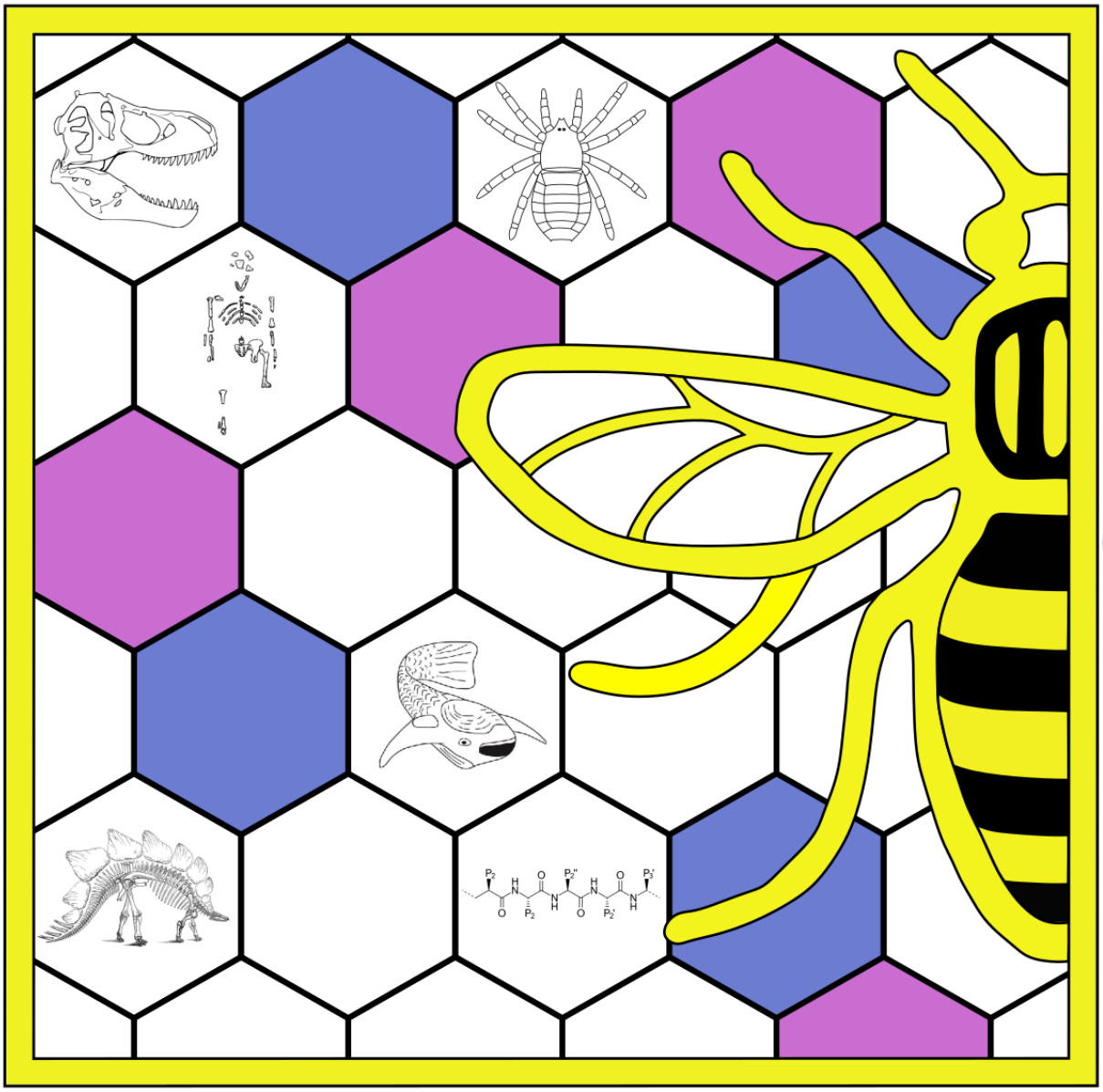
Manchester

UOM MMU



Progpal

2018

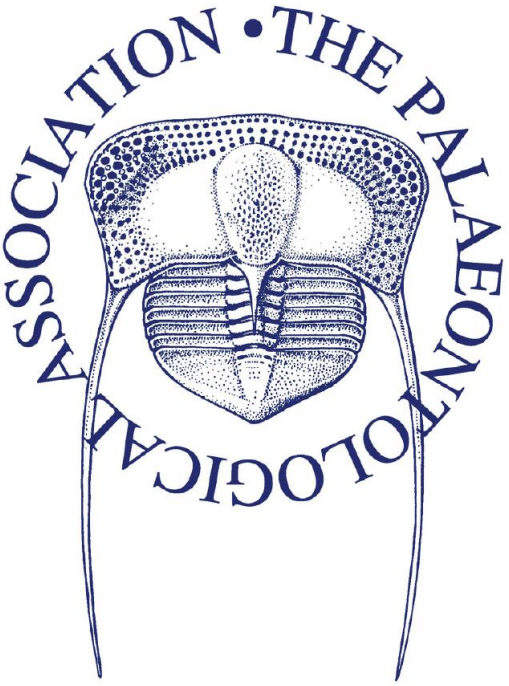
WELCOME

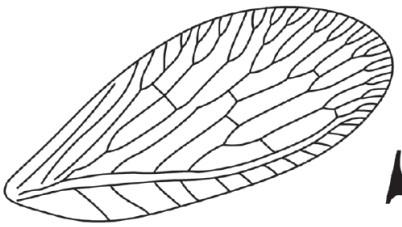
Hello and welcome to Progressive Palaeontology 2018 in Manchester! It is an absolute pleasure to be hosting this annual meeting which showcases fresh, exciting new research of up and coming palaeontologists from across the entire breadth of our discipline. We hope that you find ProgPal 2018 to be an engaging, stimulating, but above all fun conference, as well as enjoying your trip to the historic, world-class city of Manchester.

The conference this year is held jointly between the University of Manchester and Manchester Metropolitan University, in a Progressive Palaeontology first! Researchers from both institutions are part of the Interdisciplinary Centre for Ancient Life (ICAL), and their research interests span the entire palaeontological spectrum. Research topics include (but are by no means limited to): the origins and early evolution of arthropods; biomechanics of locomotion in vertebrates and invertebrates, extinct and extant; palaeoproetomics and collagen fingerprinting; Mesozoic marine reptiles; phylogenetic methods; the palaeobiology of North American dinosaurs; and sexual selection & the evolution mammal genitals.

Your ProgPal 2018 committee have endeavoured to convene a lively and thought provoking meeting and we hope you enjoy your time here. This conference would not have been possible without our numerous benefactors. We would like to thank all those who have supported us, either financially or by giving up their time, to help make ProgPal 2018 possible; particularly the Palaeontological Association and the University staff and students who have assisted us. Finally, we'd like to thank all of you, the delegates, for attending. ProgPal is a marvellous, fun and friendly forum for post-graduates to meet and demonstrate their research. We hope your experience in Manchester at #ProgPal2018 will keep up this proud tradition.

Stan the T Rex at Manchester Museum





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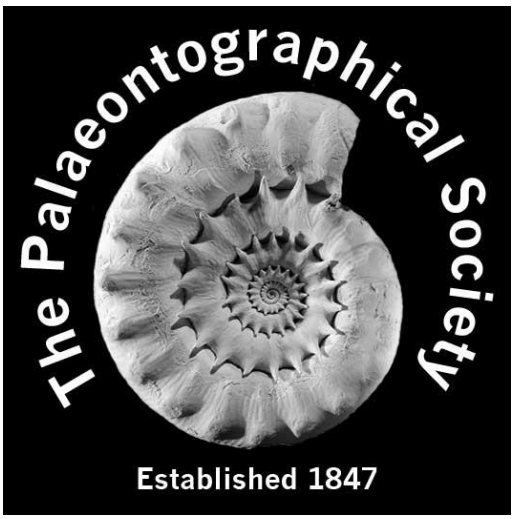
Paleontological

SOCIETY



The Palaeontological Association

Reg. Charity No. 1168330

Welcome to Progressive Palaeontology, a postgraduate student conference of the Palaeontological Association (PalAss). PalAss is a charity that promotes the study of palaeontology and its allied sciences through publications, sponsorship of meetings and workshops, provision of web resources and a large annual programme of awards and grants.

Membership fees for students are just £15 a year. In return, members receive the Association's newsletter, online access to the PalAss journals *Palaeontology* and *Papers in Palaeontology*, a discount on Field Guides and eligibility for Association awards and grant schemes including the Postgraduate Travel Fund.

Our flagship Annual Meeting is a major international conference in December with subsidised registration for students, and contributions to travel costs are made to a large percentage of student members who are presenting their work. The President's Prize and Council Poster Prize are awarded to the best presentations from early career researchers at the meeting each year with a certificate and cash prize.

The Association has a public engagement group that involves postgraduate student members as volunteers at outreach events. PalAss has members all over the globe and we welcome new members at www.palass.org. You can also find us on Facebook and Twitter (@ThePalAss).

Dr Jo Hellawell

Executive Officer, The Palaeontological Association

COMMITTEE

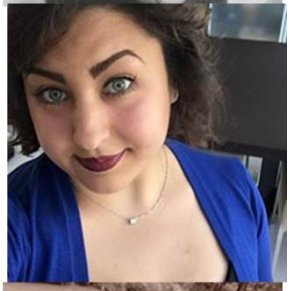
Chair - Elspeth Wallace
Elspeth is in the second year of her PhD studying the palaeoecology of the Morrison Formation at the University of Manchester. Despite the photos she isn't actually Maria von Trapp, although she is a keen singer and musician. Elspeth also knits, has a particular fondness for gin and cats, and at weekends can be found working in her family pub.

Vice-Chair - Callum Mclean
Callum studies the biomechanics of prey capture in arthropods, and is a second year PhD student at Manchester Metropolitan. This followed a brief stint trying to get robot fossil arachnids to walk, from which he still hasn't quite recovered. His other hobbies include the NFL, doing skits from Rick and Morty, liberal politics and other pointless endeavours.

Treasurer - Robert Brocklehurst
Robert is a third year PhD student studying breathing biomechanics in dinosaurs, birds and crocodilians. He's not quite sure how he wound up as treasurer, but coming from an accounting family it was probably destiny. Robert is also singer and actor with a hopeless addiction to Gilbert and Sullivan.

Secretary - Emma Randle
Not actually a student anymore, Emma was just finishing her PhD on jawless fish phylogenetics this time last year when it was decided Manchester should host ProgPal 2018. That she chose to carry on and help organise the meeting despite moving away to a new job and a new city, says an awful lot about her. In her spare time, Emma enjoys bouldering, baking and Brooklyn 99.

General Member - Leah Callendar-Crowe
Have you ever laid awake at night, wondering how to best reconcile morphological and molecular data for phylogenetic analyses? Leah understands this feeling far too well, as she's in the third year of her PhD on the subject. When not analysing trees, Leah is a keen sportswoman, martial artist and linguist.



General Member - Carolina Karoulas
Carolina is in the second year of her PhD, trying to answer big questions on the evolution of bird flight, as well as how past bird species responded to climate change. She splits her time between Manchester and her home in Essex.

General Member - Virginia Harvey
A second year PhD student using collagen sequencing to study species ID and community composition in ancient and modern fishes, Virginia's work takes her to such boring and mundane locales as the Caribbean and the Baltic states. She is also a certified scuba dive-master, and in her spare time works for the Carbon Literacy project and plays in a folk band.

VENUE

ProgPal 2018 is being hosted in beautiful, historic, occasionally sunny Manchester. The birthplace of the Industrial Revolution, Manchester showed the whole world the way forward and today is the UK's youthful, diverse and energetic "Second City". The city has shown the way forward in more ways than one. The Suffragette movement began in Manchester, and its leader Emmeline Pankhurst was born in what is now Moss Side. Alan Turing, father of modern computer science and artificial intelligence, taught at the University of Manchester for several years. Manchester was also the place where Ernest Rutherford, the father of nuclear physics, first split the atom in 1917.

On sports, Manchester City and Manchester United are two of the UK's most successful football teams, and the city centre houses the National Football Museum. Musically, Manchester's scene has included the Bee Gees, The Smiths, Joy Division, The Stone Roses and Oasis. The modern vegetarian movement is widely regarded as starting at a church in Salford. If purple soft-drinks are your thing, you'll be pleased to learn that Vimto is also a Mancunian invention. And finally, everyone's favourite wonder material graphene was discovered and characterised by researchers at the University of Manchester, for which they later won the Nobel Prize.

Tldr: We think Manchester's pretty great. Hopefully you do too!

ProgPal18 is being held jointly for the first time, between the University of Manchester (UoM) and Manchester Metropolitan University (MMU). The first day's workshops and the discussion panel will take place in the Williamson Building in UoM, named after William Crawford Williamson. In 1851, he became the first professor of natural history at Owen's College, which would become the University of Manchester, responsible for teaching geology, zoology and botany. The building is home to the School of Earth and Environmental Sciences, as well as the School of Law, and will soon house a near-complete specimen of the Tyrannosaurid *Gorgosaurus* which used to reside in the Manchester Museum. Despite being almost complete, the specimen has been through the wars, with numerous pathologies including a broken leg and brain tumour.

The full day of talks will take place in MMU's stunning Sandra Burslem building, which houses the Law School and the award-winning business school. The older of the two universities in Manchester, MMU can trace its history back to 1824 and the founding of the Manchester Mechanics' Institution. MMU has a particularly strong research focus on environmental sciences, with links to conservation groups in Africa, the Philippines, Mauritius and South America and Indonesia. Research here emphasises looking to the past to help explain the future. This is reflected in the University's wider ethos of sustainability and environmental impact. They were ranked 1st by People and Planet (the UK's only independent survey of university environmental and ethical performance).

TRANSPORT

Getting *to* Manchester

Car: Manchester is easily reached by road though parking is fairly limited in the city centre and very limited around the universities. Car parks and on-street parking are available nearby. The postcodes are M13 9PL on Oxford Rd for University of Manchester, and M15 6BH, All Saints for Manchester Metropolitan.

Coach/Bus: national coach services connect Manchester to most UK cities and airports. Coaches arrive at Manchester Central Coach Station (city centre), approximately a 15-20 minute walk from the University. See below for information on travelling within Manchester.

Rail: Manchester is easy to travel to via train, and has three major railway stations; Piccadilly, Oxford Road, with Victoria a little further away. Oxford Road is the closest station to the universities (5-10 minute walk). Next is Piccadilly (10-15 minutes), with Victoria the furthest away (25-30 minutes).

