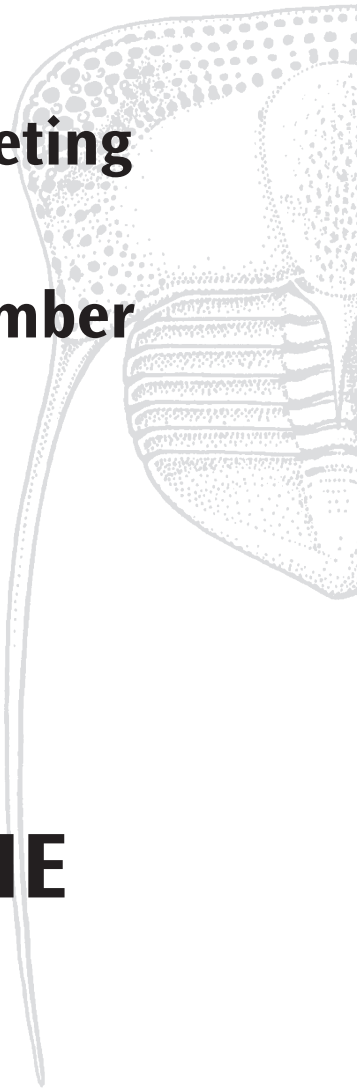
The Palaeontological Association

69th Annual Meeting

11th–15th December 2025

Portsmouth, UK



PROGRAMME ABSTRACTS

#PalAss25

The Palaeontological Association
69th Annual Meeting
11 – 15 December 2025
Portsmouth, UK

Welcome to Portsmouth!
We are delighted to welcome you to Portsmouth for the 69th Annual Meeting of the Palaeontological Association. This year's Meeting will be full of fantastic science and opportunities to connect with old and new friends, including cutting edge research in the Symposium on Experimental Palaeontology, several days of interesting research talks and posters, an exciting field-trip to the Isle of Wight, and an Annual Dinner on a ship!

The Annual Meeting of the Palaeontological Association last visited Portsmouth in 1998. The University of Portsmouth runs the largest undergraduate palaeontology course in the UK, with over 150 students across the three years of study – many of whom you will see volunteering to help with running the conference. We are especially proud of the diversity of our student body and that everyone feels welcome in Portsmouth.

This booklet provides useful and important information for the conference and associated events. If you have any queries at any time, please do not hesitate to reach out to us via e-mail to <**annualmeeting2025@palass.org**> or speak with a friendly member of the local organizing team.

Visiting Portsmouth
Situated on the south coast of the UK, Portsmouth is a compact waterfront city, with good transport links, several hotels and areas for eating and drinking within walking distance of the conference venues. There are numerous areas close to the university campus that have cafés, restaurants, pubs and bars. Gunwharf Quays has many chain restaurants and bars, whilst Guildhall Walk has several pubs that serve food. Further afield is Southsea, with the Palmerston Road and Albert Road areas. All the conference venues, main hotels and travel hubs are within an approximately 20-minute walk of each other.

Portsmouth has traditionally been known as a naval city and, as well as being the home of the modern British Navy, it is also home to the historic *Mary Rose*, *HMS Victory* and *HMS Warrior*. In more recent years, Portsmouth has welcomed a vibrant student population, it has been voted as one of the top cities to live in the UK, named as the street art capital of the UK, and is a place where every person can feel confident and safe to express themselves without prejudice. During the conference, we hope to showcase some of what Pompey (pronounced POM-pee not pom-PAY) has to offer, including local attractions and offerings from some of our breweries!

We have curated an interactive map (see page 9), featuring key conference sites and recommended food and drink venues.

Venues

Unless specified otherwise, all conference events will be held across Richmond Building and Portland Building in the northern quarter of the University of Portsmouth campus. The Annual Dinner will be on board *HMS Warrior* in Portsmouth's Historic Dockyard, and a one-day post-conference field-trip will visit the Isle of Wight.

Registration

Upon arrival, all delegates can register at the registration desk in Portland Building to receive their name badge and tickets for additional events (*e.g.* Icebreaker Reception and Annual Dinner). The registration desk will be open on Thursday 11th December (13:00 – 14:00), Friday 12th December (08:30 – 10:00 and 13:00 – 18:00) and Saturday 13th and Sunday 14th December (08:45 – 17:00).

Delegates who selected to attend the Icebreaker Reception will receive two drinks vouchers in their registration pack. Guests who booked the Annual Dinner must take their ticket with them for security at the entrance to the Historic Dockyard. Your ticket will also include your menu choices in order to help with a smooth-running dinner service.

Catering

Grab-bag sandwich lunches on Saturday 13th and Sunday 14th December are included in the registration fee and can be collected from the café in Portland Building during the lunch break. The different dietary needs specified at registration will be highlighted. Please ensure that you do not take food that is not intended for you. Tea, coffee and other refreshments will be provided during the breaks between sessions in the morning and afternoon and during the poster sessions after lunch. Self-serve stations will be set up in both Portland Building Atrium and Richmond Building Atrium.

Oral presentations

Oral presentations (talks) must be uploaded at least the day before the scheduled session. Uploading talks directly before sessions will not be possible. We highly recommend that this is done upon registration to avoid issues. Computers will be available to upload your talks on Friday 12th and Saturday 13th December. Talks should be submitted in a PowerPoint file format (*e.g.* .pptx) or as a PDF file (aspect ratio 16:9). The conference venue uses Windows 11 machines. Please ensure videos and custom fonts are embedded to avoid compatibility issues.

Standard talks will be allocated 15 minutes in total, and speakers should prepare their talks to allow for three minutes of questions and switching between speakers. Lightning talks will be allocated five minutes in total, and speakers should prepare their talks to allow for one minute of (brief) questions and switching between speakers. Lightning talks will be organized into sessions of 15 minutes (*i.e.* in groups of three). For the majority of the conference, we will have three parallel sessions occurring, so keeping to time will be especially important.

Poster presentations

Delegates with poster presentations will be encouraged to put up their posters before the Icebreaker in the late afternoon of Friday 12th December so that they can be viewed during this time. Alternatively, posters may be put up in the morning of Saturday 13th December. Instructions on where to put up posters will be available at the registration desk and volunteers will be available to assist. Posters will remain on display throughout the meeting, and dedicated poster sessions will take place after lunch on Saturday 13th and Sunday 14th December. Poster boards will accommodate an A0 poster presented in portrait format. Materials to affix your poster to the boards

will be available at the meeting. Please note that poster presentations that are eligible for the Council Poster Prize should have been submitted to the judging panel in advance of the conference as per e-mail correspondence.

Travel grants

Students who have been awarded a PalAss travel grant or INAF Fund should see the Executive Officer, Dr Jo Hellawell (e-mail <**executive@palass.org**>) in the exhibition area in Portland Building to receive their reimbursement.

Nursing facilities

Richmond Building has a dedicated room for breastfeeding on the 5th floor. For further details and to request access to the nursing facilities, please e-mail the meeting organizers at <**annualmeeting2025@palass.org**>.

Accessibility

The University of Portsmouth is committed to providing accessible learning environments for all students, staff and visitors. The lecture theatres and classrooms associated with the conference are accessible to individuals with mobility requirements. Portland Building PO 0.41 and PO 0.28 include space at the back which can accommodate wheelchair users. The Future Technologies Centre Floor 1 and Floor 2 are accessible via a lift. Portland Building PO 1.74 is accessible via a lift and offers space for wheelchair access. Richmond Building RB LT1 has two entrances; we recommend using the ground floor entrance for both entry and exit to ensure full accessibility. Richmond Building RB LT2 and RB LT3 are accessible at ground level. Portland Building PO 1.44 will be available as a quiet room on Saturday 13th and Sunday 14th December. Toilets are available on all floors and are accessible via lift or stairs if not located on the ground floor. Please note Portland Building does not have a designated men's toilet on the ground floor. However, a unisex accessible (disabled) toilet is available for use.

Annual Dinner

HMS Warrior was the first iron-hulled naval vessel; launched in 1860 as part of Queen Victoria's Navy, she acted as a strategic deterrent at the time. Guests for the Annual Dinner will dine at the mess tables (ten per table) amongst the cannons on the Main Gun Deck. A bar will serve from the galley in the middle of the Main Gun Deck. Entertainment will be provided with a quiz and sea-shanties.

Guests who selected to attend the Annual Dinner will receive their ticket in their registration pack. Guests must take their Annual Dinner ticket with them for security at the entrance to the Historic Dockyard. Your ticket will also include your menu choices in order to help with a smooth-running dinner service.

HMS Warrior. *Photo © National Museum of the Royal Navy.*

HMS Warrior is a historic ship and, whilst heaters will be provided, there is limited insulation from the December evening elements so guests are advised to bring warm layers. The Captain's Cabin will be available as a cloakroom. A separate quiet room will be available on one of the lower decks.

