours + 10 videos) *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). Content reused and delivered by other instructors in 2024 & 2025.*

Supervisions for Cambridge undergraduate mathematicians ($>$ 300 hours) *small group (usually* 2 : 1*) tutorials in applied mathematics*

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

Outreach

2025 **Origami artwork** *based on 'Poromechanical modelling of responsive hydrogel pumps' (8) with Coco Sato*

2021 **Cambridge Festival** *wrote and produced a video (link) on poroelasticity and coffee makers*

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

Talks

Ⓘ = invited, Ⓒ = contributed

2025 Ⓘ **Online CMIM group seminar, Department of Mathematics & Statistics, University of Strathclyde, UK**
A tractable framework for modelling hydrophilic large-swelling gels (01/10/25)

Ⓘ **2nd European Fluid Dynamics Conference, Dublin, Ireland**
Poromechanical modelling of pumping with responsive hydrogels (28/08/25)

Uni. of Warwick, UK
SUMR Meeting 7: How to prepare and present maths posters (20/08/25)

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

Ⓘ **Fluid Mechanics Seminars (online), Royal Society Publishing** 10.52843/cassyni.4wj1kq
Freezing of hydrogels: modelling cryosuction, deformation and ice growth (18/06/25)

Ⓘ **Department of Materials, ETH Zurich, Switzerland**
Modelling hydrogels at both ends of the temperature spectrum (27/05/25)

2024 **Modelling hydrogels: building networks in the Mathematical Sciences, Uni. 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)

Uni. of Warwick, UK
How to make a poster: ...also how you shouldn't, why you should care, and why they matter (28/08/24)

Ⓘ **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, Uni. of Warwick, UK
Tubular hydrogel pumps through a responsive LENS (30/09/24)

Ⓘ **Soft Lab Seminar, Bristol Robotics Laboratory, Uni. 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, Uni. of Manchester, UK**
A linear-elastic-nonlinear-swelling model for hydrogels (17/05/24)

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

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

2023 Ⓘ **Squishy Journal Club, Uni. 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, Uni. 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, Uni. of Cambridge, UK**
Stokes drift through corals (17/09/19)