# The University of St. Andrews and Macquarie University Global Doctoral Scholarship

The University of St Andrews and Macquarie University are pleased to offer a fully funded scholarship for entry in 2022 to support an exceptional student undertaking doctoral research in the following project:

## The impact of warming and ocean acidification on mollusc shells

Nicola Allison, School of Earth and Environmental Sciences, University of St. Andrews
Matthew Kosnik, School of Natural Sciences, Macquarie University

### Project description

Bivalves/clams, snails and their cousins (e.g. molluscs) are important components of marine food webs, represent a majority of global aquaculture production and can improve water quality by filter feeding. Molluscs produce calcium carbonate ($CaCO_3$) shells that protect the organism from the environment and predators and are crucial to their ecological success. Understanding the impact of changing ocean conditions on the preservation of mollusc shells is crucial to predicting the future status of these organisms.

Shells dissolve when they are in contact with seawater which is under-saturated with the mineral components of the shell. At present, under-saturation is rare at the sea surface but can occur in the porewaters trapped between sediment particles or reef structures[1]. Rising atmospheric $CO_2$ is increasing global temperatures and making seawater more acidic. Ocean acidification enhances under-saturation and shell dissolution is observed in molluscs cultured under conditions predicted to occur over the next 100 years[2]. It is unclear how temperature affects dissolution under environmental conditions.

This project aims to determine how rising seawater $CO_2$ and temperature affect the dissolution of mollusc shells and to resolve the likely origin of dissolution susceptibility or resistance. The student will research modern and fossil mollusc shells collected from the SE Australian coast (Figure 1). This area exhibits a pronounced gradient in seawater temperature change over the last 3 decades

**Figure 1**. Measured changes in sea surface temperatures along the SE Australian coast between 1992 and 2017 [3].

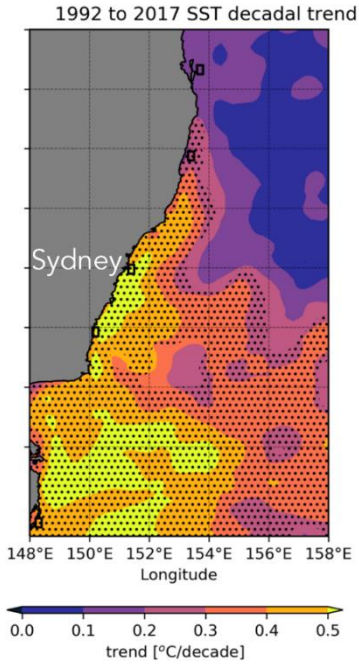
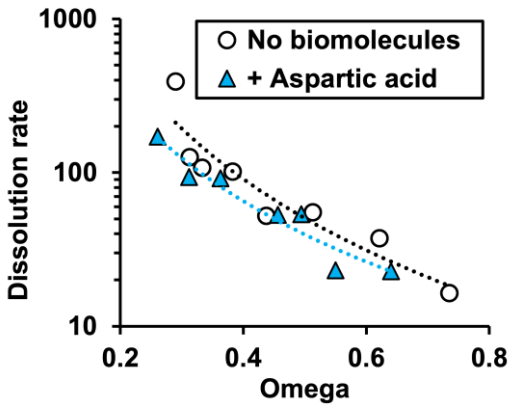



**Figure 2**. Dissolution rate (µmol/m²/h) of synthetic aragonites precipitated with or without the addition of aspartic acid. Omega indicates the saturation state of the seawater. Dissolution of aragonite with no biomolecules begins at omega ≈1.



due to changes in circulation of the East Australian Current[3]. The southern end of the coastal transect is warming rapidly while the northern end has seen little change in mean seawater temperature (Figure 1). This gradient makes SE Australia an ideal place to examine the impact of ocean change on mollusc shell dissolution resistance.