Portsmouth's Historic Dockyard have made every effort to make *HMS Warrior* accessible; however, there are limitations on the accessibility of the ship. Access on board is via one of two gangways to the Top Deck, the incline is controlled by the tide, which at high tide can be very steep (high tide on the 13th of December will be at 18:37 and low tide will be at 23:42). Access from the Top Deck is via ladder steps with a rope banister down to the Officer's Half Deck and Main Gun Deck. All steps on board the ship will be supervised by members of the Events Team.

There is a chair lift that can take guests with mobility requirements from the Upper Deck to the Main Gun Deck, where the main dining event will be held. To use the chair lift, the guest must be able to transfer themselves into and out of the chair independently. The weight limit for this is 100 kg (16 stones). There are two wheelchairs on board the ship that guests are more than welcome to use. Due to fire, health and safety regulations it is only possible to facilitate two wheelchair users on the ship at any one time.

Toilet facilities are down two flights of steps from the Main Gun Deck. There is an accessible toilet located in the Cable Deck, which is at the Bow of the Main Gun Deck. All other facilities are located two decks below the Main Gun Deck.

HMS Warrior is a historic vessel, so guests are asked to take extra care whilst on board. Please pay attention to any safety notices displayed around the ship, adhere to areas that have been cordoned off and take the lead from the Event Team staff in the unlikely event of an emergency.

HMS Warrior has trip hazards, low ceilings, limited lighting, steep ladders with rope banisters and can be slippery on a wet day. Guests are asked to be mindful of this when roaming the ship. Guests are not permitted to travel between decks or up and down ladders holding glassware or drinks, please leave any drinks on the level you are on before traversing the ladders. Smoking or vaping is not permitted anywhere on board *HMS Warrior*; this includes the Upper Deck. The dedicated smoking area is on the jetty.

Guests should be aware that they are dining on a historic vessel and there are restrictions to the footwear permitted on board. Stiletto or very narrow heeled shoes are discouraged from the ship due to the damage they can cause to the decks but also due to the uneven nature of the decks and ladders. Heels should be no narrower than a UK five-pence piece (18mm). If you do want to wear narrow heels then it is advised that you purchase heel stoppers. Shoes must be kept on at all times throughout the event to avoid splinters.

A member of the Events Team will always be present on the ship during the evening. Please do follow any instructions given by the Events Team, especially in an emergency. In the event of an emergency, the Events Team are responsible for raising the alarm and liaising with the emergency services. In the unlikely event of an evacuation, the Events Team will carry out a full sweep of the ship. All guests should evacuate the ship by using the nearest ladders, exiting in a calm and orderly manner, leaving all bags and personal belongings behind. Once the sweep is complete, a roll call for all guests will be taken. The muster point is the turning circle on the jetty.

If you have any questions or concerns about the accessibility of the conference dinner venue, please e-mail the meeting organizers at <**annualmeeting2025@palass.org**>.

Sponsors

The organizers of the 69th Annual Meeting gratefully acknowledge the support of the following sponsors and exhibitors:

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DISCOVER, EXPERIENCE & ENCOUNTER!

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Systematic Palaeontology

The Geological Society

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Organizing committee

Chair

Dr Nicholas Minter

Committee

Dr Nidia Álvarez-Amada
Dr Orla Bath Enright
Dr Anthony Butcher
Dr Sonia Camina
Meriam Chouar
Dr Laura Devine
Dr Mark Hardiman
Dr Nizar Ibrahim
Dr Adele Julier
Stella Ludwig
Dr Simon Penn
Dr Mariem Saavedra-Pellitero
Dr Roy Smith
Josephine Warner-Pallister
Dr Katherine Williams

Student volunteers

Lola Ayers
Neel Bendre
Aidan Berlinghoff
Ryan Butler
Carmen Daniels
Andrew Doyle
Charlie Dutton
Connor Edwards
Christian Graham
Isabelle Higgins
Dylan Hithersay
Clay Ingram
Ali Khalafullah
Edward Kirk-Martin
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Achilles Leigh-Firbank
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Holly Malpass
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Bradley McDowall
Connor Munro-Flanagan
Cassius Myers
Billy Parker
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Viraj Ranavaya
Oliver Read
Liam Reast
Jack Richardson
Adam Roberts
Jamie Rolt
Kieran Ross
Joe Shakespeare
Ellie Spaight
Ella Stevens
Harry Tyrrell
William Alasdair von Claasen
James Westcombe
James Wilson

The Palaeontological Association

Reg. Charity No. 1168330

Code of Conduct for Palaeontological Association Events

The Palaeontological Association holds regular meetings and events throughout the year. The Association's Events Code of Conduct relates to the behaviour of all participants and attendees at all events run by the Association, and acts alongside the Code of Conduct for Members.

Behavioural expectations:
It is the expectation of the Palaeontological Association that meeting attendees behave in a courteous, collegial and respectful fashion to each other, volunteers, exhibitors and meeting facility staff.

Delegates should respect common sense rules for professional and personal interactions, public behaviour (including behaviour in public electronic communications), common courtesy, and respect for private property.

Demeaning, abusive, harassing or threatening behaviour, discrimination on the basis of race, ethnic origins, immigration status, religion, age, marital status, parental status, sex, sexual orientation, gender identity or expression, socioeconomic background, educational background, or disability will not be tolerated. Inappropriate physical contact, unwelcome sexual attention, including verbal or physical actions of a sexual nature towards other attendees or towards meeting volunteers, exhibitors or facilities staff and security will not be tolerated, in either personal or electronic interactions.

Digital images and social media:
Respect for the intellectual property of presenters should be maintained at all times. Photographing or recording a talk without the author's express permission is forbidden. While the default assumption is to allow open discussion of presentations on social media, delegates are expected to respect any request by an author to not disseminate the contents of their talk or poster. Questions and discussion should be constructive, respectful, and focus on data and ideas rather than individuals.

Reporting unacceptable behaviour:
If you are the subject of unacceptable behaviour or have witnessed any such behaviour, you can report it (anonymously if you choose to) via the 'Report code of conduct violation' form (on the PalAss webpage <**https://www.palass.org/meetings-events/code-conduct-palaeontological-association-events**>). Alternatively you can notify a designated member of the Palaeontological Association Council on site: President Prof. Philip Donoghue; Vice- President Prof. Barry Lomax; Diversity Officer Dr Nidia Álvarez-Amada; Ordinary Member Prof. Daniela Schmidt; or Executive Officer Dr Jo Hellawell.

Anyone experiencing or witnessing behaviour that constitutes an immediate or serious threat to public safety, or a criminal act, is expected to contact the appropriate law enforcement agency (in the UK for the police, or for fire or medical emergencies, call 999). Those witnessing a potential criminal act should also take actions necessary to maintain their own personal safety.

Resulting actions

Following a report of a Code of Conduct violation, resultant action taken by the Palaeontological Association will be decided based on the individual circumstances of the violation, its severity, and whether it was a single event or a repeated infringement. As a preliminary action, the ethics committee leader and designated safe person(s) on the Association's Council will meet, investigate, and implement any necessary immediate actions to safeguard the affected individual(s). The subject of the enquiry (*i.e.* the party or parties whose behaviour is reported to be in breach of the Code) may be given a warning or asked to leave the Meeting venue while further investigations are conducted to ensure immediate safeguarding of the affected individual(s). The result of Code of Conduct violation investigations will be shared to the Association's Council at the next regular meeting.

Further reprimands may include, but are not restricted to, written reprimand or warning, removal from Association positions, suspension from presenting at Association meetings, suspension from attending future Association activities (including events, field-trips, short courses and meetings), suspension from submission of manuscripts to *Palaeontology* and *Papers in Palaeontology*, suspension of Association membership, expulsion from the Association, and/or denial or revocation of grants and awards. For full details see the Association's website.

Key contacts:

President Prof. Philip Donoghue

Vice-President Prof. Barry Lomax

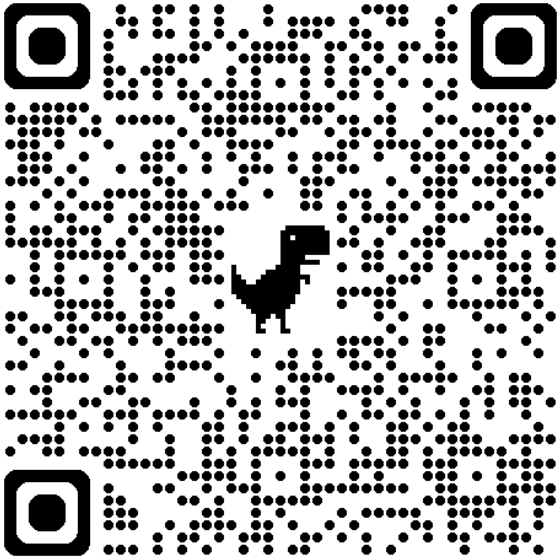
Diversity Officer Dr Nidia Álvarez-Amada

