Centre for **Sustainable & Circular** Technologies

MONASH University

UNIVERSITY OF BATH

Bath Monash Global PhD Programme in Sustainable & Circular Technologies

Project Title:	Machine learning for sustainable reaction design: A combined computational and experimental approach
Supervisors at Bath:	Dr Matthew Grayson (lead)
Supervisors at Monash:	Prof David Lupton
Home Institution:	Bath
Indicative period at Host Institution:	12 months

Project Summary

The computational design of new reactions is regarded as one of the "*Holy Grails*" of computational organic chemistry and biochemistry.[1] Accurate and fast computational approaches to predicting chemical reactivity will provide cost-effective alternatives to experimental trial-and-error, and in some cases animal testing methods, in drug design, toxicology and chemical synthesis. Of great importance are explainable, mechanism-based prediction models which are more likely to reach general acceptance compared to black-box approaches. Providing clear insight into how and why predictions are made is particularly important for accountable chemical risk assessment and drug design.[2] **This project will combine the speed of ML with descriptors derived from QM calculations in a synergistic *ML-QM* approach to explainable and rapid high-accuracy reactivity prediction.**

This project will train ML models to predict reaction barriers derived from high level DFT; such DFT calculations are far too time-consuming for use in reaction modelling studies. Using our *ML-QM* approach, rapid and accurate predictions will be possible even on a laptop and will represent a paradigm shift in reaction modelling. The pharmaceutical industry has called for new "*robust, effective methodology to model industrially relevant organic molecules and reactions*".[3] Hence, this project will develop *ML-QM* models for Michael acceptor reactivity prediction for use in covalent drug design, toxicology and pharmaceutical drug synthesis planning. These models will be validated against experimental data from pharmaceutical companies. Experimental predictions will also be made for novel substrates and catalysts. These predictions will then be tested in the Lupton lab to further validate our models. Use of these models will lead to a reduction in experimental trial-and-error and thus a more sustainable approach to reaction design. Furthermore, these models could be used to optimise atom economy which aligns with the second principle of circular chemistry (maximise atom circulation).[4]

References: [1] *Acc. Chem. Res.* **2017**, *50*, 539. [2] *Toxicol. Sci.* **2018**, *165*, 213. [3] *Drug Discov. Today* **2018**, *23*, 1203. [4] *Nat. Chem.* **2019**, 11, 190.

Features of the programme

- PhD researchers will be registered at both institutions and will be awarded a joint PhD degree.
- PhD researchers will be jointly supervised by academics from both Monash and Bath Universities.
- All PhD researchers in the joint programme will also undertake a bespoke advanced training plan covering a range of topics focusing on sustainability.
- Applicants can apply to either Monash University or the University of Bath as their nominated home institution.
- PhD researchers will undertake a period of no less than 12 months at the partner institution.
- Up to four scholarships/studentships will be offered. Additional and suitably qualified applicants who can access a scholarship/studentship from other sources will be also considered. Evidence of funding must be provided.
- The scholarships/studentships include:
  - a *full tuition fee sponsorship* provided by Monash or Bath for the course duration (up to a maximum 42 months). **Funding for Bath-based projects, such as the one advertised here, is available to candidates who qualify for Home fee status only.** In determining Home student status, we follow the UK government's fee regulations and guidance from the UK Council for International Student Affairs (UKCISA). Further information may also be found within the university's fee status guidance. EU/EEA citizens who live outside the UK are unlikely to be eligible for Home fees and funding. Funding for Monash-based projects is available to candidates of any nationality.
  - *a living allowance (stipend)* provided by Monash or Bath Universities.

Note: Overseas Student Health Cover (OSHC) must be paid by the student, unless covered by the university.

How to apply

You MUST express interest for three projects in order of preference. Please submit your application at the Home institution of your preferred project ('Home' institution details can be found in the project summary). However, please note that you are applying for a joint PhD programme and applications will be processed as such.

The deadline to submit applications is 11th April 2021

Monash University

Expressions of interest (EoI) can be lodged through https://www.monash.edu/science/bath-monash-program. The EoI should provide the following information:

CV including details of citizenship, your Official Academic Transcripts, key to grades/grading scale of your transcripts, evidence of English language proficiency (IELTS or TOEFL, for full requirements see: https://www.monash.edu/graduate-research/faqs-and-resources/content/chapter-two/2-2), and two referees and contact details (optional). You must provide a link to these documents in Section 8 using Google Drive (Instructions in Section 8).

University of Bath

Please submit your application through the following link: https://www.csct.ac.uk/bath-monash-global-phd-programme/

Please make sure to mention in the "finance" section of your application that you are applying for funding through the joint Bath/Monash PhD programme for your specified projects.

In the "research interests" section of your application, please name the three projects you are interested in and rank them in order of preference. Please also include the names of the Bath lead supervisors.