Air: Manchester has its own major airport, with frequent domestic and international flights. http://www.manchesterairport.co.uk/. Connections into the city centre are available by train (to Oxford Road or Piccadilly) or metrolink.

Getting *around in* Manchester

On foot: You are rarely more than a 30 minute walk away from a University in Manchester. The central coach station (city centre) to the Universities is a 20 minute walk through town. Oxford Road and Piccadilly train stations are less than a 20 minutes' walk to the universities, and it's just over 30 minutes from Victoria.

Public transport: Manchester is well-served by buses which connect the centre of town (coach/bus station), railway stations and University. Many of these buses serve the corridor running along Oxford Road, which leads from the centre of Manchester, past both the University of Manchester and Manchester Metropolitan, and then down towards the 'Curry Mile' and into South Manchester.

- From Piccadilly Gardens Bus Station: 14, 16, 41, 42, 43, 43a, 44, 45a, 48, 111, 140, 142, 157, 250.
- From Oxford Road Station: All buses that run along Oxford Road.
- From Cross Street outside Boots the Chemist: 47, 87, 50, 143, 197, 291.
- From Manchester Airport: 43a, 45a.
- From Piccadilly Train Station: 147.
- From Victoria Station: 42.
- From Shudehill Interchange: 18.
- Tram: Alight at St Peter's Square and walk or catch a bus down Oxford Road.

For the most up to date information, please consult: https://www.tfgm.com/public-transport/bus

Taxi: there are several taxi operators in Manchester and taxis can be booked or hailed. There are taxi ranks at each of three main train stations. If travelling by coach, the taxi rank at Piccadilly station is only short walk away.

CONFERENCE

Registration

Main registration will take place in the UoM Williamson building foyer from 12:00 - 17:00 on Thursday 7th June and again on the morning of Friday 8th June in MMU's Sandra Burslem building. See the end of the booklet for maps. Delegates will be able to collect their name badge; whilst not compulsory, in order to promote communication between delegates, it is advised you wear your name badge whilst in the university buildings.

Icebreaker

The Icebreaker will commence at 19:00 in the Fossil Gallery of the Manchester Museum. Snacks and refreshments will be provided. The ice-breaker is a great opportunity to catch-up with old friends, as well as make some new ones. All of this, whilst enjoying the many palaeontological wonders on display at the museum not least our *Tyrannosaurus rex* "Stan". After the Icebreaker closes, the committee will be happy to direct you towards one of Manchester's many drinking establishments, should you wish to continue the evening's frivolity.

Presentations

Presentations will be held in the Sandra Burslem lecture theatre, in the Sandra Burslem building in MMU. The entrance to the lecture theatre is located just off the main foyer as you enter the Sandra Burslem building (see floorplan at the back of this booklet). Committee members and ProgPal volunteers will be on hand to direct you. There will be four oral sessions and one dedicated poster session. Oral sessions will contain several Full talks, with Lightning talks at the end of each session. Both Full and Lightning talks are eligble for prizes (committee members excluded). Members of the committee will chair and judge the sessions. Full talks are 12 minutes plus 3 minutes for questions, while Lightning talks are 4 minutes with 1 minute for questions. In order to ensure the day runs smoothly we kindly ask speakers to adhere to the schedule and to keep to time. Posters will be available to view throughout the day on Friday 8th June in the ground floor attrium in the Sandra Burslem building. Committee members and volunteers will be on hand to direct you if needed. Alternatively see the floorplan at the back of this booklet. Posters should be A0 portrait or A1 landscape and printed in advance. Posters can be put up on the Friday morning or alternatively in the first coffee break, and then removed at the end of the day. Adhesive will be provided. The designated poster session is at 14:50 on the Friday, but you are welcome to view them at any time. During the poster session, authors are asked to stand with their poster.

Live Streaming

Talks will be live-streamed by Palaeocast at palaeocast.com. The committee were informed as to whether delegates wanted their talks streamed or recorded at abstract submission. If your circumstances for this have changed, please let us know ASAP.

Social Networking

I'm sure you have all been following our Facebook page and Twitter feed, if not it is a great way of keeping up-to-date with what's happening. We encourage tweeting of the conference using #ProgPal2018, but we ask you be mindful of other people's data when using social networks, in particular when taking photographs.

T-shirts

We will be selling ProgPal 2018 t-shirts (featuring the ProgPal 2018 logo by Callum McLean and Emma Randle) for £10 throughout the conference. Stocks are limited so get in early to avoid disappointment!

Lunch

We will be providing sandwiches for lunch for delegates in the foyer at 12:20.

Wi-Fi

Wi-Fi is available throughout both university campuses via Eduroam. Automatic connection should be available by delegates from participation universities. Otherwise, temporary access can be arranged by connecting to UoM or MMU guest networks.

Travel Grants

Thanks to last year's auction and the generous support of PalAss, we are delighted to announce that we have been able to award a total of 13 travel grants for delegates, including two international delegates.

Annual Dinner

The conference dinner on Friday evening is held at Lal Qila, an award winning Indian restaurant on Manchester's famous "Curry Mile" (123-127 Wilmslow Rd, M14 5AN; see map at back of booklet for guidance). You can make your own way there, or follow the committee shuttle. Volunteers will leave MMU Sandra Burslem foyer (where the main conference is) at 17:00, taking people down Oxford Road via a choice of several fine drinking establishments should you wish to refresh yourselves before the dinner starts. Doors for the conference dinner will open at 19:00, with food arriving by 19:30. This should give people the chance to buy a drink from the restaurant bar. The dinner will be in the form of a buffet, with two meat options and one vegetarian option (which is also suitable for vegans). Drinks will be available to buy from the restaurant bar, which is open all evening. The annual conference auction directly follows the dinner and we have some real star pieces up for grabs this year. From museum-quality 3D prints to palaeo-themed garments to exclusive palaeoart there is something for everyone. Make sure to raid those piggy banks before the auction so you don't miss out!

Workshops

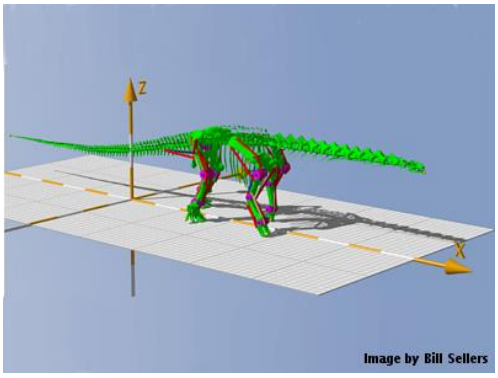
The workshops will run on the afternoon of Thursday 7th June from 12:00 - 13:30 and 14:00 – 15:30 in G16 on the ground floor of the Williamson Building, UoM. Conference volunteers and committee members will be on hand to guide you through the building. We strongly recommend you **bring your own laptops/tablets** to the workshops; desks are equipped with electrical sockets. We have two workshops during the afternoon.

Visualizing CT Data with Drishti: 12:00 – 13:30 with Dan Sykes

The Drishti workshop will cover importing CT data for fast visualisation, data exploration and segmentation. Drishti is a free software that can be used to produce both fast and high quality 3D visualisations of CT data. The basic principles of importing, manipulating and segmenting data will be demonstrated and attendees are encouraged to bring their own data to practice using Drishti, datasets will be provided for those that cannot bring

their own. The workshop will also cover how to export 3D meshes, 2D images and movies from your data and how to perform basic measurements (lengths, angles, surface areas and volumes). Attendees will need to bring their own laptops and ideally their own data to explore, however datasets will be provided in the workshop.

Biomechanics in palaeontology: 14:00 - 15:30, with William Sellers



Have you ever wondered how your favourite fossil vertebrate might have moved? Multibody Dynamics is an engineering methodology that gives you a more objective way of assessing the possibilities. This workshop will show you what information you need to assemble to do this sort of analysis and will demonstrate one of the open source software options for doing the calculations. The primary input is surface scans of the relevant bones so anyone attending the workshop is encouraged to bring suitable bone scans along. That way we can get you started with a simulation that hopefully will be useful to you. However this is not necessary! We will show you what the software can do and how you build the models and you can apply it to your preferred organism later (and we can help with that too). Ideally you should bring a laptop that you can install the software on - Windows or Mac will work, Linux might be trickier but we like a challenge. We also have computers you can use, and you can also just watch the presentations. No maths is required but you do need to be focused on the links between form and function.

Panel Discussion

The panel discussion is a new innovation for ProgPal 2018, and will be in room 2.16 in the Williamson Building, UoM, 16:00-17:00. The theme of this is "Careers in Palaeontology". After the Chair gives a brief introduction to the session, each panel member will introduce themselves and briefly describe their career track. The assembled panellists come from academia, museums and scientific publishing, and have a variety of backgrounds. Hopefully this demonstrates the variety of places people can both come from and go to with palaeontology. We will also be discussing a recent long term careers article published in the last PalAss newsletter and hearing the panel's thoughts on some of the key issues, e.g. "Does palaeontology suffer from a 'leaky pipeline' for women?" The article link is here, https://www.palass.org/publications/newsletter/long-term-career-prospects-phd-students-palaeontology. PalAss have also just produced a diversity study and for those interested the results are on the PalAss website. After the discussion of this article, we will then open the floor to questions.

Sustainability

For ProgPal 2018, we in Manchester are committed to sustainability. As part of this, this year's conference will be **PAPER FREE**. Delegates **will not** receive printed copies of the abstract book – the digital copy will have been emailed to you, and will also be available on the ProgPal 2018 website. However, as internet access is not always perfect, please try and make sure you also have the digital copy downloaded onto a phone, tablet or laptop. For the ice-breaker, compostable alternatives have been sourced to plastic glasses and plates where possible. Also, whilst we have over-catered slightly for lunch to ensure there is enough food for everyone, the key word is "slightly"; do not expect mountains of left-over sandwiches.

TIMETABLE

Thursday 7th June

12:00 - 17:00 Registration Open
University of Manchester, Williamson Building

12:00 - 13:30 **Workshop I: Visualizing CT Data**
Leader: Dan Sykes

14:00 - 15:30 **Workshop II: Biomechanics in Palaeontology**
Leader: William Sellers

16:00 - 17:00 **Panel Discussion: Careers in Palaeontology**
Chair: Elspeth Wallace
Members: Rob Sansom, Mandy Edwards, Anna Novitzky, Jamie Gardiner, David Gelsthorpe

19:00 - 21:00 **Icebreaker**
Manchester Museum, Fossil Gallery

Friday 8th June

8:00 Registration open
Manchester Metropolitan University, Sandra Burslem Building

9:00 **Introductions**

Session 1
Chair: Elspeth Wallace

9:30 **Orla Bath Enright**
Spinning the truth out of worms: Investigating the impacts of decay and transport on palaeocommunity fidelity of the Burgess Shale.

9:45 **Robert Brocklehurst**
It's a hedgehog… it's a shrew… it's a tenrec! Ecological convergence and divergence in African insectivores

10:00 **Albert Chen**
Shining a Light on Nightbird Relationships: A Total-evidence Phylogeny of Strisores

10:15 **Neil Adams**
A multi-proxy approach to reconstructing diets of K-Pg fossil mammals

10:20 **Alexander Askew**
Insular palynomorph assemblages of northern Spain: evidence for an endemic flora of Middle Devonian Iberia

10:25 **Juan Benito**
New specimens of the Mesozoic Ornithurine *Ichthyornis*

10:30 **Tea and Coffee Break**

Session 2
Chair: Robert Brocklehurst

11:00 **Alfio Alessandro Chiarenza**
Ecological niche modelling supports sustained dinosaur diversity trends prior to the Cretaceous/Paleogene mass extinction

11:15 **Savannah Cobb**
Using X-ray images to analyse the relationship between avian claw curvature and behaviour

11:30 **Claire Dobson**
Cranial osteology of *Martillichthys renwickae*, and ecological implications for suspension-feeding pachycormids.

11:45 **Emma Dunne**
The Late Triassic Latitudinal Biodiversity Gradient and Early Dinosaur Evolution

12:00 **Daniel Cashmore**
Completeness of the temnospondyl amphibian fossil record

12:05 **Mark Doeland**
Tooth replacement mechanisms in early sarcopterygians

12:10 **Kilian Eichenseer**
Latitudinal trends in marine skeletal mineralogy

12:15 **Martha Gibson**
British Zechstein palynomorphs indicate a wetter Late Permian environment

12:20 Lunch

13:30 Paul Smith
A word from PalAss

Session 3
Chair: Virginia Harvey

13:45 **Joseph Flannery Sutherland**
Does exceptional preservation distort our view of disparity in the fossil record?

14:00 **Lewis Jones**
Coupling palaeontological and neontological data: transitional distribution ranges of reef corals under global climatic change

14:15 **Carolina Karoullas**
Estimating the Flight Capabilities of Fossil Birds from Extant Bird Data and Aerodynamic Theory

14:30 **Rebecca Lakin**
Juvenile Spinosaurs (Theropoda: Spinosauridae) from the Middle Cretaceous of Morocco and variations in spinosaurine rostra within the Kem Kem

14:35 **Andrew Mair**
Utilising planktonic foraminifera to investigate Quaternary palaeoclimate from the Uruguayan margin.

14:40 **Catherine Mascord**
Worms on Film: How to Build an Ediacaran Biofilm.

14:45 **Christopher Stockey**
Preserved pigmentation of the Bolca Fishes: a first community-level palaeo-colour reconstruction.