Ordinary Member Prof. Daniela Schmidt

Executive Officer Dr Jo Hellawell

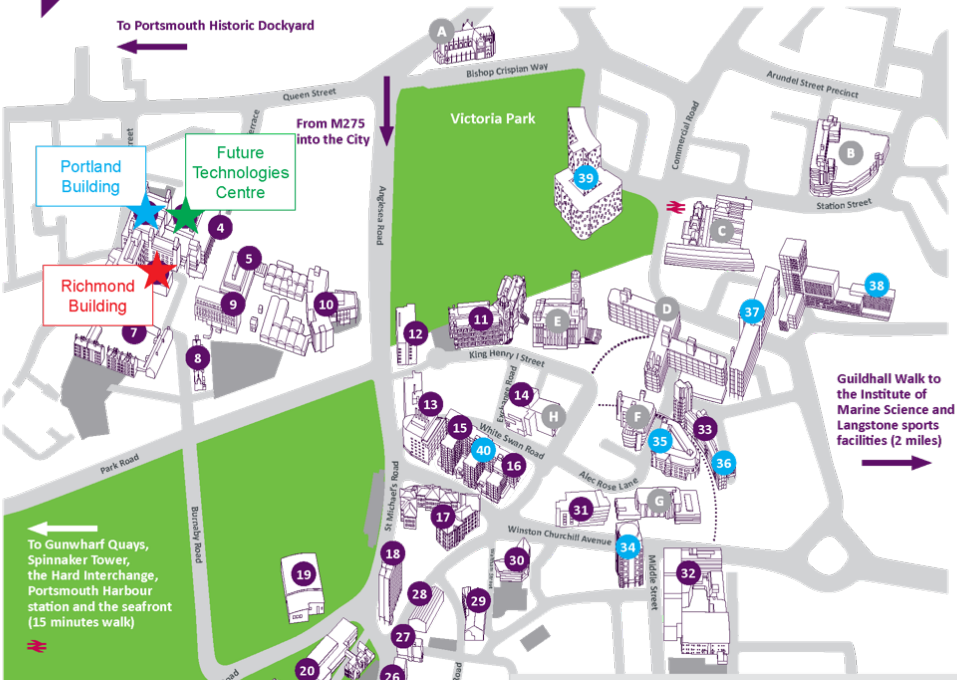
Maps

We have curated an interactive map, featuring key conference sites and recommended food and drink venues. Scan this QR code to open the map.



(If you have problems opening this link please try <**https://tinyurl.com/u9yj295f**>.)

UNIVERSITY OF PORTSMOUTH



UNIVERSITY BUILDINGS

6-8 Hampshire Terrace	26	Portland Building	●
Anglesea Building	10	Ravelin House	24
Bateson Centre	33	Ravelin Sports Centre	22
Buckingham Building	4	Richmond Building	★
Burnaby Building	5	Rosalind Franklin East	16
Burnaby Terrace	8	Rosalind Franklin West	15
Chaplaincy Centre and Prayer Rooms	29	Spinnaker Building	19
Dennis Sciama Building	9	St Andrew's Court	17
Dental Academy	25	St George's Building	23
Eldon Building	32	St Michael's Building	13
Future Technology Centre	★	St Paul's Sports Hall	29
Halpern House	27	Student Union Building	20
King Henry Building	12	University House	30
Lion Gate Building	1	University Learning Centre	31
Mercantile House	18	University Library	21
Milldam	7	Victoria House	28
Park Building	11	White Swan Building	14
		William Beatty Building	25

UNIVERSITY AND PARTNERS' HALLS OF RESIDENCE ●

Bateson Hall	36
Burrell House	41
Catherine House	39
Greetham Street Hall	38
Harry Law Hall	35
Rosalind Franklin Halls	40
Margaret Rule Hall	37
Rees Hall	42
Trafalgar Hall	34

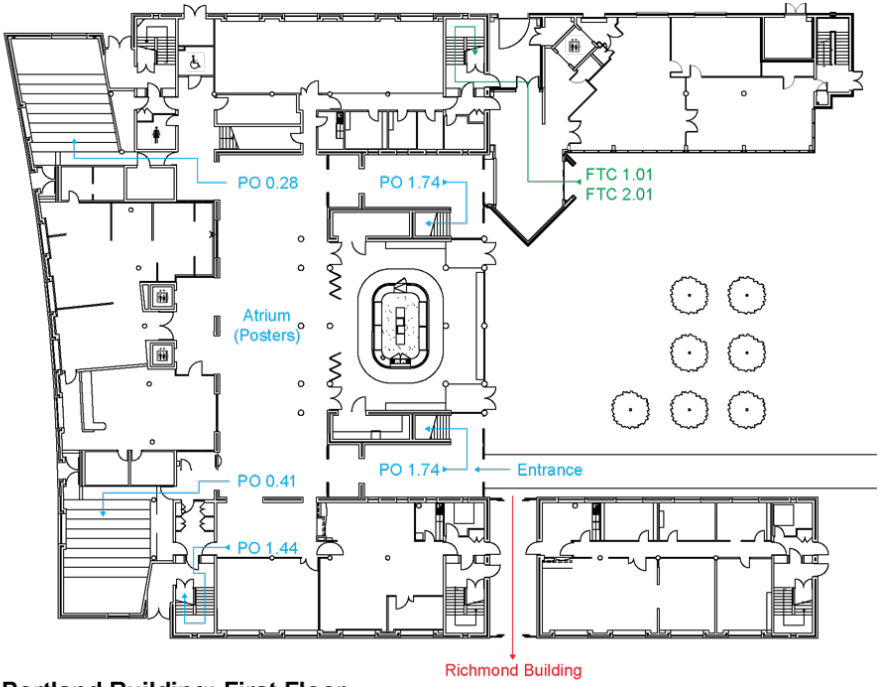
CITY BUILDINGS ●

Central Library	F
Civic Offices	D
City Museum	I
Courts	G
Portsmouth Guildhall	E
New Theatre Royal	H
Ports and Southsea station	C
Post Office	B
St John's Catholic Cathedral	A

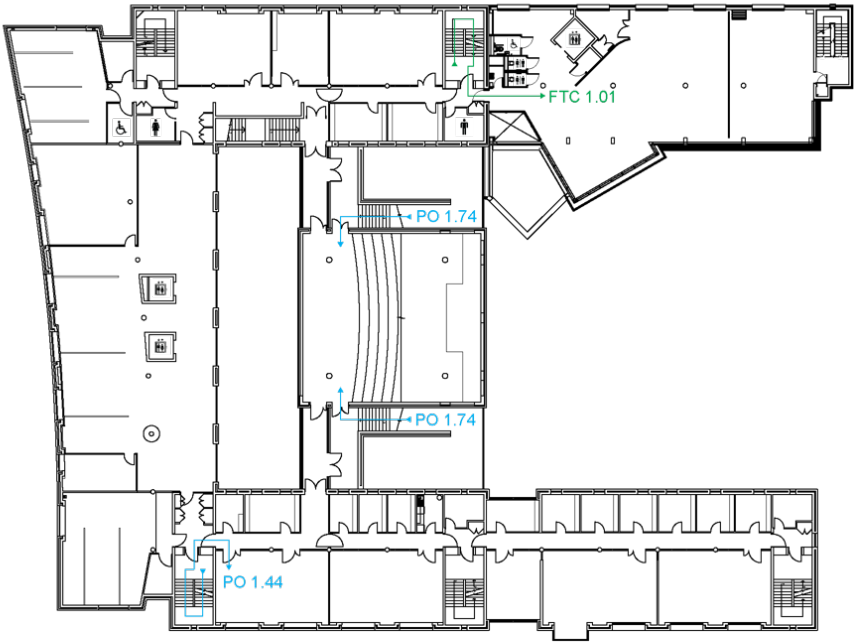
The Portland Building. Photo: Nic Minter.

The Richmond Building. Photo: Nic Minter.