Research by Kosnik's group demonstrates that shell dissolution is influenced by shell density, thickness and shape[4]. Research by Allison's group indicates that the incorporation of biomolecules in $CaCO_3$ minerals also affects mineral dissolution. Marine shells and skeletons are composite materials of $CaCO_3$ and organic macromolecules[5]. Aragonites precipitated *in vitro* with aspartic acid (the amino acid most commonly found in biogenic $CaCO_3$) are significantly more resilient to dissolution that aragonites that contain no biomolecules (Figure 2).

The student will combine the expertise of both supervisors to advance current understanding of the factors controlling the dissolution of mollusc shells under future environmental change. The student will characterize modern (live at time of collection) and fossil (deposited before anthropogenic temperature change) shells using a range of shell metrics. The organic composition and crystal fabrics of the shell mineral will be determined. This will identify if changes in the shells have occurred in response to current climate change along the coastal transect. The student will measure the dissolution of both modern and fossil shells in seawater with the $pCO_2$ and temperature currently observed and predicted to occur in seawaters and porewaters in the future. The student will produce synthetic $CaCO_3$ [5] and will explore how the inclusion of biomolecules influences mineral structure and dissolution. The combined dataset will enable the student to probe the relationships between shell structure/composition and dissolution. For example the student will identify if changes in morphology, crystal fabric and/or biomolecule composition are associated with dissolution resistance. The student will identify species which produce structures which are resilient or susceptible to dissolution and this will improve our understanding of the response of mollusc species to future climate change.

**Informal enquiries regarding this scholarship may be addressed to Nicola Allison (na9@st-andrews.ac.uk, http://nicolaallison.co.uk) or Matthew Kosnik (Matthew.Kosnik@mq.edu.au).**

References


1. Andersson AJ and Gledhill D, Ocean acidification and coral reefs: effects on breakdown, dissolution, and net ecosystem calcification. Annual Review of Marine Science 5:321-348, 2013.
2. Nienhuis S, Palmer AR, Harley CD. Elevated CO2 affects shell dissolution rate but not calcification rate in a marine snail. Proceedings of the Royal Society B: Biological Sciences. 2010 Aug 22;277(1693):2553-8.
3. Malan N, Roughen M, Kerry C. The rate of coastal temperature rise adjacent to a warming western boundary current is non-uniform with latitude. Geophysical Research Letters, 48, e2020GL090751. https://doi. org/10.1029/2020GL090751, 2020.
4. Kosnik MA, Hua Q, Kaufman DS and Wust RA. Taphonomic bias and time-averaging in tropical molluscan death assemblages: differential shell half-lives in Great Barrier Reef sediment. Paleobiology 35, 565-586, 2009.
5. Kellock C, Cole C, Penkman K, Evans, D, Kroger R, Hintz C, Hintz K, Finch A, Allison N, The role of aspartic acid in reducing coral calcification in acidifying oceans, Sci. Rep., 10.1038/s41598-020-69556-0, 2020.


## Project management

The project will be managed jointly between the School of Earth & Environmental Sciences at St Andrews and the School of Natural Sciences at Macquarie. The student will be supervised by Dr Nicola Allison (St Andrews) and Dr Matthew Kosnik (Macquarie).

**Eligibility -** Admission and scholarship criteria of both universities must be met.

**Geographical criteria -** No restrictions.

**Domicile for fee status -** No restrictions.

**Level of study -** Postgraduate Research (Doctoral)

**Year of entry -** 2022-2023 academic year.
Students will enrol at both institutions from the outset. In terms of their location for study, entry points for students beginning at St Andrews are, 27 September or 27 January. If beginning at Macquarie, entry points are 1 October or 1 February.

**Schools**

School of Earth & Environmental Sciences (St Andrews) and Natural Sciences (Macquarie)

**Additional criteria**

Applicants must not already (i) hold a doctoral degree; or (ii) be matriculated for a doctoral degree at the University of St Andrews or another institution.

**What does it cover?**

**Duration of award**

Up to 3.5 years. The student will be expected to spend approximately half of the award term at the University of St Andrews and half at Macquarie University. The successful candidate will be expected to have completed the doctorate degree by the end of the award term. The award term excludes the continuation period and any extension periods.