14:50 Poster Session w. Tea and Coffee

Session 4
Chair: Callum McLean

15:40 **Ryan Marek**
The surrogate arm: analysing the role of regionalisation in the variation of the avian neck

15:55 **Omar Rafael Regalado Fernandez**
A reassessment of the phylogeny of basal Sauropodomorphs through comparative cladistics and the super-matrix approach

16:10 **Adam Woodhouse**
IODP Expedition 375 – Scientific objectives and biostratigraphic outputs of ocean drilling

16:25 **Conrad van den Ende**
A new marine snake (Palaeophiidae) from the Early Palaeogene of Morocco, a signal of early Cenozoic diversification

16:30 **Rebecca Walley**
Palynological Record of Changing Environments across the Triassic-Jurassic Boundary Interval in Northern Ireland

16:35 **James Chester**
A Total Evidence Approach to Scorpion Evolution

16:40 Concluding Remarks

ABSTRACTS

Session 1

Spinning the truth out of worms: Investigating the impacts of decay and transport on palaeocommunity fidelity of the Burgess Shale

Orla Bath Enright[1], Esther Sumner[2], Gabriela Mangano[3], Luis Buatois[3]
[1]University of Portsmouth, [2]University of Southampton, [3]University of Saskatchewan

Lagersttäten are traditionally viewed as 'windows' into past life on Earth and demonstrate a more complete fossil record that is used to reconstruct original palaeocommunities. This is based on the assumption that they have a greater fidelity to a community than the normal fossil record due to the preservation of soft-bodied organisms. The Burgess Shale Lagerstätte, is viewed as one such window, offering a unique insight into a middle-Cambrian marine community. However, the fossils from the Burgess Shale are entombed within flow deposits which has profound implications for the reconstruction of its original palaeocommunity. Fieldwork and laboratory analysis of the material from the Walcott Quarry of the Burgess Shale was used to design novel transport experiments. We identified the deposits as those of an upper-transitional to quasi-laminar plug flow that was replicated using an annular flume. In a two-factorial design, we tested the hypothesis that increasing pre-transport decay and transport duration would affect the state of degradation of the polychaete, *Alitta virens*. The flow contained 11 vol. % kaolinite clay and had a constant velocity of 0.4 m/s. In addition, we compared our observed states of degradation in *A.virens* to the preservation of the fossil polychaetes Burgessochaeta and Canadia from the Walcott Quarry. Our results show that pre-transport decay has a statistically significant effect on the state of degradation on both transported and non-transported groups, however, transport duration did not affect overall degradation. The implications of these results are discussed here.

It's a hedgehog… it's a shrew… it's a tenrec! Ecological convergence and divergence in African insectivores

Robert Brocklehurst[1]
[1]University of Manchester

Tenrecids (tenrecs) are a diverse group of insectivorous Afrotherian mammals, many of which are found only in Madagascar. The Malagasy tenrecs in particular show a wide range of body-forms, which repeatedly converge on other mammal species not found on the island e.g. hedgehogs, shrews and moles. However, few studies have tried to objectively measure the degree of divergence within tenrecs and convergence between tenrecs and other mammals. Jaw shape was quantified using geometric morphometrics in tenrecs, their sister group the Chrysochlorids (golden moles) as well as other more distantly related clades of insectivorous mammal e.g. Talpidae (moles), Erinacidae (hedgehogs), Soricidae (shrews) and Solenodontidae (Caribbean solenodons). This was combined with comparative phylogenetic methods to test for convergent trait evolution using Stayton's C-metrics as well as SURFACE-type approaches to test for convergent adaptive regimes. Preliminary results show significant convergence with other insectivorous mammals (i.e. are more similar than expected based on their evolutionary history). These findings provide insights into patterns and processes of ecological convergence and macroevolution in mammals. Future work will measure

evolutionary rates and jaw disparity in order to test hypotheses for adaptive radiations, as well as incorporating functional data from biomechanical analyses of the jaws. We also hope to include more phylogenetic outgroups, to test the effects of taxon sampling.

Shining a Light on Nightbird Relationships: A Total-evidence Phylogeny of Strisores

Albert Chen[1], Daniel Field[1]
[1]University of Bath

Strisores is a clade of crown-group birds that includes highly specialized fliers such as the Apodiformes (swifts and hummingbirds), as well as the nocturnal Caprimulgidae (nightjars), Steatornithidae (oilbird), Nyctibiidae (potoos), Podargidae (frogmouths), and Aegothelidae (owlet-nightjars). Recent molecular and morphological phylogenetic analyses have recovered the nocturnal strisorians as a paraphyletic grade with respect to Apodiformes. However, despite the use of large-scale molecular datasets, the phylogenetic relationships between the nocturnal strisorians have been resolved inconsistently by different studies and remain controversial. Given the lack of consensus between results based on molecular data, we examined the possibility that incorporating morphological data from fossils might improve resolution of this phylogenetic problem. Putative stem-members of nearly all major strisorian lineages have been described from Eocene fossil deposits, potentially providing critical information on ancestral character states within Strisores. We adopted a total-evidence approach combining both molecular and morphological data, which has hitherto only been applied to strisorian phylogeny to a limited extent. Our phylogenetic dataset includes 117 morphological characters scored for 24 strisorian taxa (of which 14 were fossil taxa) as well as DNA sequences from the extant taxa. This dataset was analyzed using Bayesian phylogenetic methods in MrBayes, resulting in a novel phylogenetic topology of Strisores that is nonetheless largely congruent with the findings of a comprehensive recent molecular phylogenetic analysis of modern birds. In future work, we aim to further clarify the early evolution of Strisores by performing a tip-dating analysis on our dataset to generate a time-calibrated phylogeny of these specialized birds.

A multi-proxy approach to reconstructing diets of K-Pg fossil mammals

Neil Adams[1], Mark Purnell[1], Stephen Brusatte[2], Thomas Williamson[3]
[1]University of Leicester [2]University of Edinburgh [3]New Mexico Museum of Natural History and Science

Over the last twenty years there has been a revolution in our understanding of mammalian evolution and diversity. Traditional views hold that dinosaurs dominated Mesozoic terrestrial ecosystems, limiting mammals to small niches of terrestrial generalism and/or insectivory until the Cretaceous-Paleogene (K-Pg) mass extinction. Only after the extinction of non-avian dinosaurs were mammals able to achieve high diversity by exploring newly vacant ecospace. However, exceptionally preserved Jurassic fossils discovered recently have shown early mammals to be far more ecologically diverse than previously recognised. These finds, in combination with emerging evidence for Late Cretaceous increases in ecomorphological disparity and phylogenetic diversification among mammals, have questioned the traditional 'suppression hypothesis'. Exceptionally preserved fossils demonstrating ecological diversity have been less forthcoming from Cretaceous strata, and the majority of the Late Cretaceous and Paleocene mammal record is known only from dental remains. Nevertheless, these dental remains have unrealised potential to test the suppression hypothesis from a dietary perspective. This project applies a novel multi-proxy approach (using 3D dental microwear texture

analysis, analyses of dental complexity from tooth morphology, and stable isotopes) to Late Cretaceous and Paleocene fossils, with the aim of reconstructing dietary diversity before and after the K-Pg mass extinction. These analyses provide independent tests of the suppression hypothesis and enable examination of the coupling between taxonomic and ecological diversity during one of the classic examples of adaptive radiation from the fossil record.

Insular palynomorph assemblages of northern Spain: evidence for an endemic flora of Middle Devonian Iberia

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During the Middle Devonian Iberia was part of a relatively isolated island complex, separated by considerable tracts of ocean from the supercontinents of Laurussia to the northwest and Gondwana to the southeast. The entirely marine Middle Devonian deposits of northern Spain were deposited around these islands and consist of a thick clastic unit sandwiched between extensive carbonate deposits. The clastic unit, the laterally equivalent Naranco, Huergas and Gustalapiedra formations of Asturias, León and Palencia provinces, represents a nearshore-offshore transect across a marine shelf. This unit is of particular significance, as it has a very well defined age based on conodont stratigraphy as well as encompassing an important global extinction event called the Kačák, though the rocks have not received detailed study since the 1960s. Here we identified almost 20,000 marine and land-derived microfossils, revealing a highly unusual community of land plant spores, marine acritarchs and chitinozoans. The assemblage includes a number of taxa known only from this region, various taxa with discordant ranges compared with elsewhere, and the complete absence of certain prominent taxa characteristic of coeval assemblages around the world. The assemblage's biostratigraphy suggests deposition took place very rapidly, over only 4-6 Mya, while the fossiliferous deposits date to the lemurata-langii Assemblage Zone (lemurata Subzone), indicating a probable early (but not earliest) Givetian age, immediately after the Kačák Event. The abrupt interruption of carbonate deposition, with a change to rapid deposition of thick clastic deposits, supports a monsoonal cause for this major event.

New specimens of the Mesozoic Ornithurine *Ichthyornis*

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The Late Cretaceous bird Ichthyornis dispar was one of the first known Mesozoic avialans, and is recognized today as one of the closest relatives of crown birds among Mesozoic stem birds. As such, the skeletal morphology of Ichthyornis may be more representative of the ancestral condition of modern birds than that of any other known Mesozoic avialan, and its study has crucial implications for understanding the origins and early evolution of crown birds. Previous work on Ichthyornis has largely been based on limited fossil material discovered over a century ago. Here we present high resolution scans of new, exquisitely preserved three-dimensional specimens of Ichthyornis from the Late Cretaceous of Kansas, focusing on the pectoral girdle and wing elements. The new specimens are more complete and in better condition than the classic material, and include some previously unrepresented elements, as well as better preserved examples of several bones. These include a complete, three-dimensionally preserved sternum, including robust caudolateral processes and relatively developed sternal incisures. The coracoid exhibits very large and recurved acrocoracoid and procoracoid processes, and the scapula preserves a robust and hook-shaped acromion process, differing from previously referred specimens. This last character is of particular interest, as it represents a previously described autapormorphy of Ichthyornis dispar. Wing bones, carpals and

hand elements are well preserved as well, and include the first complete radiale known from Ichthyornis. Ongoing work in these and other new Ichthyornis specimens will shed new light across the proximal-most portion of the stem-bird phylogenetic tree.

Session 2

Ecological niche modelling supports sustained dinosaur diversity trends prior to the Cretaceous/Paleogene mass extinction

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In the lead-up to the Cretaceous/Paleogene mass extinction, dinosaur diversity is argued to have been either already in long-term decline or thriving until their sudden demise. One of the main methodological obstacles when interpreting these hypotheses is the estimation of the impact of spatial bias when modelling diversity. Ecological niche modelling, using species occurrences and climatic data to reconstruct habitat distribution through space, could offer a possible solution for interpolating biogeographic patterns in the presence of fragmentary information, helping integrating models of distributional patterns from unsampled areas. In this study, we combine fossil occurrence data with climatic and environmental modelling to define latest Cretaceous North American dinosaur habitat availability. A time series analyses of species distribution models was developed from the early Campanian to the late Maastrichtian of North America. The ecological niches modelled on available outcrop area through time show a decline for major non-avian dinosaur clades, an outcome mirroring the trends based on previous diversity analyses. However, when continental projections are considered, the pattern shifts dramatically, showing an overall increase in niche suitability from the Campanian to the Maastrichtian. An ordination framework is applied to quantify metrics of niche change between Campanian and Maastrichtian, showing relative niche stability between two stages. These evidence hint at a hidden diversity of dinosaurs in the Maastrichtian, obscured by a reduction in the spatial sampling window, resulting from formation of the proto-Rocky Mountains and regression of the Western Interior Seaway, highlighting the impact of spatial bias in interpreting important macroecological dynamics.

Using X-ray images to analyse the relationship between avian claw curvature and behaviour

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Previous studies have sought to measure the relationship between avian, squamate, and avialan claw curvature and behavior using angles measured via a method that approximates pedal claws of digit III to the arc of a circle (Feduccia, 1993; Pike & Maitland, 2004; Glen & Bennett, 2007; Birn-Jeffery et al., 2012). The ranges of claw angles found with this method are correlated with behavioural categories perching, climbing, ground-dwelling, and/or predation. The determined correlations are often used to infer behaviours of extinct avialans. Issues with methodologies of past studies include reliance on homologous points located on soft tissue, limited sample size, failure to account for confounding effects related to body size and phylogeny, and reconstruction of soft tissue in fossil claws using untested or unquantifiable methods. This study seeks to resolve conflicting results of past studies using the Nomad Pro Radiography Unit to study the relationship between inner ungual bone and outer keratinous sheath of digit III pedal claws of a large, phylogenetically diverse sample of modern birds of weights .2kg to 2kg from behavioural categories perching, ground-dwelling, climbing, and

predatory using digital X-ray images, a custom-made program DinoLino.exe, and statistical analysis in R. Intended results are to provide a reliable method of reconstructing incomplete fossil claws and give an accurate relationship between behavior and claw angle in avians for purposes of inferring behaviours in extinct avialans through comparative analyses of claw curvature.

Cranial osteology of Martillichthys renwickae, and ecological implications for suspension-feeding pachycormids.

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Pachycormids are a modestly diverse family of putative stem teleosts, ranging in age from the Early Jurassic to the Late Cretaceous, and are found in marine deposits across the globe. Most notably, this group shows wide ecomorphological variation of their feeding mechanisms; from large, sharp teeth for carnivory, to elaborate gill rakers for suspension feeding. While some members of the group are well represented in the fossil record, the most famous pachycormids — the giant suspension feeders, including the largest ever fish, Leedsichthys — are almost exclusively known from crushed, disarticulated material, and have been largely characterized by fragments, limiting understanding of their ecology and evolution. Here, we use CT-scanning to re-describe an articulated, though moderately flattened, cranium of Martillichthys renwickae from the Middle Jurassic (Callovian) Oxford Clay of the UK. This scan reveals internal details of perhaps the most complete suspension-feeding pachycormid skull known, and revises several details of the anatomy of Martillichthys. Most significantly, Martillichthys shows specialized characters with an apparently restricted distribution among suspension feeding pachycormids, including gill rakers with elongated raker teeth, and a greatly extended occipital stalk. By mapping described characters onto a cladogram, we show that our virtual models of Martillichthys reinforce past systematic interpretations of the interrelationships of suspension feeding pachycormids, and can now provide a model for interpreting the less complete remains of other members of this enigmatic but long-lived group of fishes.

The Late Triassic Latitudinal Biodiversity Gradient and Early Dinosaur Evolution

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The latitudinal biodiversity gradient (LBG) is one of the most widely recognised patterns in macroecology. This gradient, the increase in species richness towards the equator, has been extensively documented in modern terrestrial vertebrate faunas, yet the evolution and drivers of this gradient through time remain uncertain. The fossil record offers a deep time perspective on the LBG; however, previous studies have been hampered by uneven spatial and temporal sampling, particularly very poor sampling of low-latitude regions. The Late Triassic tetrapod fossil record provides a unique opportunity to study the evolution of the LBG, as sampling in low- and mid-latitude regions during this interval has been extensive, and the climate and continental configuration were very different from those today. Here, we explore the relationships between Late Triassic tetrapod diversity, palaeolatitude, and climate using recently-updated data from the Paleobiology Database, sampling standardisation, and tree-based biogeographic and character-mapping approaches. Results suggest that Late Triassic tetrapods do not conform to a modern-type LBD; instead diversity is higher at mid-latitudes than at low-latitudes. We also find that tetrapod communities are latitudinally structured, suggesting that climate controlled species distribution. To further examine these patterns, we are utilising models of global climate and vegetation to uncover the drivers of spatial variation in the diversity of major Late Triassic tetrapod groups (e.g.

archosaurs, pseudosuchians, and temnospondyls). We focus in particular on the evolution of the first dinosaurs, making this the first study to quantitatively test the current hypotheses of early dinosaur evolution using climate models.