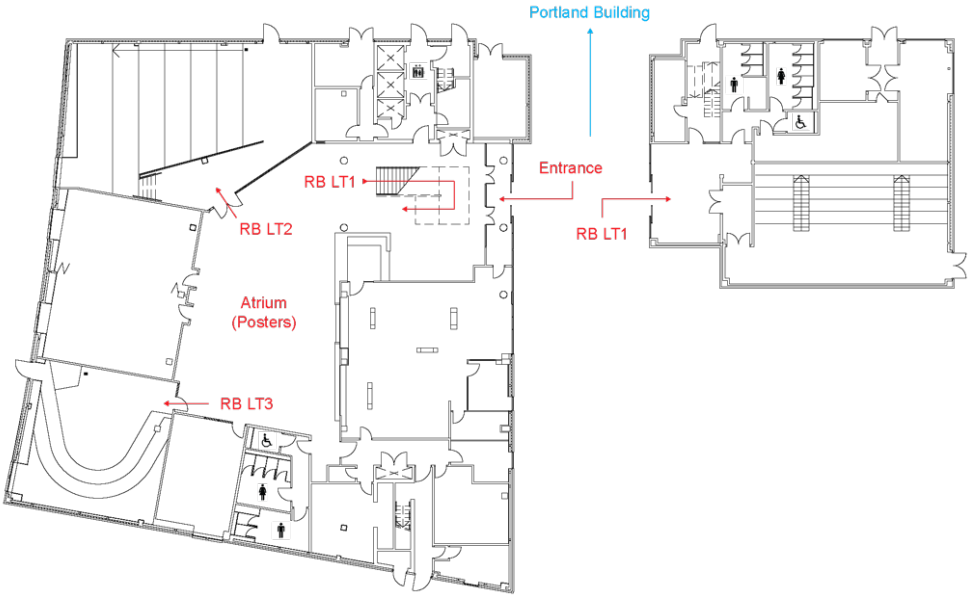
Portland Building: Ground Floor



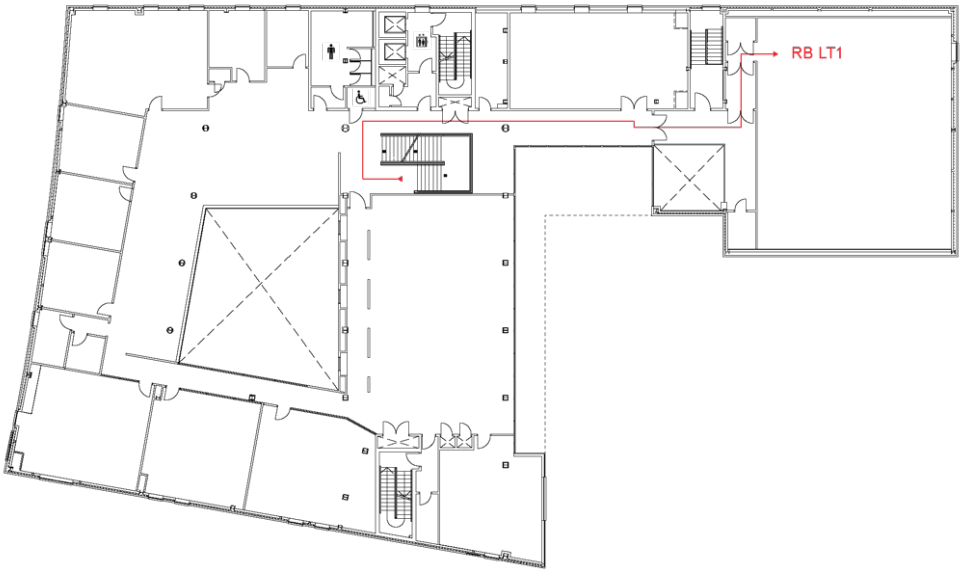
Portland Building: First Floor



Richmond Building: Ground Floor



Richmond Building: First Floor



Summary of Schedule

Thursday 11th December: early-career researcher workshop and social

Learning from experience: publishing, grants and jobs

The early-career researcher workshop is being convened by Dr Orla Bath Enright (ERC Officer) and Dr Nidia Álvarez-Amada (Diversity Officer). It will focus on the transitions from PhD student to postdoctoral researcher and on to lecturer; with talks on publishing, applying for grants, and applying for permanent positions. There will also be a panel discussion with senior experts, and opportunities for networking with peers during the workshop and social event. Registration for participants in the early-career researcher workshop will be available in Portland Building from 13:00 to 14:00.

The early-career researcher evening social will be held in the upstairs bar at Guildhall Village and will be catered with a pizza buffet.

Friday 12th December: pre-conference workshops, Symposium and Icebreaker

The morning of 12th December features four workshops led by specialists from the University of Portsmouth, other institutions across Europe, and industry. Registration for delegates who previously selected to attend workshops will be available in Portland Building from 08:30 to 10:00.

The scientific part of the meeting will begin with a Symposium entitled 'Experimental Palaeontology'. Registration will be available from 13:00 to 18:00 in Portland Building.

Following the Symposium there will be an Icebreaker Reception from 17:30 to 19:30, which will be spread across Portland Building Atrium and Richmond Building Atrium. Delegates with poster presentations will be encouraged to put up their posters so that they can be viewed during this time. Delegates who selected to attend the Icebreaker Reception will receive two drinks vouchers in their registration pack.

Saturday 13th December: conference, AGM, Annual Address and Annual Dinner

Registration will be open from 08:30 to 17:00 in Portland Building.

The Conference will start with a welcoming address at 08:45 in Richmond Building RB LT1, with the first session of oral presentations beginning at 09:00. Following the first session, the Conference will break in to three parallel sessions of oral presentations that will be held across three rooms (Richmond Building RB LT1, Richmond Building RB LT2 and Portland Building PO 1.74).

Posters will be set up in Portland Building Atrium and Richmond Building Atrium, where morning and afternoon tea / coffee breaks and lunch will also be held. There will be a dedicated poster session after lunch.

During the lunch break there will be a Diversity Meeting convened by Dr Nidia Álvarez-Amada (Diversity Officer) in Richmond Building RB LT3.

The Annual General Meeting (AGM) will be held at 16:30 in Richmond Building RB LT1, followed by the Annual Address given by Prof. Jennifer McElwain at 17:00.

The Annual Dinner will take place on the evening of Saturday 13th December on board *HMS Warrior* in Portsmouth's Historic Dockyard. Doors open at 18:30. A delicious menu of festive food will be served at the mess tables of the Main Gun Deck, as pre-selected by participants. Guests will also be able to enjoy a variety of local beers and other alcoholic and non-alcoholic drinks from the cash bar serving from the galley of the ship. Guests who elected to attend the Annual Dinner will receive their ticket in their registration pack. Guests **must** take their Annual Dinner ticket with them for security at the entrance to the Historic Dockyard. Your ticket will also include your menu choices in order to help with a smooth-running dinner service.

Sunday 14th December: Conference

Registration will be open from 08:30 in Portland Building.

Oral presentations will begin at 09:00 with two parallel sessions held across two rooms (Richmond Building RB LT1 and Portland Building PO 1.74). Following the first session, the Conference will break in to three parallel sessions of oral presentations that will be held across three rooms (Richmond Building RB LT1, Richmond Building RB LT2 and Portland Building PO 1.74).

Posters will be set up in Portland Building Atrium and Richmond Building Atrium, where morning and afternoon tea / coffee breaks and lunch will also be held. There will be a dedicated poster session after lunch.

During the lunch break there will be an LGBTQ+ Meeting convened by Dr Nidia Álvarez-Amada (Diversity Officer) in Richmond Building RB LT3.

The final session of oral presentations will start at 16:30 in Richmond Building RB LT1, after which the Conference will close with presentations by the organizing committees of upcoming meetings, the awarding of the President's Prizes and the Council Poster Prizes, and concluding remarks.

Monday 15th December: post-conference field-trip

Isle of Wight

The one-day post-conference field-trip will visit the Isle of Wight. The Isle of Wight, situated off the south-central coast of England, is long famous for its geology and palaeontology of Cretaceous to Oligocene sediments in nearly continuous, sea-washed exposures. The trip will focus on the Cretaceous–Eocene succession in Whitecliff Bay, on the east of the island; and the Lower Cretaceous (Barremian) Wessex Formation on the southwest coast.

The trip will depart from Southsea Hoverport (see the interactive map on page 9 for the location) on the morning of Monday 15th December at 08:30, travelling from Portsmouth using the Hovercraft to Ryde on the Isle of Wight where participants will board a coach. In the morning, participants will

visit the spectacular cliff exposures in Whitecliff Bay which extend from Campanian chalk (Portsdown Formation) through to the late Eocene Bembridge Limestone (Priabonian lacustrine facies). This is the type section of the London Clay Formation. Following this, participants will be able to purchase their own lunch from the Wight Mouse Inn in Chale, which provides good standard pub fare. During the afternoon, participants will travel to the southwest of the island to explore the habitats of Wealden dinosaurs. Participants will visit the excellent exposures of the Lower Cretaceous (Barremian) Wessex Formation between Grange Chine and Chilton Chine, which has been the source of numerous spectacular finds of vertebrates for nearly 200 years. As the light begins to fade, the coach will return to Ryde for the hovercraft back to Portsmouth, with the aim to be back no later than 18:00.

This trip will visit two coastal/cliff localities; therefore, participants must wear appropriate footwear (ankle-supporting walking boots) and bring their own hard hat. Participants are also advised to bring a spare pair of shoes, and we strongly advise carrying wet- (and very cold-!) weather clothes.

Whitecliff Bay. Photo: Nic Minter.

Detailed Schedule

Thursday 11th December

Registration

13:00 – 14:00 Portland Building

Early-career researcher workshop and social

This is for pre-booked participants only as spaces are limited.

14:00 – 17:00 **Learning from experience: publishing, grants and jobs**
Portland Building PO 1.74

Conveners: Dr Orla Bath Enright (Stuttgart State Museum of Natural History; ERC Officer), Dr Nidia Álvarez-Amada (The University of Manchester; Diversity Officer)

14:00 – 14:30 **Icebreaker and introductio**n

14:30 – 15:00 **Academic publishing**
Prof. Philip Donoghue (University of Bristol)

15:00 – 15:30 **Grant applications**
Prof. Daniela Schmidt (University of Bristol)

15:30 – 16:00 **Applying for permanent jobs**
Prof. Barry Lomax (University of Nottingham)

16:00 – 16:15 Tea / coffee break

16:15 – 17:00 **Panel discussion and closing remarks**

18:00 – 20:00 **Early-career researcher social**
Guildhall Village

Friday 12th December

Registration

08:30 – 10:00 Portland Building

Pre-conference workshops

These are for pre-booked participants only as spaces are limited.