**Value of award**

The funding comprises a scholarship equivalent of a full-fees award and stipend for a period of up to 3.5 years. It is expected that the student will spend half of the scholarship term at the University of St Andrews and half at Macquarie University:

- For the period spent at the University of St Andrews, the scholarship will comprise a full fees award and a stipend paid at the current UK Research Council rate (£15,609 each year in 2021–2022)
- For the period spent at Macquarie University, the scholarship will comprise a stipend (tax exempt and indexed annually), paid pro-rata. The rates can be found here: https://www.education.gov.au/research-training-program. A tuition fee scholarship will be granted for the period of joint enrolment. Macquarie University will also pay for one return economy airfare between Scotland and Australia up to a maximum value of $2,500 AUD to be arranged by the Graduate Research Academy.

**Tuition or maintenance award**

Tuition and maintenance.

**About St Andrews**
**Doctoral Research at St Andrews**

As a doctoral student at the University of St Andrews you will be part of a growing, vibrant, and intellectually stimulating postgraduate community. St Andrews is one of the leading research-intensive universities in the world and offers a postgraduate experience of remarkable richness.

St Leonard's Postgraduate College is at the heart of the postgraduate community of St Andrews. The College supports all postgraduates and aims to provide opportunities for postgraduates to come together, socially and intellectually, and make new connections.

St Leonard's Postgraduate College works closely with the Postgraduate Society which is one of the most active societies within the Students' Association. All doctoral students are automatically welcomed into the Postgraduate Society when they join the University.

In addition to the research training that doctoral students complete in their home School, doctoral students at St Andrews have access to GRADskills – a free, comprehensive training programme to support their academic, professional, and personal development.

**About Macquarie**
**Doctoral Research at Macquarie University**

Macquarie University is recognised globally as a leading university, consistently ranking among the world's best due to a strong tradition of innovation and exploration. With an enviable reputation for research excellence and a driving desire to produce solutions with real-world impact, Macquarie's discoveries are paving the way to a brighter future. As a doctoral student at Macquarie, you will be able to draw on the expertise of the University's knowledgeable and passionate research community.

The definition of a research problem, the exploration of the problem, and the dissemination of findings to the academic and general community, are central to the process of research candidacy at Macquarie. Candidates are supported throughout these stages by various central, faculty and departmental activities and assisted with the administration and management of their candidacy and research through the services provided by the Graduate Research Academy.

The doctoral program at Macquarie is a pathway to a career as a researcher in both academia and industry. In addition to managing their candidature and understanding their requirements as a researcher, doctoral students will complete a university-wide and a faculty-specific commencement program. They also have the opportunity to take advantage of a range of face-to-face courses and online training resources to leverage their degree to reach future career goals.

**How to apply**

Submit an application to the supervisors at na9@st-andrews.ac.uk. Applications should include the following documents:

- CV
- Transcripts of most relevant/recent degrees
- Statement of suitability as a candidate for the project including why the project interests you, what you would bring to the project in terms of previous skills and expertise and an outline of your career plans and professional goals (maximum 800 words)

Following a successful application for the scholarship, candidates may be invited to submit an application to both universities for admission into the program and award of the scholarship. Please indicate in your application that you wish to be considered for this Global St Andrews scholarship (reference Allison-Kosnik). Applications should be submitted to the co-supervisors via email to: na9@st-andrews.ac.uk.

Please contact us should you have any questions regarding the scholarship: pgscholarships@st-andrews.ac.uk or gr.international@mq.edu.au.

**When do applications open:** February 2022

**Scholarship application deadline:** 14 April 2022**.**

**When will I hear if my application has been successful?**

By 14 May 2022. Awards are subject to final signatures of contracts between the parties and successful admission to both institutions. Successful scholarship applicants must apply to both institutions and meet all relevant entry requirements for admission including any immigration requirements that may be in place.

**Next steps**

Once notified, successful candidates should proceed to fulfil the application requirements for each University and must meet all normal entry requirements for admission – please see the **advice on applying for research degree programmes** at St Andrews and the step-by-step guide on how to apply for research degree programmes at MQ.