Completeness of the temnospondyl amphibian fossil record

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Changes in fossil specimen completeness can alter the amount of observable character states per species, and therefore affect macroevolutionary interpretations. The quality of the tetrapod fossil record has previously been quantified as the proportion of phylogenetic characters that can be scored for an individual species. Here, we calculate this character completeness metric (CCM) for temnospondyl amphibians, a highly successful group of early tetrapods that first appeared in the Carboniferous, rapidly diversified after the Permian-Triassic extinction, and even survived into the mid-Cretaceous. Results reveal temnospondyl character completeness is the highest of any previously studied tetrapod group, but has a similar range in values to Anomodontia. They have consistently very high mean completeness (~60-95%), with little fluctuation through time, apart from relative peaks in mid-late Mississippian and Ladinian, and lows in the Bashkirian and Capitanian. Completeness does not correlate with changes in taxonomic richness through time, which suggests that it is unlikely to be limiting our understanding of temnospondyl macroevolution. Furthermore there is relatively little change in the range of CCM values between different hemispheres and continents, and subtle differences between different lithologies and depositional settings. Calculating how completely known individual characters are through time reveals that the postrcranial elements have a significantly lower mean completeness than the skull, which alone constitutes 72.5% of all temnospondyl characters. Further study aims to quantify the skeletal completeness of individual specimens and the preservation potential of different skeletal elements to attempt to explain the high quality of the temnospondyl record and uncover any potential bias.

Tooth replacement mechanisms in early sarcopterygians

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The study of tooth development in sarcopterygians (lobe-finned fishes and tetrapods) is important for understanding their evolution and resolving basal osteichthyan phylogeny. Although tooth replacement in extant sarcopterygians and stem osteichthyans has been intensively studied, dental development in early sarcopterygians is largely unknown. Current hypotheses predict that basal resorption and extraosseous replacement are primitive sarcopterygian characters and that tetrapods are united by intraosseous replacement from a deep dental lamina. This study aims to describe patterns of tooth replacement in early sarcopterygians and test the scenarios for tooth replacement evolution. Fossil dental tissues of the basal sarcopterygian Onychodus, the tetrapodomorphs Eusthenopteron and Tiktaalik and a modern coelacanth are examined with synchrotron tomography and X-ray micro-CT. Three-dimensional models of growth stages of dental tissue are created by mapping lines of arrested growth and resorption. In Onychodus replacement teeth seem to have overgrown the resorbed preceding teeth, just as in Latimeria. Hence intraosseous replacement seems to have evolved within crown-group sarcopterygians. Further results from this study will offer insights into the evolution of tooth replacement mechanisms and help clarify character states critical to resolving sarcopterygian phylogeny.

Latitudinal trends in marine skeletal mineralogy

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The Mg/Ca ratio and temperature of seawater both affect abiotic and biogenic CaCO3 formation: High Mg/Ca ratios and temperatures favour aragonite over calcite precipitation, and vice versa. Whereas the marine Mg/Ca ratio is similar across the oceans today, temperature shows a strong latitudinal gradient. We raise the hypothesis that aragonitic calcifiers are more abundant in warm, tropical seas, whereas calcitic taxa prevail in higher latitudes. Qualitative observations seem to confirm this trend, but a rigorous quantitative assessment is lacking. We use the fossil record of marine calcifiers from the Paleobiology Database to assess latitudinal differences in the prevalence of aragonitic and calcitic taxa. We find that while there is no consistent latitudinal pattern across the Ordovician – Pleistocene, a weak tropical preference of aragonitic taxa emerges in intervals with a pronounced latitudinal temperature gradient.

British Zechstein palynomorphs indicate a wetter Late Permian environment

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The Zechstein Sea was a semi-isolated inland sea that occupied the Southern Permian Basin during the Late Permian (~255Ma). The sea endured at equatorial latitudes for 5 to 7 million years during which time it underwent five cycles of evaporation and transgression, causing cyclic evaporative down draw and hypersaline conditions. This resulted in dramatic short term reductions in biotic abundance and diversity throughout the marine and terrestrial realms. However, it is hypothesised that transgression phases experienced sufficient precipitation to facilitate ecosystem recovery. Palynological investigation of borehole material from northeast Yorkshire has yielded unexpected palynomorph abundance from the fourth Zechstein cycle. The assemblage is dominated by taeniate and striate bisaccate pollen accompanied by monosaccates and trisaccates, including Lueckisporites, Taniaesporites, Klausipollenites, Protohaploxypinus, and Vittatina. These taxa support a transient gymnosperm dominated Euramerican flora composed of phylogenetically advanced conifers, one to two species of ginkgophytes, and rare cycads, pteridosperms and pteridophytes. The presence of such an abundance of palynomorphs questions previous assumptions that Late Permian equatorial climates were continuously arid, suggesting instead that the climate was at times damp enough to support extensive gymnosperm forests despite the impending Permian-Triassic extinction event. Quantitative analysis of assemblages is revealing how the vegetation changed in response to repeated environmental cyclicity and Late Permian climate trends. TEM analysis of pollen wall ultrastructure is underway to elucidate parent flora affinities for key pollen taxa, allowing for a more accurate ecological reconstruction as well as contextualising the Zechstein vegetation with regards to the floristic changes occurring at the Palaeozoic-Mesozoic boundary.

Session 3

Does exceptional preservation distort our view of disparity in the fossil record?

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How much of evolutionary history is lost because of the unevenness of the fossil record? Lagerstätten, sites of exceptional fossil preservation, provide remarkable, yet distorting insights into past life. When examining macroevolutionary trends in the fossil record, they can generate an uneven sampling signal for taxonomic diversity; by comparison, their effect on morphological variety (disparity) is poorly understood. Ichthyosaurs, Mesozoic marine reptiles, are generally said to have a good fossil record, yet we show here that lagerstätten impact their disparity signal through the preservation of higher diversity and more complete specimens. Elsewhere in the fossil record, missing data due to lower diversity and more fragmentary specimens produce spurious results, and highly incomplete taxa show strongly altered positions in morphospace. We identify a novel effect, that as the proportion of missing data increases, a taxon moves closer and closer to the average of the dataset. We term this effect 'centroid slippage', as a disparity-based analogue of phylogenetic stemward slippage. Our results suggest that uneven sampling may present profound issues for observation of trends in disparity in the fossil record. Mitigation of missing cladistic data is possible by phylogenetic gap filling, and the heterogeneous effects of lagerstätten on disparity may be accounted for by a better understanding of the factors affecting their spatiotemporal distribution. Together, these corrections may provide a way of disentangling the true disparity record of a clade from the biases induced by uneven sampling.

Coupling palaeontological and neontological data: transitional distribution ranges of reef corals under global climatic change

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Anthropogenic climate change, with a projected global warming of 2–4.8 °C, is likely to leave coral reefs at substantial risk. Reef (zooxanthellate) corals are currently undergoing poleward range expansions and show slight evidence for range retractions at lower latitudes. However, as modern studies are based on short-term observations, it is difficult to predict whether this expansion/retraction trend will persist under global warming. The fossil record provides the only empirical evidence for the responses of organisms to environmental perturbations over geological time intervals. This record suggests reef corals experienced dramatic poleward range shifts during the last interglacial (LIG; 125,000 years ago), a time of rapid global warming potentially analogous to today. However, the fossil record is inherently biased, both temporally and spatially, and existing methods cannot account for the absence of data. Using ecological niche modelling (ENM), modern and fossil occurrence data, and general circulation models, we show that the ranges of reef corals during the LIG were comparable to the present, with no prominent decrease in habitability at equatorial paleolatitudes. These results point to a potential sampling or taphonomic bias in the LIG fossil record. We also projected our ENMs to two future climate change scenarios (RCP4.5 and RCP8.5), finding that reef corals are likely to experience prominent range expansions under both scenarios, but with large equatorial declines only under the latter. The fossil record provides vital complementary information on the environmental conditions that reef corals can occupy, improving biodiversity risk assessment through consideration of the niche hypervolume.

Estimating the Flight Capabilities of Fossil Birds from Extant Bird Data and Aerodynamic Theory

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Understanding fossil avian flight capability is key to understanding their ecology as well bettering our understanding of the origins of powered flight in vertebrates. Using current aerodynamic theory in the form of aerodynamic power curves as well as extant data has great potential in helping palaeontologists answer questions about fossil avian flight capability. However, the potential error associated with using extant data to extrapolate back to fossil taxa is often ignored. This error must be explored in greater detail to ascertain if aerodynamic power curves can be used in avian palaeontological research. Subsequently, this study explores how the error associated with the regression equations required to calculate the morphological variables needed to produce the aerodynamic power curves affects the resolution of estimates about flight capabilities. Predictions of the aerodynamic cost of flight for all taxa are associated with large errors, but are less pronounced for small fossil taxa (<0.2 kg). Nonetheless, inferences about the flight capabilities of any fossil taxa using this aerodynamic power curve approach should be approached with caution.

Juvenile Spinosaurs (Theropoda: Spinosauridae) from the Middle Cretaceous of Morocco and variations in spinosaurine rostra within the Kem Kem

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The Spinosauridae is a family of specialised theropod dinosaurs known from the Berriasian to the Cenomanian of Africa, South America, Europe and Asia. The spinosaurs were unique among non-avian dinosaurs in exploiting a piscivorous niche within riverine and coastal habitats. This group also contains the largest theropod currently known.
Although fossils of giant spinosaurs are increasingly well-represented in the fossil record, juvenile material has not been explored in depth, nor its ecological implications. Here, we describe the first examples of juvenile Spinosaurusmaterial from the middle Cretaceous (Cenomanian) Kem Kem beds of Morocco. The fossils include material from a range of body sizes, suggesting that juveniles exploited the same semiaquatic niche as the adults throughout ontogeny, and that the Cenomanian delta habitats supported an age-inclusive population of Spinosaurusthat was neither geographically or environmentally separated, though some ecological separation is likely based on the new minimum and known maximum size of Spinosaurus. We also identify two distinct cranial morphs of Spinosauridae present within the Kem Kem, potentially supporting the previous recognition of distinct taxa in the assemblage.

Utilising planktonic foraminifera to investigate Quaternary palaeoclimate from the Uruguayan margin.

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A series of 200 drop cores collected in the Punta del Este basin will be analysed to investigate Quaternary climates and the biological response of the plankton on the Uruguayan Margin. The cores were taken over the middle and lower continental slope, in an area cut by several submarine canyons and turbidites in a contouritic system. The cores enable study of glacial/interglacial climate change in a southern hemisphere, in a sub-tropical setting from a region of confluence for major oceanic water masses. The study will aim to target the Last Glacial Maximum, a period during the last ice age, approximately 20 kya, during which ice sheets reached their maximum extent. The project aims to document the impact of climatic change on planktonic foraminiferal communities, and ecologies, since the LGM and through the subsequent deglaciation. Fossil assemblage work, morphometric analysis and geochemical data will aim to provide a palaeoclimate and palaeobiological record for the region. The talk will outline the project, the approach being taken and work to date.

Worms on Film: How to Build an Ediacaran Biofilm

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The activity of benthic organisms is a dominant control on conditions within marine sediment. Two key elements of the benthic community, burrowing metazoans (infauna) and matground-forming microbes, appear to have an antagonistic relationship. Most modern marine sediments are metazoan-dominated; however, matgrounds develop in metazoan-poor conditions, and further inhibit burrowing. During the Cambrian explosion, infaunal size, abundance and diversity increased dramatically, while matgrounds, which dominated Proterozoic seafloors, declined. Much, however, remains uncertain about how early infauna interacted with Precambrian matgrounds. Experiments designed to document interactions between modern Metazoa and microbial mats may help us to determine the role infauna played in the decline of the Ediacaran microbial epibenthos. Modern matgrounds are likely to have different constituent taxa than those of the Ediacaran, and as a result may have had different impacts on sediment properties and infaunal behaviour. Nonetheless, experimental work may provide new insights into the interaction between infauna and microbial mats of different structure and composition. Initial experimental work has focused on developing methods to culture different communities of microbial mats, as a basis for exploring the impact of biofilm structure on conditions on and within the sediment. Early results indicate that in light-limited conditions, anoxic—probably bacterial—biofilms rapidly develop, whereas, in illuminated cultivations nearly monospecific diatom communities form. The importance of a range of physical conditions on the microbial consortia that develop within our experimental matgrounds will be explored, with the ultimate aim of creating analogues for the Precambrian seafloor, into which infauna can be introduced.

Preserved pigmentation of the Bolca Fishes: a first community-level palaeo-colour reconstruction

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The understudied Eocene Bolca Lagerstätte contains exceptionally preserved shallow marine community assemblages that demonstrate major macroevolutionary shifts in Cenozoic reef composition. Their biota represents the earliest known acanthomorph dominated reef ecosystem, highlighting a faunal shift towards modern community structures. The localities formed part of an ancient biodiversity hotspot, in an archipelago at the western edge of the Tethys Ocean, described as analogous to modern Indo-Pacific systems in sedimentary analysis. Despite their significance, there has been limited study of the Bolca fishes' ecology. Preserved pigment patterns in fossils are used to infer the ecologies of extinct taxa. Previous studies have reconstructed the pigmentation of single specimens, limiting their ecological implications to individual species. Here we present the first community-level description of palaeo-colour, providing greater context for inferred ecological niches and ecosystem processes. Polarised light and an LSF light box were used in photography to better highlight preserved pigment in specimens. Fish colouration is primarily associated with camouflage and varies between different niches and habitats. Comparisons between the preserved pigment patterns of the Bolca fishes and extant taxa were used to infer the ecologies of specimens. Specimens present camouflage pigmentation patterns used in substrate matching, countershading and disruptive coloration. These camouflage patterns are associated with different ecologies and trophic levels within modern shallow-marine ecosystems, facilitating novel approaches to inferring ecological niches within palaeontological data. Our study expands our knowledge of palaeo-colour beyond that of individual specimens or species, demonstrating its power for investigating ecologies at a community-level.