09:00 – 12:30 **Building models for stratigraphic palaeobiology in R**
Future Technologies Centre Floor 2
Conveners: Dr Niklas Hohmann, Dr Emilia Jarochowska and Dr Xianyi Liu (Utrecht University)

09:00 – 12:30 **Capacity Building in Palaeontology: an African perspective to a global challenge**
Portland Building PO 0.41
Convener: Dr Nizar Ibrahim (University of Portsmouth)

09:00 – 12:30 **Introduction to digital data capturing**
Future Technologies Centre Floor 1
Conveners: Stella Ludwig, Dr Roy Smith, Edward Bartlett, Julen Martinez (University of Portsmouth)

10:30 – 12:30 **Applications of biostratigraphy through the energy transition**
Portland Building PO 0.28
Convener: Paul Cornick (Petrostrat Ltd)

Registration

13:00 – 18:00 Portland Building

Symposium: Experimental Palaeontology: 13:30 – 17:15

Portland Building PO 1.74
Underlined author is the presenter.

Chair: Nicholas Minter

13:30 – 13:45 **Opening remarks and welcoming address**

13:45 – 14:15 **What more do we need to know about ancient fire? The why and how**
Claire M. Belcher

14:15 – 14:45 **The paradox of exceptional preservation: laboratory experiments reveal that decay is the engine of soft tissue fossilization**
Thomas Clements

14:45 – 15:15 **Validating palaeoecological computational fluid dynamics simulations using experiments**
Harriet B. Drage, Stephen Pates and Nicholas J. Minter

15:15 – 15:45 **tea / coffee break** (Portland Building Atrium)

Chair: Orla Bath Enright

15:45 – 16:15 **Experimental insights into coccolithophore ecology and survival in past ocean stress events**
Jelena Godrijan

16:15 – 16:45 **Experimental misshapes, mistakes and misfits: sporomorph malformations and mass extinctions**
Matthew S. Kent, Bas van de Schootbrugge, Cindy V. Looy, Ivo A. P. Duijnstee, Thijs R. A. Vandenbroucke and Barry H. Lomax

16:45 – 17:15 **Physiological insights as a bridge between palaeontological and geochemical records**
Erik A. Sperling

Icebreaker reception

17:30 – 19:30 Portland Building Atrium and Richmond Building Atrium)

Saturday 13th December

Underlined author is the presenter.
* Presenters eligible for the President's Prize are marked with an asterisk
† Lightning talks are marked with a dagger.

Registration

08:30 – 17:00 Portland Building

Conference, AGM, Annual Address and Annual Dinner

Session 1 (08:45 – 10:30)
(Richmond Building RB LT1) Chair: Philip Donoghue

08:45 – 09:00 **Opening remarks and welcoming address**

09:00 – 09:15 **Breaking the bottleneck: fully automated CT segmentation of fossils using deep learning**
Arindam Roy, Poulami Ghosh, Roger B. J. Benson, Ben Scott, Arianna Salili-James, Sanson T. S. Poon, Susannah C. R. Maidment and Richard J. Butler

09:15 – 09:30 **Fossilized skin of dinosaurs illuminates stepwise evolution of the avian integument**
Zixiao Yang, Xing Xu, Baoyu Jiang, Peter Chung and Maria E. McNamara

09:30 – 09:45 **Constraining the lifespans of early animals of the Ediacaran**
Emily G. Mitchell and Alayva Dhughana

09:45 – 10:00 **Curved tracks from straight toes: kinematics distorting morphology in tridactyl penetrative tracks**
Benjamin Griffin, Tash Prescott, Andreás Jannel and Peter L. Falkingham

10:00 – 10:15 **3D morphologies of Early Cambrian arthropods from the Chengjiang Biota**
Yu Liu and Xianguang Hou

10:15 – 10:30 **Big birds, big data: palaeognath phylogeny tested using morphology, DNA and ancient collagen**
Joseph N. Keating, Edmund R. R. Moody, Andrew Kitchener and Michael Buckley

10:30 – 11:00 **tea / coffee break** (Portland Building Atrium and Richmond Building Atrium)

Session 2A (11:00 – 12:30)
(Richmond Building RB LT1) Chair: Manabu Sakamoto

11:00 – 11:15 **Otoliths don't lie: metabolic secrets of Eocene fishes**
Emily Ball*, Clive N. Trueman, Richard J. Twitchett and James D. Witts

11:15 – 11:30 **Investigating the functional morphology of iguanodontian thumb spikes**
Emily Driscoll*, David J. Button and Joseph N. Keating

11:30 – 11:35 **The evolution of theropod tooth form and function †**
Morgan Whitley*, Manabu Sakamoto and Chris Venditti

11:35 – 11:40 **Row, row, row your bone: using computational fluid dynamics to investigate the formation of fossil bone beds †**
Fraser Weston*, Zekun Wang, Susannah C. R. Maidment and Imran A. Rahman

11:40 – 11:45 **Finite element analysis of horse toe bones: the next step in decoding anchitheriin locomotion †**
Tanya Gunnarsdottir*, Natalia Trepp Centellas and Christine M. Janis

11:45 – 12:00 **Insights into the locomotor modes of giant extinct kangaroos from vertebral morphology**
Megan Jones*, Andrew Pask, Axel Newton and Katrina Jones

12:00 – 12:15 **Morphospace testing of published pterosaur depictions: are pterosaur reconstructions fit to fly?**
Benton Walters*, Emily J. Rayfield and Philip C. J. Donoghue

12:15 – 12:30 **Decoupled evolution of melanosome geometry and chemistry in amphibians and reptiles**
Aaron Quigley*, Beatriz Carazo del Hoyo, Daniel Cirtina, Valentina Rossi, Catherine McCarney, Jane Brennan, Soudeh Ziapour and Maria E. McNamara

Session 2B (11:00 – 12:30)
(Richmond Building RB LT2) Chair: Thomas Smith

11:00 – 11:15 **Optimizing CT scanning parameters for high-aspect ratio specimens**
Paula Wilson, Richard P. Dearden, Ivan J. Sansom and Mark Williams

11:15 – 11:30 **Conserving and communicating palaeontology: novel methods from Charnwood Forest Geopark**
Jack J. Matthews

11:30 – 11:35 **#Yourpalaeolife: interrogating the status of fieldwork amongst early-career palaeontologists †**
Harriet E. Nuttall*

11:35 – 11:40 **Are humans a transient agent of destruction or a potential persistent driver of biosphere net gain? †**
Thomas W. Wong Hearing and Mark Williams

11:40 – 11:45 **The emergence of metabolisms through Earth history and implications for biospheric evolution †**
Edmund R. R. Moody, Tom Williams, Sandra Álvarez-Carretero, Gergely Szöllősi, Davide Pisani, Timothy M. Lenton and Philip C. J. Donoghue

11:45 – 12:00 **Can we reconcile molecular and morphological clock disparities in a group with a rich fossil record?**
Johnny Clavo Yamahuchi*, Philip C. J. Donoghue, Christine M. Janis, Luke T. Holbrook and Joseph N. Keating

12:00 – 12:15 **Phylogenetic inference from an incomplete fossil record**
Niklas Hohmann*, Rachel C. M. Warnock and Emilia Jarochowska

12:15 – 12:30 **Evolution on rugged terrain: how complex fitness landscapes shaped the Cambrian Explosion**
Charles Bates*, Russell J. Garwood, Luke A. Parry, Thomas Smith, and Frances S. Dunn

Session 2C (11:00 – 12:30)
(Portland Building PO 1.74) Chair: Sarah Losso

11:00 – 11:15 **Changes in metazoan functional diversity across the first Phanerozoic mass extinction: the Cambrian Sinsk Event**
Adam Murphy*, Amelia M. Penny, Andrey Zhuravlev and Rachel A. Wood

11:15 – 11:30 **Multi-scale community dynamics revealed by Bayesian network analysis in the Ediacaran Shibantan Biota, South China**
Yarong Liu*, Emily G. Mitchell, Xunlai Yuan and Zhe Chen

11:30 – 11:35 **Macroscopic carbonaceous compression fossils from the Tonian Changlingzi Formation in the Liaonan region of North China †**
Mingyang Qiu*, Guangjin Li, Ke Pang, Chwngxi Wu and Hanzhi Qu

11:35 – 11:40 **The Porma Biota: a community of wiwaxiids, priapulimorph worms and palaeoscolecids from Cambrian Epoch 2 northwestern Gondwana †**
Blanca Martínez-Benítez*, Teodoro Palacios and J. Javier Álvaro

11:40 – 11:45 **Filling in a knowledge-gap: early Late Ordovician cephalopod assemblages of Estonia †**
Martina Aubrechtová and Tõnu Meidla

11:45 – 12:00 **The community ecology of the Early Ordovician Fezouata Shale biota of Morocco**
Jared Richards*, Karma Nanglu and Javier Ortega-Hernández