Session 4

The surrogate arm: analysing the role of regionalisation in the variation of the avian neck

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Acting as a surrogate forelimb, the avian neck allows for the head to perform environmental manipulation tasks usually accompanied by the forelimbs, which are primarily adapted for flight in birds. This additional selection pressure on the cervical system has led to a vast array of neck morphologies in modern avians, yet no systematic study of this variation has occurred, owing to fluctuating cervical counts. Hox genes regulate axial regionalisation in vertebrates and the number of cervical regions is fixed within a group of vertebrates. Thus, studying cervical regionalisation overcomes problems associated with varying cervical counts. Using a combination of 3D geometric morphometrics and Phenotypic Trajectory Analysis this study assesses the number, size and shape of cervical regions amongst a diverse selection of extant birds. Results support 5 cervical regions within all birds. The anterior- and posterior-most regions (supporting the head and neck as a whole) show little change in region size, yet the middle 3 regions vary enormously in size. Further analysis reveals that region size is associated with neck length, with regions 2 and 4 responsible for neck elongation in birds. Whilst region size shows little correlation with ecology (diet and flight style), Phenotypic Trajectory Analysis reveals that mean region shape appears significantly correlated with both diet

and flight style amongst modern birds. Not only have birds evolved an extra cervical region (5 compared to the 4 of ancestral archosaurs), the variation within each region has allowed for the diverse neck morphology seen throughout Aves

A reassessment of the phylogeny of basal Sauropodomorphs through comparative cladistics and the super-matrix approach

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Basal Sauropodomorphs have been thoroughly studied in recent years. Several hypotheses on the interrelationships within this group have been proposed, ranging from a complete paraphyly, where the group represents a grade from Basal Saurischia to Sauropoda, to a group on its own. The grade-like hypothesis is the most accepted, however the relationships between the different taxa are not consistent amongst the proposed scenarios. These inconsistencies have been attributed to missing data and unstable (i. e., poorly preserved) taxa, nevertheless, an extensive comparative cladistic analysis has found that these inconsistencies come from the character coding and character selection, plus the strategies on merging data sets. This analysis also produced the largest and most comprehensive matrix after the reassessment and operationalisation of every character applied to this group far. Furthermore, partition analyses performed on this data set have found consistencies in the interrelationships within Basal Sauropodomorpha, and has cast doubt on the validity of several clades and taxa, such as Massospondylidae, Massospondylus, Yunnanosaurus, and Coloradisaurus. The results of these studies also highlight a different scenario on how quadrupedality evolved, independently originating twice within the group, and provide a better framework to understand the palaeo-biogeography and diversification rate of the first herbivore radiation of dinosaurs.

IODP Expedition 375 – Scientific objectives and biostratigraphic outputs of ocean drilling

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The International Ocean Discovery Program (IODP) represents a 26-nation marine research collective which utilizes ocean-going drilling platforms to recover and record data from the seafloor sediment and rock record. The program aims to guide multidisciplinary international collaboration on scientific ocean drilling to elucidate the Earth's dynamic past. IODP Expedition 375 was recently undertaken at New Zealand's offshore Hikurangi subduction zone. The Hikurangi subduction zone, located offshore the east coast of New Zealand's North Island is where the Pacific Plate is subducted beneath the Australian Plate. It is of particular interest to the scientific community due to the periodic reoccurrence of slow-slip events (or silent earthquakes), occurring at shallow-enough depths to be investigated through riserless drilling by the IODP vessel *JOIDES Resolution*. This represents the first-ever scientific drilling effort targeted at understanding the physical processes that produce slow slip events on plate boundary faults. In this presentation I will briefly outline the key expedition aims, and provide an overview of the logistics involved in drilling and extracting core from the ocean floor. I will then focus on the preliminary biostratigraphic findings of the expedition using foraminera and nannofossils ranging through the Cenozoic and Upper Cretaceous, and how

they were combined with results from the expedition chronostratigraphy team to provide age-control on the sediments recovered from the Hikurangi margin.

A new marine snake (Palaeophiidae) from the Early Palaeogene of Morocco, a signal of early Cenozoic diversification

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The early Cenozoic phosphates of Morocco have yielded a diverse marine vertebrate fauna. Among these are the Palaeophiidae, a diverse taxon of marine snakes. Previously, all Palaeophis from Morocco have been identified as P. maghrebianus. We describe a new palaeophiid from the Ypresian (Lower Eocene) of the Oulad Abdoun basin, and describe a previously unknown species from Morrocco, Palaeophis toliapicus. The new specimen consists of disarticulated vertebrae and ribs, and is referred to the family Palaeophiidae based on the horizontal axis of the cotyle-condyle, the low position of the synapophyses, the long and slightly curved ribs, and lateral compression of the vertebrae. It differs from primitive palaeophiid snakes and resembles Pterosphenus in exhibiting a hypertrophied neural spine, which extends to twice the length of the centrum on trunk vertebrae, and in the pterapophysis protruding slightly over the dorsal height of the zygosphene at a low angle. Parsimony analyses based on 54 characters, including 29 novel quantitative characters and 26 fossil snake taxa suggests a relatively derived form of Palaeophis. The specimen illustrates the extreme adaptations to the aquatic environment of this clade, the phylogeny suggests that Palaeophiidae underwent a major radiation in the Paleocene and early Eocene in response to the extinction of Cretaceous marine reptiles and Paleocene-Eocene global warming.

Palynological Record of changing environments across the Triassic-Jurassic boundary interval in Northern Ireland

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The Triassic-Jurassic boundary is a globally important transition that has been under-studied in Northern Irish sections. Using material from a completely-cored record of the late Triassic to earliest Jurassic interval, this project provides a biostratigraphic and palaeoenvironmental context for the Carnduff-1 Borehole, near Larne, Northern Ireland. The assemblages in Carnduff-1 are well-preserved and diverse, but dominated by Classopollis, Corollina, Leiosphaeridia and bisaccate pollen. Dinoflagellate and acritarchs are present throughout the section but occur in lower abundance than the pollen and spore components. The section can be split into three assemblages; Rhaetian Assemblage, Boundary Assemblage and Hettangian Assemblage. These assemblages highlights that the Triassic-Jurassic boundary is transitional, and biostratigraphy of this section relies heavily on the presence of marker species. A cycle of marine regression-transgression across the Triassic-Jurassic boundary can be inferred from this section using Sporomorph Ecogroups, that show a shift from Upland dominated, to River/Lowland dominated, back to Upland dominated assemblages. Statistical testing supports the chronostratigraphically constrained palynological assemblages.

A Total Evidence Approach to Scorpion Evolution

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There has been a notable lack of consensus between successive phylogenetic analyses of scorpions (Arachnida, Scorpiones), with clear discordance between morphological trees from parsimony-based cladistic analyses, and likelihood-based based trees from phylogenomic analyses. In addition, palaeontological data from the extensive scorpion fossil record has largely been neglected, presenting a constraint on current interpretations of scorpion macroevolution. We performed total-evidence based phylogenetic analyses (Bayesian and maximum-likelihood), combining morphological data from extant and fossil taxa with transcriptome data for the first time, producing a fully dated scorpion phylogeny. Internal relationships of the scorpions now have improved clarity and additional divergence time analyses provide us with further insight in to the changes through time of this lineage. Disparity analyses tested how scorpion morphology, traditionally viewed as somewhat static, has changed through time. Future work will focus on integrating Cainozoic scorpion morphology in to analyses and producing an even fuller morphology matrix of scorpions through time.

Posters

Morphofunctional trends of feeding modes in Crocodylomorpha

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Crocodylomorpha are the long-lived clade of archosaurs that include extant crocodiles and their closest fossil relatives. Since their origin in the Carnian (~230 Ma), a considerable diversity of lineages radiated during the Mesozoic and occupied a wide spectrum of ecological niches and feeding modes, including small cursorial insectivores, fully pelagic piscivores and heterodont herbivores. After the Cretaceous, this functional disparity plummeted, with extant crocodilians specialising on the limited ecological role of semiaquatic ambush predators. Among these forms, the peculiar Indian gharial (Gavialis gangeticus) is commonly used as an extant model to infer function in extinct longirostrine taxa, such as the Mesozoic marine Thalattosuchia. Here, we use a varied range of computational techniques, biomechanical and macroevolutionary analyses to explore the past functional diversity and evolution of feeding modes in Crocodylomorpha. Firstly, 3D virtual reconstructions of the cranial musculoskeletal anatomy of the Early Jurassic basal thalattosuhian Pelagosaurus typus and G. gangeticus were generated from CT scan data and compared, revealing osteological similarities in their mandibles. Finite element analysis (FEA) is being conducted to test the hypothesis of functional convergence to a piscivorous diet between these two taxa. Secondly, the evolution of functionally-relevant characters of the lower jaw is being analysed across crocodylomorph lineages to test for correlation of feeding diversity with radiation and extinction events. FEA of lower jaws will indicate differences in biomechanical performance among clades. These approaches will enable us to assess the importance of feeding specialization in the macroevolution of Crocodylomorpha during the Mesozoic.

The use of CT in discerning the life habits of the Early Triassic archosauriform, Proterosuchus fergusi

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Proterosuchids are a group of carnivorous basal archosauriform reptiles characterised by a bizarre enigmatic overhanging premaxilla. While traditionally considered semi-aquatic, recent histological studies suggest that they were likely terrestrial, however there is currently no consensus. By utilising CT data, we virtually reconstruct the brain cavity and endosseous labyrinths from two adult specimens of Proterosuchus fergusi from the Early Triassic of South Africa, in an attempt to understand its life habits within the context of basal archosauriform evolution. Endocasts reveal the brain cavity is tubular in shape and the endosseous labyrinths are highly pyramidal, analogous to modern adult crocodiles and thalattosuchians respectively. The angle of the lateral semi-circular canal of the inner ear reveals P. fergusi naturally held its head upwards ~17°, while the length of the cochlear duct suggests its auditory abilities were similar to that of the American alligator. Furthermore, the rostrum of P. fergusi is found to be highly resistant to both mediolateral and dorsoventral bending when compared to modern crocodilians and is even enhanced by the overhanging premaxilla. With an upwards-tilted rostrum, the laterally-positioned nostrils of P. fergusi would be held above water level, and such a resistant snout could allow it to hunt large prey and withstand additional hydrodynamic forces. The retained primitive brain morphology of modern crocodilians makes them a good analogue for proterosuchids and other basal archosauromorphs. The comparative anatomical analyses suggest P. fergusi was likely a semi-aquatic, generalist apex predator capable of surviving the harsh environmental perturbations of the Early Triassic.

A Study of Taxonomy and Fossil Identification of the Larnagol Vertebrates

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The fossil deposit in the Bathonian aged Larnagol locality are poorly known to the palaeontological community. Clear species and genusidentification of the taxa from this region has yet to have been completed, although taxa identification has been narrowed down to a select number of atoposaurid taxa for the crocodilian remains. The ornithischian remains consist of teeth and some possible bone fragments. They proved impossible to identify at the family level. However a preliminary assignment to a more narrowed clade of ornithischians: that being the Thyreophora clade, has been attempted.

Extensive transfer of membrane lipid biosynthetic genes between Archaea and Bacteria

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The divergence between Bacteria and Archaea may represent the deepest split in the tree of life. One of the key differences between the two domains lies in their membrane lipids, which are synthesised by distinct biosynthetic pathways with non-homologous enzymes. This ‘lipid divide’ has important implications for the early evolution of cells, and motivates the hypothesis that the last universal common ancestor (LUCA) may have lacked a cell membrane. However, we still know surprisingly little about the natural diversity of prokaryotic lipids in modern environments, or the evolutionary origins of the genes that produce them. In particular, the discovery of environmental lipids, such as glycerol dialkyl glycerol tetraethers with a mixture of classically archaeal and bacterial features, suggest that the 'lipid divide' may be less clear cut that previously believed. Here, we investigated the distribution and evolutionary history of membrane lipid biosynthesis genes across the two domains. Our analyses reveal extensive inter-domain horizontal transfer of core lipid biosynthetic genes, and suggest that many modern Bacteria and Archaea have the capability to biosynthesize membrane lipids of the opposite “type”. Gene tree rooting further suggests that the canonical archaeal pathway could be older than the bacterial pathway, and could have been present in LUCA.

Sedimentology of a Terminal Proterozoic ‘micro-Lagerstätte’ from Estonia and its Palaeobiological Significance: A Palaeoenvironmental Approach

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A suite of exceptionally preserved and undeformed mudstones from the Baltic Basin in Estonia and Russia capture the transitional interval between the Precambrian and Phanerozoic Eons. The mudstones contain a rich assemblage of exceptionally preserved carbonaceous fossils, including the dominant filamentous structure Vendotaenia. These fossils could hold key insights into the processes involved in the Cambrian Explosion. However, reliable interpretation of these fossils is hampered by

a lack of constraint on the sedimentary depositional environment; it is important to understand a detailed palaeoenvironmental framework prior to palaeobiological interpretation. Detailed petrographic analysis and submillimetre-scale logging of thin sections from core sections of the Kotlin Formation (Ediacaran) and the Lontova Formation (Fortunian/Cambrian Stage 2) was undertaken and microfacies and facies associations were identified. Fossil material was extracted, identified and interpreted alongside petrographic analysis of the thin sections. Seven microfacies were identified and indicate a sedimentation regime dominated by mud-rich microturbidite flows. Compared to the Ediacaran, microbial mats are markedly sparse in the Cambrian suggesting a transition from matground to mixground ecologies. The palaeontology is broadly split into decayed cyanobacterial filaments and sheaths as well as large sphaeromorphic acritarchs and algae. The Kotlin Formation is interpreted as a shallow marine, inner to mid-shelf environment; a maximum depth of 200m is suggested due to dominant cyanobacterial growth on the substrate. Our results support the theory of the Agronomic Revolution and display a rapid transition from a microbially dominated substrate of low diversity to a ventilated substrate with penetrative movement consistent with derived metazoans.

A student-staff-museum collaboration to restore, image and display the skeleton of a Lower Cretaceous ornithopod dinosaur (Tenontosaurus tilletti LL.1227)

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Originally unearthed from the Lower Cretaceous Cloverly Formation of Montana, the Tenontosaurus tilletti specimen LL.1227 was the centrepiece of the Manchester Museum fossil gallery from 1999 to 2004. The skeleton is estimated to be approximately 70% complete, with the most notable missing elements being the hemal arches of the tail and the outer cranial frame (both of which were restored by the original preperators). LL.1227 was a popular addition to the gallery, but the original mount contained multiple anatomical inaccuracies – most notably the tripodal tail-dragging stance and the strongly pronated forelimbs. Several incomplete elements (particularly the forelimbs) were artificially extended apparently without reference to the well-documented literature on the species. Many of these elements remain glued to the now-dismantled material currently in the University of Manchester's storage. As Tenontosaurus tilletti is an extensively known species, there is little novel research that can be carried out on the LL.1227 specimen. However, the skeleton has provided a unique opportunity for student-staff-museum collaboration and community outreach. We present our progress on fully documenting, restoring and remounting the LL.1227 specimen, which is eventually planned to be re-displayed to modern standards in a renovated section of the Manchester Museum. A particular highlight of this student-led project is the high specification 3D imaging of the specimen using photogrammetry via Agisoft Photoscan. This will allow us to create a 3D print of the skeleton for mounting within the University, and provide a high quality open-source model for research purposes.