12:00 – 12:15 **Microanatomy and functional morphology of the trilobite exoskeleton: a case study of *Morocops? degener***
Matěj Šilinger*, Oldřich Fatka and Petr Budil

12:15 – 12:30 **Re-evaluating the Cambrian chelicerate *Molaria***
Edna Rodríguez-Sánchez*, Ailin Chen, Yu Liu and Javier Ortega-Hernández

12:30 – 13:30 **Lunch**
(Portland Building Atrium and Richmond Building Atrium)

12:45 – 13:30 **Diversity Meeting**
(Richmond Building RB LT3)

13:30 – 14:30 **Poster Session**
(Portland Building Atrium and Richmond Building Atrium)

Session 3A (14:30 – 16:00)
(Richmond Building RB LT1) Chair: Laura Devine

14:30 – 14:45 **The Chimaera Beds Lagerstätte: taphonomic window for Burgess Shale-type preservation of marine invertebrates still open during the Cretaceous**
Javier Luque, Germán Bonilla, Duván García, Sebastián Gómez-Coronado, Javier Ortega-Hernández and Farid Saleh

14:45 – 15:00 **Taphonomic insights into fossil preservation and accumulation in Tham Khao Phak Kut cave, Peninsular Thailand**
Holly Anderson, Prasopsook Sritangwong, Jirasak Charoenmit, Nattanakorn Songpracha and Kantapon Suraprasit

15:00 – 15:15 **Postmortem biochemical evolution may control kaolinite formation: implications for exceptional preservation**
Piyush Sriwastava, Nicholas J. Tosca, Julie G. Cosmidis and Ross P. Anderson

15:15 – 15:30 **The unexpected role of sulphate-reducing bacteria in the replication of organic matter in aluminosilicates**
Nora Corthésy*, Camille Thomas and Farid Saleh

15:30 – 15:45 **Variable mechanical properties given by the presence/absence of pigment molecules in insect cuticle**
Nidia Álvarez-Amada and Craig Williams

15:45 –16:00 **Can immunohistochemistry reliably detect fossil proteins?**
Tiffany S. Slater, Tara Foley and Maria E. McNamara

Session 3B (14:30 – 16:00)
(Richmond Building RB LT2) Chair: Luke Meade

14:30 – 14:45 **Polar adaptations in the life histories of Australia's earliest mammals revealed via synchrotron X-ray tomography**
Andre Rowe, Elis Newham, Nuria Melisa Morales-Garcia, Pamela G. Gill and Emily J. Rayfield

14:45 – 15:00 **Reconciling molecular clocks and the fossil record in placental mammals**
Mary Kate Branigan*, Graham E. Budd and Richard Mann

15:00 – 15:15 **Early Cenozoic mammal radiation coincides with increased terrestrial habitability**
Nicholas Hadjigavriel, Alexander M. Dunhill, Khushboo Gurung and Benjamin J. W. Mills

15:15 – 15:30 **New data on the Late Triassic/Early Jurassic vertebrate faunas of Zimbabwe**
Paul M. Barrett, Michel Zondo, Lara Sciscio, Darlington Munyikwa, Timothy Broderick, Kimberley E. J. Chapelle, Atashni Moopen and Jonah N. Choiniere

15:30 – 15:45 **Regional variation drove disparity in functional diversity and ecosystem structure in the Late Cretaceous**
Cassius Morrison*, Franco Aspromonte, Zak Lewis, Josh Wasserlauf, Ezekiel O'Callaghan, Robert Mayer, Harry Jones, Jordan Mallon and Diego Pol

15:45 -16:00 **Micro- and mesofossil analyses of an *Edmontosaurus* Bonebed from the Late Cretaceous Lance Formation: palaeoecological insights**
Nicolas Adrian Stagg*, Haytham El Atfy, Dieter Uhl, Philipe Havlik and Benjamin Bomfleur

Session 3C (14:30 – 16:00)
Sponsored by The Micropalaeontological Society
(Portland Building PO 1.74) Chair: Emma Hanson

14:30 – 14:45 **Reconstructing spore evolution recalibrates the timescale of land plant diversification**
Jack Hooper*, Annabel Worth, Charles H. Wellman, James Clark and Philip C. J. Donoghue

14:45 – 15:00 **Larger foraminifera as archives of intra-annual temperature variation**
Laura J. Cotton, David Evans, Max Fursman, Wolfgang Müller, Willem Renema and Paul N. Pearson

15:00 – 15:15 **Life in the deep – morphological plasticity in benthic foraminifera across environmental changes of the Palaeogene**
Yujie Shi, Monsuru Adebowale, Madhura Gosh, Ellen Thomas, Bridget Warren and Daniela N Schmidt

15:15 – 15:30 **Chitinotax: an open-access global database bridging traditional and digital chitinozoan research in the Palaeozoic**
Sonia C. Camina, Jeremy R. Young, Anthony Butcher and Stephen Stukins

15:30 – 15:45 **Teratological chitinozoans help confirm that hydrothermal brine expulsions caused the Ireviken extinction event**
Iris Vancoppenolle*, Poul Emsbo, Jay Thompson, Pat McLaughlin, Mikael Calner and Thijs R. A. Vandenbroucke

15:45 -16:00 **Anoxia optional: local redox does not control Proterozoic microfossil preservation**
Christina R. Woltz, Susannah M. Porter and Erik A. Sperling

16:00 – 16:30 **tea / coffee break**
(Portland Building Atrium and Richmond Building Atrium)

Annual General Meeting

(Richmond Building RB LT1)

16:30 – 17:00 **Annual General Meeting**. The agenda and papers pertaining to the AGM can be found in *Palaeontology Newsletter* **119**, available under the Publications tab on the Association website.

Annual Address

(Richmond Building RB LT1)

17:00 – 18:00 **Exploring Earth's dynamic atmospheres and ecosystems**
Jennifer C. McElwain, Trinity College Dublin, Ireland

Annual Dinner

(*HMS Warrior*, Portsmouth Historic Dockyard)

18:30 – 23:30 **Annual Dinner**
Doors open: 18:30
Guests to be seated for 19:00

This is a separate ticketed event that guests must have selected and paid for during registration.

Sunday 14th December

Registration

08:30 – 17:00 Portland Building

Conference

Session 4A (09:30 – 10:30)
Sponsored by The Palaeontographical Society
(Richmond Building RB LT1) Chair: Anthony Butcher

09:00 – 09:15 **A climbing carnivorous eutriconodont mammal exceptionally preserved from the Middle Jurassic of Skye, Scotland**
Luke E. Meade, James R. G. Rawson, Elsa Panciroli, Stig Walsh, Richard J. Butler and Roger B. J. Benson

09:15 – 09:30 **A decade of spinosaurids: is the UK a centre for a golden age in spinosaurid research?**
Neil J. Gostling, Chris T. Barker, Darren Naish and Jeremy Lockwood

09:30 – 09:45 **Dinosaur of the round table: redescribing *Camelotia borealis* highlights its importance to our understanding of sauropod origins**
Jack Lovegrove*, Samantha L. Beeston, Philip D. Mannion, Paul Upchurch and Paul M. Barrett

09:45 – 10:00 **The world's most diverse Early Ordovician fauna?**
John Cope

10:00 – 10:15 **High-resolution micro-CT reveals new morphological data in 3D-preserved *Lepidodendron* specimen (Brymbo Fossil Forest, Duckmantian, North Wales)**
Ewan Titcombe*

10:15 – 10:30 **Benthic palaeoecological response to environmental changes across the Cenomanian – Turonian interval in the UK Chalk Sea**
James D. Witts, Harriet Bohun, Andrew S. Gale, Zoë E. Hughes and Richard J. Twitchett

Session 4B (09:30 – 10:30)
(Portland Building PO 1.74) Chair: Frances Dunn

09:00 – 09:15 **A new frondose taxon from the Shibantan Lagerstätte illuminates the palaeoecology of Ediacaran fronds**
Chengxi Wu*, Ke Pang, Alexander G. Liu, Yarong Liu, Xiaopeng Wang, Chuanming Zhou, Zhe Chen, Xunlai Yuan and Shuhai Xiao

09:15 – 09:30 **The terminal Ediacaran Quanjishan macrofossil assemblage from the Qaidam Basin, Northwest China**
Ke Pang, Chengxi Wu, Xiaopeng Wang, Yarong Liu, Hanzhi Qu, Mingyang Qiu, Guangjin Li and Alexander G. Liu

09:30 – 09:45 ***Hallucigenia*'s diet illuminates the ecology of Cambrian lobopodians**
Javier Ortega-Hernández

09:45 – 10:00 **The Brioverian–Cambrian transition in the Armorican Massif: straddling the boundary between horizontality and verticality**
Jules Charrondière*, Didier Néraudeau, Marc Poujol, Baptiste Coutret, Arnaud Mazurier, Isabelle Bihannic, Damien Gendry and Alfredo Loi

10:00 – 10:15 **Two new exceptionally preserved biotas from North Dakota reveal cryptic Ordovician shelf ecologies**
Giovanni Mussini* and Nicholas J. Butterfield