Investigating the evolution of symmetry in Cambrian echinoderms

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Echinoderms are a successful group of marine invertebrates, with a rich fossil record that dates back to the Cambrian. Extant forms are characterized by a body plan that is radically different from that of other deuterostomes such as hemichordates and chordates, and which is unique among bilaterians

in exhibiting pentaradial (five-fold) symmetry. The reasons why pentaradial symmetry evolved in echinoderms but not in other phyla are unclear. However, the fossil record includes a range of forms with different types of symmetry (bilateral, asymmetrical, triradial and pentaradial), and hence study of these extinct taxa could shed light on the evolution of symmetry in echinoderms more broadly. To uncover the significance of symmetry in early echinoderms, Cambrian fossil forms exhibiting different types of symmetry were digitally reconstructed as three-dimensional models in the computer graphics software Rhinoceros. This included models of the only echinoderms with triradial symmetry (helicoplacoids) and the earliest echinoderms with pentaradial symmetry (helicocystoids). Computational fluid dynamics was then used to quantitatively evaluate patterns of water flow around these virtual echinoderms, with analyses conducted in the simulation software COMSOL Multiphysics. The results demonstrate that a large region of recirculating flow formed downstream of models of both triradial and pentaradial echinoderms. However, recirculating flow was directed towards different parts of the model depending on the morphology and symmetry of the fossil. This suggests that symmetry was important for governing fluid flow in early echinoderms, with implications for the evolutionary significance of symmetry across the phylum.

Extant facultative bipeds: are they a 'model' for understanding the evolution of diapsid bipedality?

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The transition from quadrupedal to bipedal styles of locomotion imposes very contrasting anatomical and biomechanical demands on the body; bipedal and quadrupedal animals can be observed to have very different shapes in both the fossil and living records. Between the end-states of obligate quadrupedality and bipedality there are a variety of species that are capable of employing both two-legged and four-legged styles of locomotion: the facultative bipeds. The facultatively bipedal condition is observed in extant diapsid (lepidosaur) species such as Basiliscus, Chlamydosaurus and Crotaphytus and, exceptionally, among mammals such as pangolins.Dimensions of the axial and appendicular skeleton were measured in 14 species of extant lepidosaur that exhibit one of the two primary locomotor modes. A variety of osteological as well as whole body (including soft tissue) specimens were examined using microCT imaging. Using linear discriminant analysis and standardised major axis regressions in the R packages MASS and smatr, the anatomy and morphospace related to each locomotor mode has been partially constrained. Based purely upon a literature survey, a maximum likelihood-based 'ancestral state' reconstruction of archosauromorph (diapsid) bipedal capability was performed using a phylogenetic tree derived from that developed by Turner & Nesbitt (2013). The systematic approaches, and in particular the diagnosis of character-states in the literature are variable, inconsistent and often exhibit little or no quantitative assessment. Using the anatomical/quantitative constraints that I have identified in extant taxa, facultative bipedality in well-preserved extinct taxa can be accurately estimated, and traced, in the fossil record.

Comparative geochemical analysis of fossil feathers from Jehol.

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Dramatic discoveries of early birds and feathered dinosaurs from the Early Cretaceous Jehol biota of NE China have led to major revisions of our understanding of the palaeobiology of Mesozoic organisms. Fossil melanosomes, preserved either as external moulds or three-dimensional microbodies, have been used to interpret coloration in diverse feathered taxa, but often without a

broad analysis of the geochemistry of the preserved tissues and associated sediment. Here we report the geochemistry of feathers and sediment sampled from diverse fossils from Jehol: Sinornithosaurus, Confuciusornis and an unidentified isolated wing, and compare this to the fidelity of morphological preservation of feather structures. Samples were analysed using Scanning Electron Microscopy (SEM), Fourier-transform infrared- (FTIR) and RAMAN spectroscopy, and Synchrotron Rapid Scanning-X-Ray Fluorescence (XRF) for analysis of concentrations of Fe, Zn, Cu, Mn, Ni, Ti, Ca, K, Cl, S and P. Linear Discriminant Analysis and ANOVA reveal consistent differences in composition among the fossil feathers, and between each feather and its host sediment. Variations in the concentration of differences in trace metal chemistry are associated with differences in the fidelity of morphological preservation, suggesting intimate links between the morphological and chemical degradation of the fossil feathers. These data plus the FTIR and Raman data on feather chemistry are critical to informing on the taphonomy of the Jehol fossils and to building a more accurate picture of how feathers and their constituent melanosomes and keratin alter during fossilization.

The Deep Evolution of Ecdysozoa

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Ecdysozoa is a super-clade comprising eight phyla of protostome animals, including arthropods and nematodes - the most diverse and most abundant of all animal phyla respectively. Modern phylogenetic analyses support Ecdysozoa as a monophyletic group, but internal relationships remain unresolved, with conflict both within and between morphological and molecular hypotheses. Of particular concern is the monophyly of the vermiform subclade Cycloneuralia, which remains in common use despite generally lacking molecular support. Furthermore, previous studies utilizing molecular clocks suggest ecdysozoans diverged in the Precambrian, but ecdysozoan fossils are not identifiable until strata of Cambrian age. This lack of clarity in early ecdysozoan evolution cascades onto adjacent branches of the Tree of Life and presents a considerable constraint on interpreting the origins of animal biodiversity and the nature/existence of the Cambrian evolutionary "Explosion". By combining molecular and palaeobiological techniques to estimate phylogenetic divergence times with cladistic interpretations of exceptionally preserved Cambrian fossils, we seek to elucidate the evolution of Ecdysozoa during a critical phase in the establishment of the Phanerozoic animal-dominated biosphere. Our preliminary results from Bayesian analyses of phylogeny and divergence times, circumscribing all 8 ecdysozoan phyla, support a sister group relationship between nematoids and panarthropods (rendering Cycloneuralia paraphyletic), and an Ediacaran origin of Ecdysozoa.

Lower Jurassic marine reptiles: A review of the collections at the Yorkshire Museum and Gardens

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The North Yorkshire coastline is known worldwide for its famous Lower Jurassic Lias Group outcrops which have periodically yielded abundances of fossil marine reptiles including ichthyosaurs, plesiosaurs and crocodylomorphs. These have made Yorkshire one of several important Lower Jurassic localities in Europe which laid down the understandings of early vertebrate palaeontology. The collection of Lower Jurassic marine reptiles from the Lias Group of Yorkshire at the Yorkshire Museum and Gardens has not been studied in detail for some time; the only exception being the

holotype of Rhomaleosaurus zetlandicus which has received abundant contemporary research. Therefore, a review of the material has been long overdue. A total of sixty-one Lower Jurassic marine reptile specimens, including the holotypes of the large ichthyosaur Temnodontosaurus crassimanus, and plesiosaurs Microcleidus homalospondylus and Rhomaleosaurus zetlandicus, as well as isolated elements and partial skeletons, have been catalogued, measured, and taxonomic suggestions have been given where appropriate. Although the complete collection at YORYM has not been accounted for, the research highlighted the need for a revised account of many museum collections, as well as the improvement of storage and cataloguing at YORYM. Furthermore, it also provided a specimen-level assessment of the current condition of each specimen, including damage and preservation.

Experimental decay of volvocalean algae and the affinities of Precambrian 'animal embryos'

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The emergence of animals is one of the most important events in the history of life, yet its timing remains mysterious. The fossil record shows confirmed specimens of metazoans in the Cambrian, starting 541 Ma, while older reports of animals have been contentious. On the other hand, molecular clocks estimate an origin during the Cryogenian with a diversification in the Ediacaran. The Weng'an biota contains fossils that potentially include animal embryos, which could represent the oldest animals in the fossil record. Located in South China, the Weng'an biota dates back to 609 Ma and presents spheroidal specimens. These microfossils, known as Megasphaera (among other names), are a few hundred microns in diameter and various hypotheses have been proposed for their affinities. The animal embryo interpretation is the one that is currently preferred, however another interpretation keeps resurfacing. This project aims to test the hypothesis that these fossils are green algae. However, comparisons cannot be made directly between the fossils and living algae because the specimens have undergone decay before fossilisation. As knowledge of algal decay is limited, taphonomy experiments are required to understand more about the decay of green algae in order to to assess this interpretation of the Weng'an fossils. We present preliminary results of decay experiments on the volvocalean alga Pandorina, considered as very similar to the specimens, and assess the implications for the competing interpretations of the fossils.

The origin of planktic foraminifera – novel methods for an old question

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Despite their wide use in paleoclimatic and ecological reconstructions, the origin of the planktic foraminifers is uncertain. Planktic foraminifera emerged during the Marine Plankton Revolution though the details of this transition from benthic foraminifers is still unclear. Lineages can be differentiated by their morphological characteristics, and previous phylogenetic work has shown that not all modern planktic foraminifers have the same ancestral benthic link. It is assumed that in the middle and late Jurassic predominantly small species of the genus Globuligerina produced large populations. These simple globular forms almost died out at the Jurassic-Cretaceous transition quickly diversifying during the Cretaceous. Previous studies on early planktic foraminifera have been conducted on thin-section and cast specimens, hindering our ability to study their development and

compare to modern counterparts. Utilisation of a Zeiss XRadia µCT-scanner provides high quality images of submicron resolution to create 3D reconstructions. We analyse the developmental history of specimens from the mid Jurassic to the Cretaceous, determining the number and shape of chambers, proloculus size, and growth trajectories to establish differences and similarities of the growth of more basal planktic foraminifera and modern forms. We compare our scan data with growth trajectories of species from the Danian, Upper Eocene, Lower Oligocene, Miocene, and several extant species. It is expected that the Mesozoic specimens will show similar growth trajectories, but ending earlier, with strong morphological constraints on each species.

Three dimensional soft tissue preservation of acritarch-like cysts from the Ediacaran Weng'an Biota

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While undisputed fossil evidence of animals is not known before the Cambrian, molecular clocks estimate animal evolutionary history to extend deep into the Neoproterozoic. The 609 Ma Weng'an Biota of South China provides one of the few Lagerstätten with which to test such estimates and has famously yielded microfossils that have been interpreted controversially as the embryos of animals. The biota is more diverse, however, and not all of its components have been described. Here we introduce a new class of embryo-like fossil characterized by a marginal excystment structure resembling acritarch cysts. The excystment structure varies in its extent, approaching half the circumference at its greatest extent. The majority of the internal volume is comprised of a granular matrix with a variable chemistry reflected in differences in X-ray attenuation. The matrix is permeated by micrometer scale unconnected pores. Many specimens preserve a central inner body, exhibiting a low X-ray attenuation, some with an inner core with a homogeneous high attenuation mineralogy. These central structures are reminiscent of the structures interpreted as nuclei preserved in the embryo-like Tianzhushania from the same samples. We consider the affinity of this new class of Weng'an fossil within protist, algal and animal milieu.

Genome duplication and the evolution of arthropod phenotypic complexity

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Whole genome duplications are biological phenomena that occur throughout fauna and flora. These occurrences are very well documented in vertebrate lineages and were considered to be a strong macroevolutionary driver, whereas invertebrates were suggested to be driven by small scale changes in genomic interactions. Recent findings demonstrate a chelicerate whole genome duplication, but there appears to be a lag-time of up to 50 Myr prior to an expansion of diversity. Therefore, whole genome duplication (WGD) events may not drive macroevolution. However, the event remains poorly constrained. To solve this, chelicerate transcriptome data will be converted into orthologues to produce gene trees. By comparing these trees, the changes in gene family duplications will be demonstrated and therefore the event will be accurately constrained to a particular lineage and then would be dated to a high degree of precision. Using this information, as well as morphological data from extinct and extant chelicerates, a disparity matrix will be created to determine how disparity responds to a whole genome duplication. This would then be used in further study to compare with well-known vertebrate whole genome duplications to disentangle the complicated relationship present between whole genome duplications and disparity.

The evolution of vertebrate terrestrial feeding: insights from salamanders!

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Salamanders can provide an extant analogue to study the feeding kinematics of early tetrapods across the water-land transition. During their aquatic larval stages many salamanders use suction feeding for prey capture; but after metamorphosing into terrestrial adults, they must rely on biting for prey capture. This requires changes in skull morphology, musculature and mechanics. Though past studies have characterised the kinematic behaviour of some species, this study provides a comprehensive analysis of the cranial musculoskeletal system, and a comparison between aquatic and terrestrial species. This study focuses on the aquatic common mudpuppy (Necturus maculosus) and the terrestrial fire salamander (Salamander salamandra). These specimens were scanned using Computer Tomography to identify the bones, and Contrast-enhanced CT to differentiate muscles. Digital dissections were conducted in Avizo, and supported and confirmed through physical dissection. This provided a comparison of skull morphology, suture form and jaw musculature of the two species. Using Finite Element Analysis, we have analysed the stress and strain distributions across both skulls during feeding. In addition, the skulls' resistance to bending and torsional forces have been calculated. These data provide a detailed analysis of the morphology, function and mechanics of both species, and an analogue for the morphological and mechanical changes in feeding among early tetrapods.

2D extruded Finite Element Analysis: a new biomechanical approach to the study of Mesozoic mammals

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Little is known regarding the ecology of Mesozoic mammals due to their relatively poor representation in the fossil record; in fact, they were long considered generalised insectivores that did not diversify ecologically until after the demise of non-avian dinosaurs. Over the past two decades, the discovery of exceptionally preserved fossils and the advent of cutting-edge biomechanical techniques, such as Finite Element Analysis (FEA), have completely changed our understanding of the dietary performance and behaviour of our earliest ancestors. FEA is an engineering technique used in vertebrate palaeontology to assess the functional performance of the skull and/or jaw at the moment of biting; this technique traditionally uses 3D digital models built from computed-tomography (CT) scan data. However, CT scan data are often expensive and sometimes inaccessible. We have developed an inexpensive and easy-to-build alternative to traditional 3D FE models built from CT scan data, which we call 2D extruded FEA. This method uses digital models built from 2D outlines of relatively flat jaws which are then extruded medially to an average width. We have validated this technique using the jaws of stem mammals Morganucodon and Kuehneotherium, and found that, in comparison to 3D FE models, 2D extruded FE models reliably reproduce stress and strain patterns. The use of 2D extruded FE models constitutes a reliable alternative to costly 3D FE models built from CT scan data and opens up the possibility of efficiently performing macroevolutionary studies of jaw function among early mammals.

The patterns and trends of homoplasy in morphological datasets

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When analysing the phylogenetic relationships between species, homoplasy, i.e. similarity not due to shared ancestry, is often observed in some characters within the dataset. However, the amount of homoplasy present varies within and between different datasets. The aim of this research was to update our understanding of the patterns and trends of homoplasy in morphological datasets using the vast abundance of datasets and increased computing power available today. To do this, 2583 morphological datasets and their corresponding first maximum parsimony tree were obtained online. Overall and per character Consistency Index (CI) and Retention Index (RI) were then calculated for each dataset as a measurement of homoplasy. Statistical analyses were conducted to assess the relationship between homoplasy and several explanatory variables such as number of taxa, number of characters, year of publication, etc. Results show a significant relationship between the number characters in a dataset and the overall CI and RI values, and a significant relationship between the number of taxa in a dataset and overall CI, but not with overall RI. As both the number of characters and the number taxa increase, the amount of homoplasy also increases. This indicates that larger datasets contain more homoplasy, which is consistent with findings from previous studies. The information obtained from this study can be used to update our understanding of how homoplasy is distributed in datasets. Information from this study will also be useful when simulating datasets to ensure the simulated data represents biological data as accurately as possible.

The early Miocene Maltese crocodile Melitosaurus champsoides, and a re-examination of the phylogenetic relationships of Tomistominae

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Tomistomines are a clade of longirostrine, piscivorous crocodiles represented today by a single species (Tomistoma schlegelii). Likely originating in the early Eocene (~55 Ma), they have a globally extensive fossil record; however, the current taxonomic placement of Tomistominae within Crocodylia varies depending on the use of morphological versus molecular datasets. As such, revisions of taxa and phylogenetic relationships are required to ultimately reconcile such discrepancies. Melitosaurus champsoides, from the early Miocene of Malta, is re-described based on the anterior section of a snout, and is found to be potentially synonymous with three spatio-contemporaneous taxa (Tomistoma calaritanum, Tomistoma lyciensis, and Tomistoma gaudense), all of which are based on fragmentary cranial material. An in depth revision of an existing data matrix is conducted, and several additional species are incorporated into a phylogenetic analysis, resulting in a matrix comprising 68 taxa scored for 243 characters. The possession of a longirostrine snout, and elongate premaxillary processes which extend beyond the 3rd maxillary tooth, confirm a position of Melitosaurus champsoides within Tomistominae. A posteromedial orientation of the posterior three premaxillary teeth, the presence of thin postorbital bars, and a narrow interfenestral bar, suggest a close relationship with the derived tomistomines Tomistoma lusitanica, Gavialosuchus eggenburgensis, and the extant species. This continued work aims to elucidate the phylogenetic relationships within the group, and provide a more comprehensive understanding of early tomistomine evolution.

The not so boring billion: Problematic Mesoproterozoic microfossils from the Torridonian Supergroup, North-West Scotland.

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Precambrian evolution is relatively well-studied; however, in-depth knowledge of the ecology and anatomies of Pre-Ediacaran organisms is rare and frequently represented only by marine taxa. Recent works on the Mesoproterozoic Torridonian supergroup have begun to reveal the complexity of Mesoproterozoic terrestrial ecosystems, yet these enigmatic eukaroytic organisms remain poorly understood, and despite advances in the understanding of Precambrian terrestriality, the evolutionary implications of a complex terrestrial Precambrian biota are frequently ignored. Here, we identify and analyse microfossils from the Torridonian supergroup using both light and scanning electron microscopy to better understand the extent of terrestrial eukaryotic complexity during the Mesoproterozoic. The specimens presented here exhibit multicellular organisation, cellular differentiation, and complex extracellular structures, reinforcing the theory that the acquisition of key eukaryotic characteristics occurred terrestrially during the hostile oceanic conditions of the Boring billion (ca. 1.8-0.8Ma).

Dating tips for palaeobiologists

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Establishing an evolutionary timescale of the Tree of Life is only possible by means of the molecular clock and fossil calibrations, which are not easy to define. Tip-calibration offers a new approach in which fossils are included among living relatives in a molecular and morphological analysis using evolutionary models. It also enables the co-estimation of time and topology in the tree. However, it presents many issues that still make it a technique less reliable than node-calibration. Among them, the lack of an appropriate morphological evolution model, extreme sensibility to the prior of times, conservation biases in the fossil record, and a failure to integrate the uncertainty of fossil ages. I addressed this last difficulty associated with the uncertainty of fossil ages, investigating different ways to calibrate tip-calibration analyses including the uncertainty associated with each calibration, trying to find the best way to include this uncertainty. In order to do this, I simulated morphological matrices, fossil occurrences and sequence data in fixed intermediated balanced tree topologies, analysing the effects on precision and accuracy in divergence time analysis when applying different approaches to determine the minimum and maximum fossils constraint ages.

A Phylogenetic Super-Matrix of the Armoured Dinosaurs (Ornithischia, Thyreophora)

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Thyreophora, the armoured dinosaurs, have been known since the early 1800s and include some of the most recognisable dinosaurs such as Stegosaurus and Ankylosaurus. The individual lineages, Ankylosauria and Stegosauria, have been studied thoroughly but there has never before been a thorough whole-group cladistic analysis of Thyreophora. This has hindered efforts to understand the macroevolution of the group, and, in particular, has obscured character-state transformations at the base of Eurypoda (Stegosauria + Ankylosauria), making the identification of basal taxa and clades

problematic, and the degree of convergence difficult to assess. Here, the first species-level phylogenetic super-matrix of the whole-group Thyreophora is presented, incorporating all previous known cladistic analyses of both ankylosaurs, stegosaurs and basal thyreophorans and utilising multiple optimality criteria. The effects of continuous versus discrete character data, as well as different character coding techniques, are investigated, and partitioned datasets are analysed to compare phylogenetic signal in various body parts. This phylogeny will become the framework for macroevolutionary studies of Thyreophora, including the investigation of the diversity and disparity over time, as well as the study of the biogeographic evolution of the group.

Skull mechanics and functional morphology of Brasliodontidae, the sister clade to mammaliaforms

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The Late Triassic vertebrate assemblages of the Santa Maria Supersequence in Brazil have yielded many specimens of cynodont therapsids including members of the clade Brasilodontidae. Recent phylogenetic analyses have placed this clade as the sister clade to Mammmaliaformes. While the cranial anatomy of brasilodontids has been described in some detail, we understand little of the skull mechanics of their members, and how this contributes to the functional evolution of mammals. Here, the skulls of three putative species referred to brasilodontids *Brasilodon quadrangularis*, *Brasilitherium riograndensis*, and *Minicynodon maieri* are studied in order to (i) compare their functional morphology and biomechanics; and (ii) to determine similarities and differences to the Early Jurassic mammaliaforms Morganucodon watsoni and Kuehneotherium praecursoris and (iii) to infer any additional information on the proposed ontogenetic relationship of each taxon, which were inferred as representing a single taxonomic unit. At this stage, we compare the results of second moment of area and finite element analysis of the mandibles of *Brasilodon* and *Minicynodon* to each other and those of *Morganucodon* and *Kuehneotherium* from a previous study.

The Silurian Graptolites of the Co To Islands, Northeast Vietnam

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The lower Palaeozoic graptolite-bearing strata of Vietnam have been noted since the time of the French colonial era, yet most of the assemblages are yet to be illustrated. More recently, Vietnamese and Japanese geologists have examined the Vietnamese lower Palaeozoic succession in detail, including the Co To Formation that crops out over 40 islands and islets of the Co To Archipelago in NE Vietnam. The Co To Formation is more than 1000 m thick and regionally has been considered to be of Late Ordovician and Silurian age, though only strata of Silurian age have been recognised in our study. Newly collected graptolites such as Spirograptus turriculatus, Torquigraptus proteus, Monograptus priodon, Oktavites spiralis, Oktavites excentricus and Monoclimacis subgeinitzi identify strata that are lower Silurian (Llandovery Series) and further constrain the biostratigraphical age of part of the formation to the Torquigraptus proteus Subzone of the Spirograptus turriculatus Biozone, and the Oktavites spiralis Biozone, both of the Telychian Stage. The material likely includes at least one new graptolite species.

Constraints and adaptations in Crocodilian skull form and function

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Extant and fossil crocodilians are one of the most diverse and successful groups of diapsids, acting as important models in biomechanics by serving as analogues to other fossil groups with similar morphologies. Fossil crocodilians exhibited high morphological disparity, which is generally more pronounced in the cranium. The relationship between form and function has been of great interest in palaeontological studies and certain complexities may arise in functional analyses when the two cannot be linked directly, leading to the formation of many-to-one relationships. The classic hypothesis is that crocodilian skull shape is responsive to selective forces for feeding; yet extant crocodilians possess broad and flat snouts (platyrostral), thought to be sub-optimal for feeding due to the conflicting demands of predation versus drag reduction. In contrast, various Mesozoic crocodilians possessed dome shaped (oreinirostral) skulls and were terrestrial, therefore freed from hydrodynamic constraint. We aim to determine the role of constraint in determining crocodilian skull form and test the hypothesis that feeding mechanics differ between semiaquatic extant and terrestrial extinct crocodilians due to the lack of hydrodynamic constraint in terrestrial taxa. Here we present initial results of our beam analysis and finite element analysis (FEA) for analyzing stress and strain patterns, mechanical advantage, bite force and resistance to bending and torsion. We present results for the Mesozoic taxa Baurusuchus salgadoensis, Montealtosuchus arrudacamposi and Caipirasuchus paulistanus, which have highly oreinirostral skulls. These are compared to the extant Paleosuchus palpebrosus, Gavialis gangeticus, Alligator mississippiensis and Crocodylus niloticus, which have platyrostral skulls.

Phylogenetic relation of Sclerorhynchids

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The sclerorhynchids are a very peculiar group of Cretaceous batoids, they are one of the four groups of neoselachians that develop an elongated rostral blade and present several synapomorphies that place them within Batoidea, but further from that their phylogenetic relations remain uncertain. There is only one cladistic study that explores the phylogenetic relationships of sclerorhynchids Kriwet (2004). This analysis included several errors in matters of character definitions and coding which contributed to the proposal of Pristiorajea and the placement of sclerorhynchids within it. The present study carries a phylogenetic analysis using parsimony and Bayesian methods trying to solve the phylogenetical relations of this group with other Batoids.

The pes of the extinct ‘giant wallaby’: something strange afoot

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Macropodoidea (kangaroos and rat kangaroos) were once far more diverse than today, with over 60 extinct species. Species of the genus Protemnodon represent an extinct group from the Plio-Pleistocene, commonly referred to as the ‘giant wallabies’ due to their wallaby-like dentition (bilophodont but not highly hypsodont) and large size. Despite their dental similarity to wallabies, the post-cranial skeleton of Protemnodon spp. is in many ways unique, a fact that has gone largely unnoticed and undescribed in the literature. For example, Protemnodon spp. have proportionally

shorter tibiae and metatarsals and longer necks than most other kangaroos, anatomical features that have been cited as an indication that they may have evolved to become secondarily quadrupedal rather than employing the bipedal hopping commonly associated with macropods. We highlight a previously unnoticed feature of the pes of Protemnodon spp.: in natural articulation, the phalanges do not lie flat on the substrate as in other kangaroos, but rather form a 'hook' with the apex between the 2nd (middle) and 3rd (distal) phalanges. We propose that this further supports the hypothesis of quadrupedal locomotion as it would have made propulsion from the toes for bipedal hopping problematic. This observation emphasises the importance of studying the postcrania in inferring the ecologies of Macropodoidea.

Benthic foraminiferal response to the Early Eocene Climatic Optimum

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To understand possible biotic responses to climate change, efforts to date have focussed on laboratory studies. These studies are temporally limited, and as such cannot inform about the potential for long term adaptation to climate change. Studying biotic responses to climate change in the fossil record can reveal which aspects of climate change cause the most stress, and how biotic systems respond to this. This study will use benthic foraminifer species Oridorsalis umbonatus and Nuttalides truempyi over the Early Eocene Climatic Optimum (EECO; 49-54 Ma). This time interval is key to understanding how organisms respond to changes in their environment as it shows both elevated long-term temperature trends and rapid perturbations associated with "hyperthermal" events. Specimens over the time interval were imaged via Computer Tomography and reconstructed in the 3D imaging software AVIZO. The size, number of chambers, and size of the proloculus (first chamber) are contrasted. As the two species represent epifaunal and infaunal life states, their differing responses will be compared to test the impacts of factors such as nutrient availability and temperature change over the interval. We hypothesize a stress response to high temperatures expressed by a reduction in growth at the height of the event, that decreases in magnitude in more mild periods. The morphological response to the EECO sheds light on changes in morphology and reproductive strategy under stress, and reveal in which ways the organism adapts to energy and food limitations similar to those which modern climate change is likely to cause.