10:15 – 10:30 **Description of one of the oldest crinoids shows a unique mix of crinoid and edrioasteroid features**
Christophe Dupichaud*, Tom Guensburg, Forest Gahn, Rich Mooi, Martina Nohejlová and Bertrand Lefebvre

10:30 – 11:00 **tea / coffee break**

Session 5A (11:00 – 12:30)
(Richmond Building RB LT1) Chair: Darja Dankina

11:00 – 11:15 **New data on Late Jurassic ichthyosaurs help to resolve a conundrum in the taxonomy of the Ophthalmosauria**
Nikolay G. Zverkov, Megan L. Jacobs and Benjamin G. Thomas

11:15 – 11:30 ***Osedax*-like borings, soft tissue preservation, and more in Jurassic and Cretaceous marine vertebrate remains from Japan and UK**
Christina Shears-Ozeki* and Robert G Jenkins

11:30 – 11:35 **Reassessment of a gigantic pliosaur mandible from the Kimmeridge Clay Formation of Cumnor, Oxfordshire, UK †**
Edward Bartlett*, Roy Smith, David Martill, Jake Kean and Judyth Sassoon

11:35 – 11:40 **A new phocid seal from Peru highlights ancient diversification of monk seals in the Southern Hemisphere †**
Rafael M. Varas-Malca*, Mario Urbina and Vanessa Meza-Vargas

11:40 – 11:45 **A new three-dimensional description of *Saurostomus esocinus* and its implications for asthenocormine success †**
Benedict Emmerson*, Samuel L. A. Cooper, Sam Giles and Michael J. Benton

11:45 – 12:00 **Casting light on melanosome geometry and visual strategies in fishes**
Daniel Cirtina* and Maria E. McNamara

12:00 – 12:15 **Histology-guided analyses show fossil shark teeth can serve as geochemical time capsules**
Synnøve M. Saugen, Jay M. Thompson, Heather A. Lowers, Jørn H. Hurum, Thijs R. A. Vandenbroucke and Poul Emsbo

12:15 – 12:30 **First report of whitlockite in the dental plates of crown Holocephalii**
Esther Manzanares, Zerina Johanson, Jens Najorka, Joseph Razzelliot, Charlie J. Underwood and Richard J. Twitchett

Session 5B (11:00 – 12:30)
(Richmond Building RB LT2) Chair: Barry Lomax

11:00 – 11:15 **Investigating ichnological characteristics of Ordovician braid deltas**
Hamilton Allport* and Neil S. Davies

11:15 – 11:30 **Vegetation-induced sedimentary structures (VISS): their biogeomorphological, sedimentological and evolutionary significance**
James Craig*, Neil S. Davies and William J. McMahon

11:30 – 11:35 **Review of femoral length as a body mass predictor in Aves †**
Alex Colesmith*

11:35 – 11:40 **A new cranial reconstruction of the gliding tanystropheid *Ozimek volans* from the Triassic of Poland †**
Thomas Ducrey*, Torsten Scheyer and Feiko Miedema

11:40 – 11:45 **Extinction and survival at the dawn of plant life on land †**
Rosa Parkin*, Alexander J. Hetherington and Paul Kenrick

11:45 – 12:00 ***Prototaxites* and friends: a unique extinct eukaryotic lineage**
Laura Cooper*, Coretin Loron, Michael Krings and Alexander J. Hetherington

12:00 – 12:15 **CAM photosynthesis: a key trait in surviving Earth's largest extinction?**
Zhen Xu, Jason Hilton, Jianxin Yu, Paul B. Wignall, Alexander Farnsworth, Isabel P. Montañez, Benjamin Mills and Barry H. Lomax

12:15 – 12:30 **Climate was not the only driver explaining the asymmetry of the Great American Biotic Interchange**
Lucas Buffan*, Adrián Castro Insua, Fabien L. Condamine and Sara Varela

Session 5C (11:00 – 12:30)
(Portland Building PO 1.74) Chair: Laura Mulvey

11:00 – 11:15 **Dynamics and drivers of the first radiation of ray-finned fish in a spatially controlled framework**
Joseph Flannery-Sutherland and Sam Giles

11:15 – 11:30 **The Covariant Evolutionary Tempo Model**
Richard Mann and Graham E. Budd

11:30 – 11:35 **Analytical minimization of squared change solves parsimony and likelihood problems fast †**
Jennifer F. Hoyal Cuthill and Graeme T. Lloyd

11:35 – 11:40 **Were areas of higher ecological uniqueness consolidated as centres of recovery after the end-Cretaceous extinction? †**
Emma Ayres*, Jorge García-Girón and Stephen L. Brusatte

11:40 – 11:45 **The complex relationship between brachiopods, bivalves, and the environment †**
Thomas J. Smith, Cooper M. Malanoski, Benjamin R. Shipley and Erin E. Saupe

11:45 – 12:00 **Biodiversity dynamics during the initial Devonian radiation of ammonoids**
Ninon Allaire, Claude Monnet, Dieter Korn, Diego Balseiro and Catherine Crônier

12:00 – 12:15 **Range size or thermal tolerance: exploring climatic and environmental controls on bivalve biogeography**
Sarah C. Gale*, Katie S. Collins and Shan Huang

12:15 – 12:30 **Evolutionary dynamics and environmental controls on marine biodiversity hotspots during the Cenozoic**
Kella Venu Gopal* and Devapriya Chattopadhyay

12:30 – 13:30 **Lunch**
(Portland Building Atrium and Richmond Building Atrium)

12:45 – 13:30 **LGBTQ+ Meeting**
(Richmond Building RB LT3)

13:30 – 14:30 **Poster Session**
(Portland Building Atrium and Richmond Building Atrium)

Session 6A (14:30 – 16:00)
(Richmond Building RB LT1) Chair: Alice Leavey

14:30 – 14:45 **Reconstructing the binocular visual system of a stem-group mantis and its predatory function**
Ryo Taniguchi*, Yuki Fukuda, Kanta Sugiura and Yasuhiro Iba

14:45 – 15:00 **Quantitative ichnology: from trace fossil morphology to evolutionary landmarks**
Zekun Wang

15:00 – 15:15 **The earliest Cambrian lobopodians illuminate the origin of legs**
Deng Wang, Martin R. Smith, Jean Vannier, Georg Mayer and Jian Han

15:15 – 15:30 **The functional performance of spiral feeding structures in Palaeozoic echinoderms**
James McDermott*, Louis Dudit, Zekun Wang, Frances S. Dunn, Ferdinand Marlétaz, John A. Cunningham and Imran A. Rahman

15:30 – 15:45 **Feeding strategies of raptorial radiodont predators in the Cambrian**
Mingjing Zhang*, Stephen Pates and Xiaoya Ma

15:45 -16:00 **New multidiciplinary insights into trilobite respiration**
Sarah R. Losso, Federica Vallefuoco, Igino Foglia, Léo Laborieux, Ana Belén Muñoz-García and Javier Ortega-Hernández

Session 6B (14:30 – 16:00)
(Richmond Building RB LT2) Chair: James Witts

14:30 – 14:45 **The character of the semi-enclosed Baltoscandian Basin during the Furongian (late Cambrian) and Tremadocian (early Ordovician)**
J. Javier Álvaro, Lars Holmer, Mansoureh Ghobadipour, Leonid Popov and Per Ahlberg

14:45 – 15:00 **Ocean circulation modelling linked to Lagrangian particle transport to explore connectivity of Mesozoic methane seep communities**
Stephen J. Hunter, Crispin T. S. Little, Steffen Kiel and Alan M. Haywood

15:00 – 15:15 **The effects of taxa through the Messinian Salinity Crisis on the biogeography of the Mediterranean Sea**
Andrej Spiridonov, Liudas Daumantas and Konstantina Agiadi

15:15 – 15:30 **Exploring the supposed freshwater Mesozoic xiphosurids**
Jonatan Audycki*, Russell D. C. Bicknell, Grzegorz Niedźwiedzki, Andreas Hecker, Błażej Błażejowski and Kenneth De Baets

15:30 – 15:45 **Climatic niche conservatism and the macroevolutionary history of crocodile-line archosaurs**
Alfio Alessandro Chiarenza, Alexandra Howard, Grace Varnham, Alexander Farnsworth, Paul Valdes and Philip D. Mannion

15:45 -16:00 **The Austral Antarctic Forest during the Early Eocene Climatic Optimum – biogeography, diversity and the fate of polar lineages**
Miriam Slodownik* and Robert S. Hill

Session 6C (14:30 – 16:00)
(Portland PO 1.74) Chair: Chengxi Wu

14:30 – 14:45 **The evolutionary history of radiodonts, great predators of the early Palaeozoic seas**
Gaëtan Potin* and Allison C. Daley

14:45 – 15:00 **Reinterpretation of *Jianshania furcatus***
Lorenzo Lustri and Yu Liu

15:00 – 15:15 **Novel insights into fossil ecdysozoans from the Sirius Passet Lagerstätte (Cambrian Series 2, Stage 3, North Greenland)**
Thomas P. Farrell*, Gregory D. Edgecombe, Tae-Yoon S. Park and Jakob Vinther