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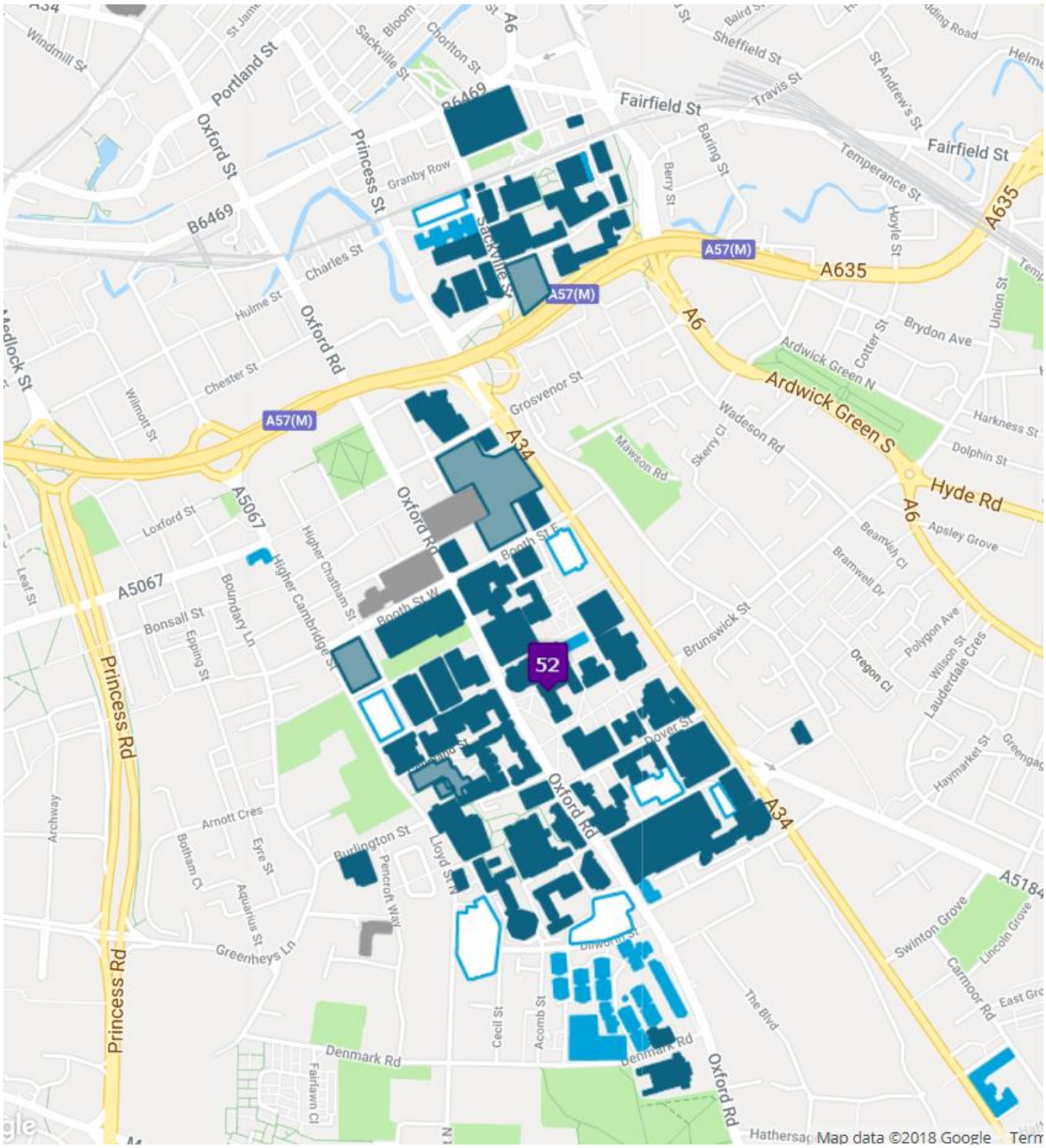
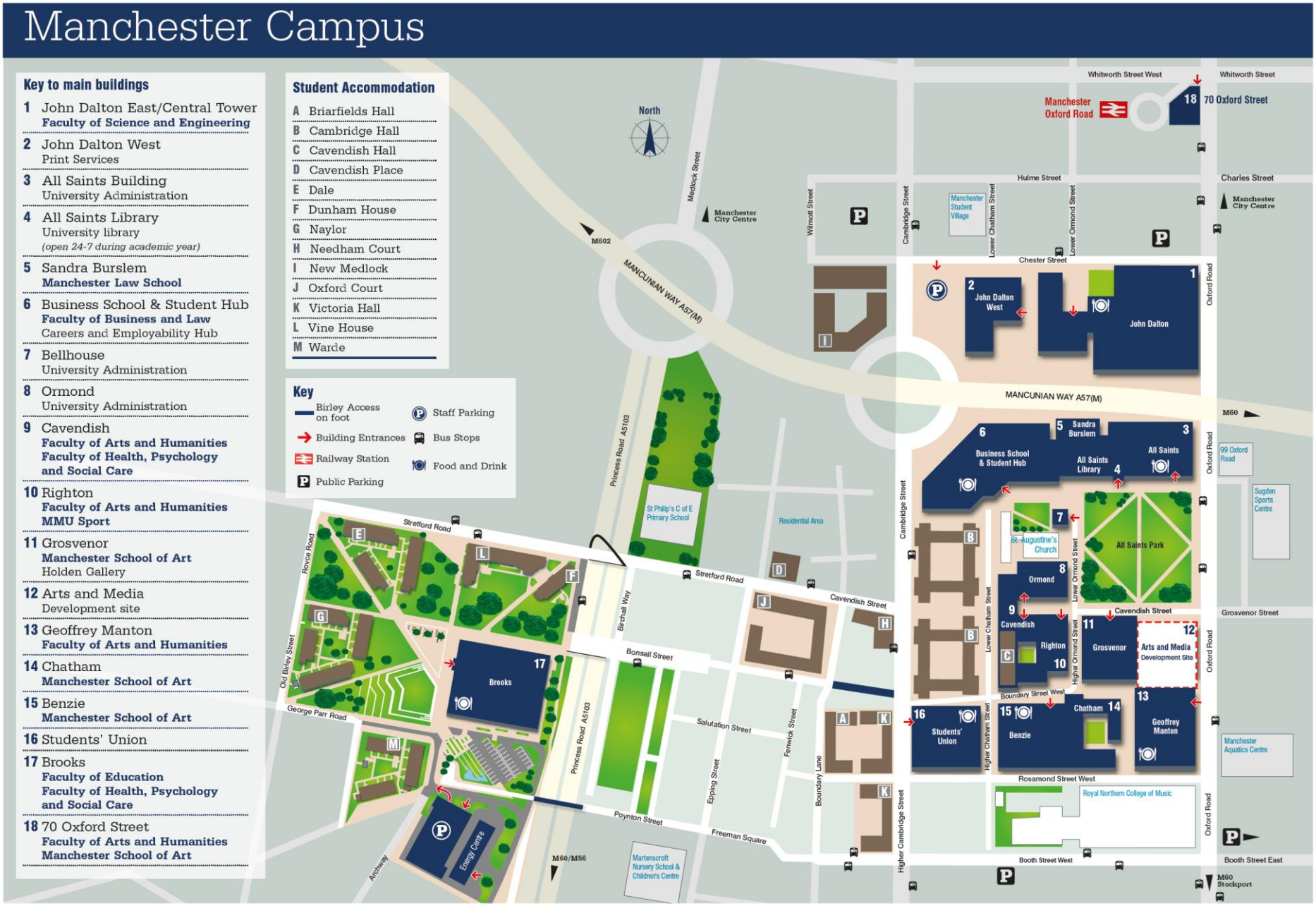
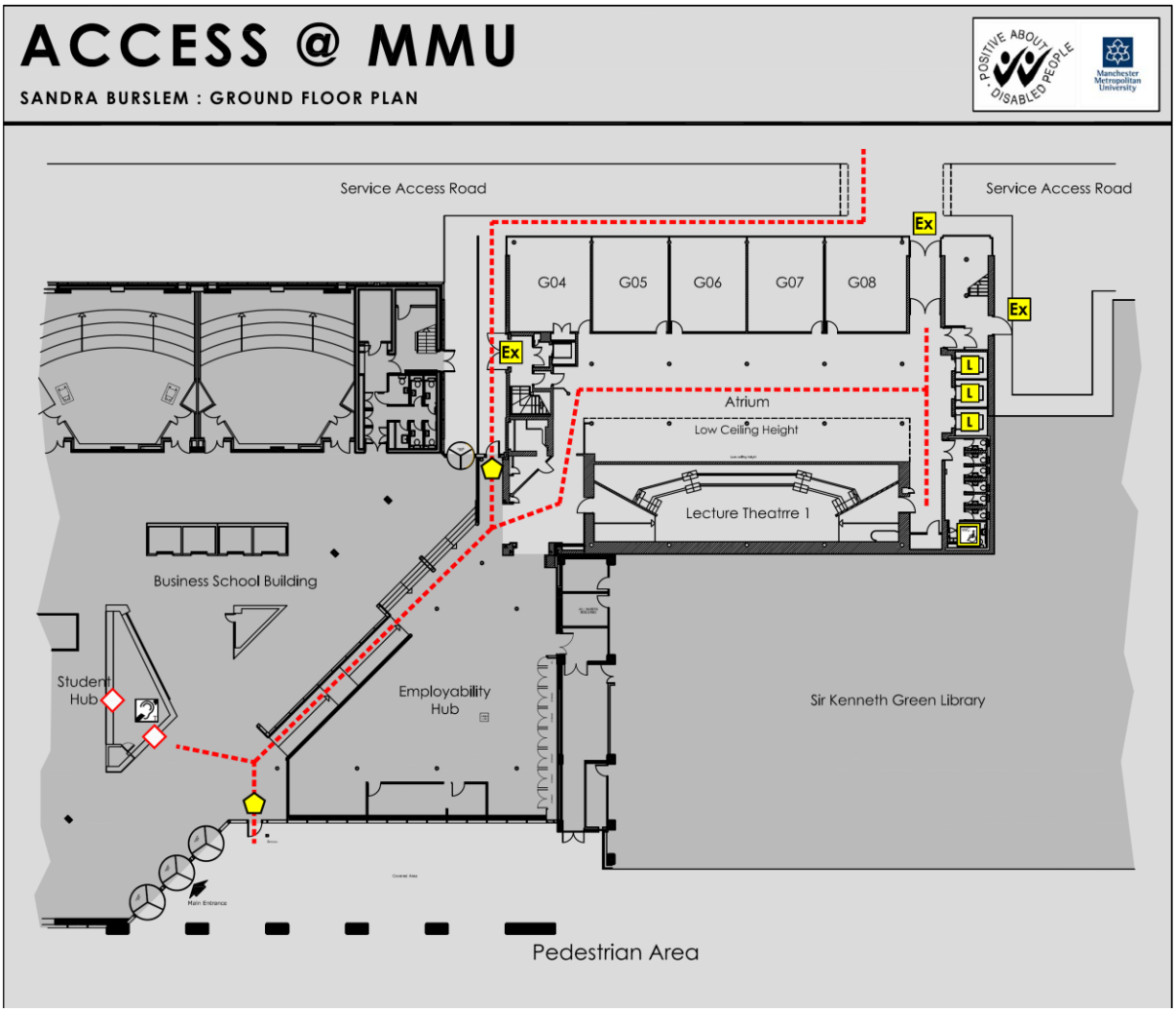
MAPS



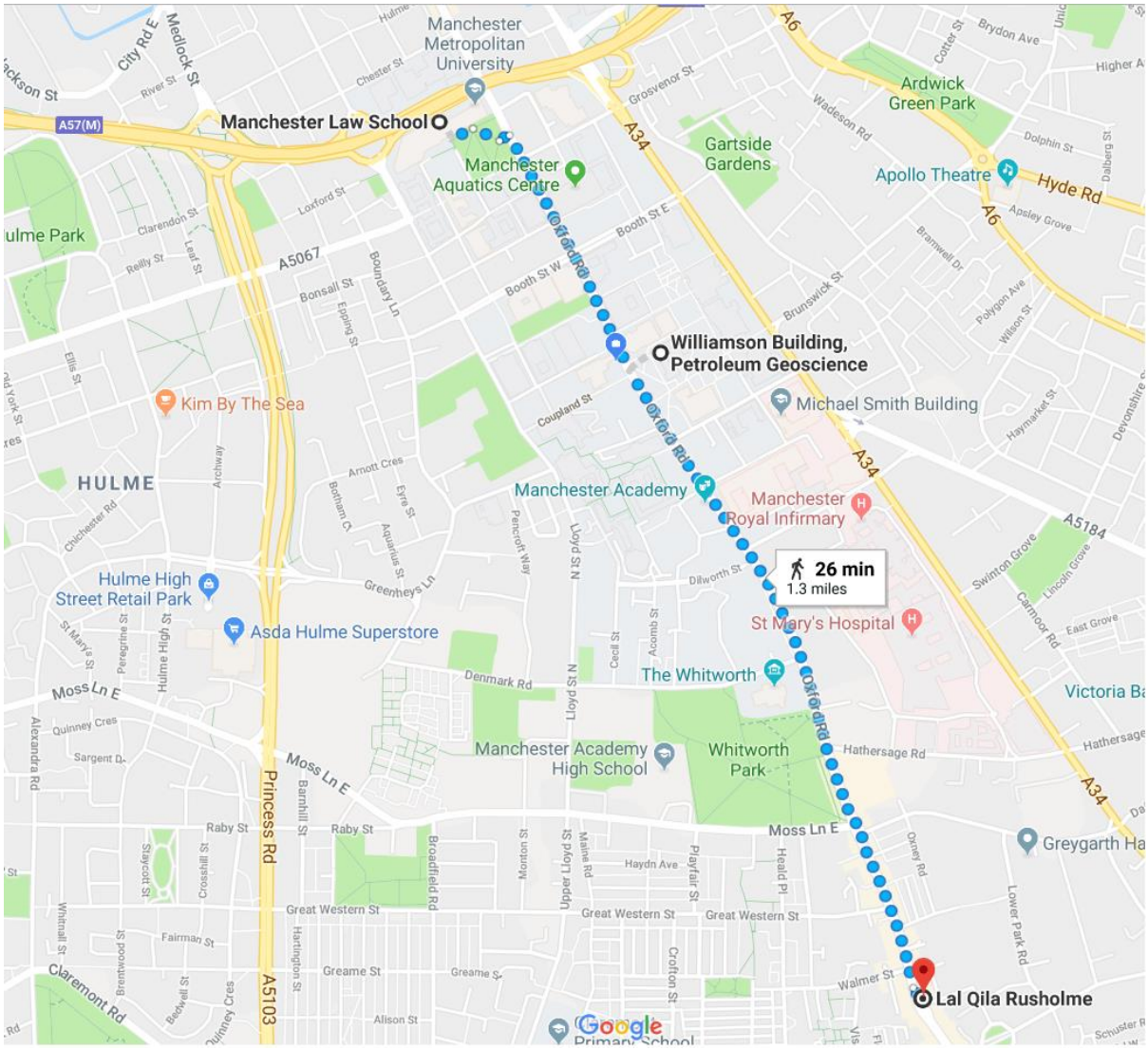
1 Map of the UoM campus. The Williamson Building is marked with the 52.



2 Map of MMU Campus. The Sandra Burslem building (5) can be accessed through the Business School & Student Hub (6)



3 Floor plan of the Sandra Burslem Building. Talks will take place in Lecture Theatre 1.



4 Map showing route for the annual dinner, down Oxford Road from the Manchester Law School (Sandra Burslem Building) past the Williamson Building, to Lal Qila