15:15 – 15:30 **Tomographic analysis of an exceptionally preserved bilaterian larva from the Cambrian of Mongolia**
Kirsten Flett*, Michael Steiner and Philip C. J. Donoghue

15:30 – 15:45 **Diverse mycelial microfossils from the early Ediacaran Doushantuo Formation, South China**
Hanzhi Qu*, Corentin Loron, Ke Pang, Tian Gan, Sean McMahon, Taiyi Luo, Qing Ouyang, Xunlai Yuan and Shuhai Xiao

15:45 -16:00 **Interspecific competition in Avalon (Ediacaran) communities**
Shujie Chang*, Nile P, Stephenson, Frances S. Dunn, Andrea Manica and Emily G. Mitchell

16:00 – 16:30 **tea / coffee break**

Session 7 (16:30 – 18:30)
(Richmond Building RB LT1) Chair: Emma Dunne

16:30 – 16:45 **Clade-level constraints to ecological diversification of Phanerozoic marine animals**
Philip M. Novack-Gottshall

16:45 – 17:00 **Exploring the transition from the lower- to the upper stem groups of arthropods: gaps and facts**
Peiyun Cong

17:00 – 17:15 **Flammability and functional traits in conifers: evolutionary perspectives from the fossil record**
Rebecca A. Koll, Claire M. Belcher, Cindy V. Looy and William A. DiMichele

17:15 – 17:30 **An exceptionally preserved polar window on the Cambrian–Ordovician transition**
Farid Saleh and Pierre Gueriau (to be presented by Allison C. Daley)

Closing business

17:30 – 18:00 Presentations from organizing committees for ProgPal 2026 and PalAss 2026

18:00 – 18:30 Presentation of awards and closing remarks

Monday 15th December

08:30 – 18:00 Post-conference field-trip – Isle of Wight (lead: Dr Anthony Butcher).

Departure and return: Southsea Hoverport (see the interactive map on page 9 for the location).

This is a separate ticketed event that participants must have selected and paid for during online registration.

Annual Address

The Annual Address will be given on Saturday 13th December in Richmond Building RB LT1, from 17:00 to 18:00.

Exploring Earth's dynamic atmospheres and ecosystems

Prof. Jennifer C. McElwain
Trinity College Dublin, Ireland

Understanding deep-time evolution of Earth's dynamic atmosphere and ecosystems provides a critical context for the nature of current climate change and biodiversity loss. Advances in the development and application of fossil plant proxies based on chemical, anatomical, morphological and functional-traits have provided a methodological basis to explore the magnitude and tempo of atmospheric change associated with mass extinction events, oceanic anoxic episodes and critical episodes of biotic change and evolutionary innovation. The coupled use of fossil plant proxies of palaeo-atmospheric CO_2 and palaeo-functional trait analysis now enables palaeobotanists to quantify the scale of terrestrial ecosystem response to, and effect on, Earth system processes such as the hydrological cycle, weathering, fire ecology and photosynthetic productivity. This talk will briefly recount the historical development of fossil plant atmospheric CO_2 proxies and their application through Earth history, and introduce the concept and potential of palaeo-functional traits. Novel palaeo-functional traits will be highlighted and their broad and powerful application potential to understanding the evolution of terrestrial ecosystem function over the Phanerozoic will be discussed.

Abstracts of Symposium presentations

Experimental Palaeontology

What more do we need to know about ancient fire? The why and how

Claire M. Belcher
University of Exeter, UK

Fire is a keystone biophysical process; it has shaped the evolutionary history of plants since their appearance on Earth and interacts across a huge number of Earth system processes such that our planet would not function as it does without fire. Fire by nature consumes organic material such that many past fires have left no direct fossil trace of this biophysical process. Where combustion is incomplete fire leaves charcoal that can be incorporated into the fossil record, but fires produce biased records of char before they even reach sedimentary settings. This means that a combination of experimental and modelling practices is required alongside ecological understanding to decipher fire's long-standing role in the evolutionary history of life on Earth. In this talk I will overview what key aspects of fire feed into driving evolutionary innovations, ecological change and chemical and physical feedbacks and explore a range of approaches that can be used to expand our understanding of fire's place in the history of life and our planet.

Friday 12th December, Symposium, Portland Building PO 1.74, 13:45–14:15.

The paradox of exceptional preservation: laboratory experiments reveal that decay is the engine of soft tissue fossilization

Thomas Clements
University of Reading, UK

All fossils have undergone decay before preservation. Typically, decay and fossilization are considered as separate phenomena: biological degradation followed by geological stabilization. Yet, evidence from our experiments shows that decaying carcasses are not passive substrates awaiting geological processes; they are geochemical 'bioreactors' inhabited by dynamic bacterial communities whose metabolic byproducts create the very conditions that can, alongside amenable environmental conditions, trigger soft tissue preservation via mineralization. This talk will present a range of hypothesis-driven experiments, including new non-destructive XCT visualization techniques that allow us to observe decay in real-time within sediments, that demonstrate that decomposition actively drives soft tissue mineralization. I will also showcase our recent approaches that reveal where the bacterial 'microbiome of decay' originates and how these communities generate the steep geochemical gradients that drive – and bias – mineralization. Our experiments are designed to create a holistic framework for understanding the dynamics of soft tissue mineralization, fundamentally shifting the perception that exceptional fossils result not despite decay, but because of it.

Friday 12th December, Symposium, Portland Building PO 1.74, 14:15-14:45.

talks

Validating palaeoecological Computational Fluid Dynamics simulations using experiments

Harriet B. Drage[1], Stephen Pates[2,3,4], Nicholas J. Minter[5]
[1]*University of Lausanne, Switzerland;* [2]*University of Cambridge, UK;* [3]*University of Exeter, UK;* [4]*University College London, UK;* [5]*University of Portsmouth, UK*

Computational Fluid Dynamics (CFD) simulations are increasingly used to test palaeoecological hypotheses. These analyses output simulated velocity and pressure profiles and drag and lift forces values acting on a model. These outputs are internally consistent, assuming consistent parameters. However, many simulations lack validation at the flow speeds and animal sizes modelled, so the margins of error remain unquantified. Without having certainty in simulated outputs, we risk the resulting palaeoecological hypotheses lacking robustness. We present in-progress work producing a broadly applicable protocol for performing Experimental Fluid Dynamics (EFD) analyses to validate CFD results, and discuss the methodological considerations involved. We tested idealized sphere models against theoretical drag calculations, recorded lift forces and velocity profiles, and compared animal model results to published CFD simulations. Our sphere experimental results tracked theoretical drag force patterns reasonably well, though were too high in magnitude, while comparisons to an ammonite model almost exactly replicated data reported from simulations. Refinements to experimental protocol are under way, to develop a modifier by which experimental data can be adjusted to reflect theoretical data. We will then produce CFD-validation values for early Palaeozoic arthropod body plans. The protocol is available to support others with EFD validation of palaeoecological hypothesis-testing.

Friday 12th December, Symposium, Portland Building PO 1.74, 14:45-15:15.

Experimental insights into coccolithophore ecology and survival in past ocean stress events

Jelena Godrijan
Ruđer Bošković Institute, Croatia

Coccolithophores – key calcifying phytoplankton that dominate the calcareous nannofossil record – suffered near-total extinction at the Cretaceous–Palaeogene (K–Pg) boundary yet rebounded to become major drivers of the modern ocean carbon cycle. Their persistence through prolonged post-impact darkness remains a central question in marine palaeobiology. Unlike many diatoms and dinoflagellates, which form resting cysts, coccolithophores are not known to produce such protective stages, implying that other survival mechanisms must have been at play. Using an experimental approach with living coccolithophore analogues of K–Pg survivors, we tested physiological pathways that could enable persistence when photosynthesis fails. Laboratory and field experiments combining darkness incubations, radiotracer uptake, and flow-cytometric sorting show that coccolithophores can osmotrophically assimilate dissolved organic carbon, sustaining metabolism – and even limited calcification – without light. A fraction of this organic carbon is incorporated into cells inorganic pools, their calcite armour, linking osmotrophy to the biological and alkalinity pumps. Complementing these findings, emerging experimental work and genome analyses also indicate capacities of coccolithophores for bacterivory. Together, these results reveal under-recognized metabolic routes conferring

ecological flexibility under extreme stress and offer a mechanistic explanation for coccolithophore survival and evolutionary continuity across mass-extinction and other low-light events in Earth's history.

Friday 12th December, Symposium, Portland Building PO 1.74, 15:45-16:15.

Experimental misshapes, mistakes and misfits: sporomorph malformations and mass extinctions

Matthew S. Kent[1], Bas van de Schootbrugge[2], Cindy V. Looy[3], Ivo A.P. Duijnstee[3], Thijs R. A. Vandenbroucke[4], Barry H. Lomax[1]

[1]University of Nottingham, UK; [2]Utrecht University, the Netherlands; [3]University of California, Berkeley, USA; [4]Ghent University, Belgium

The sporomorphs (spore and pollen) fossil record is one of the richest records of past life available for palaeobiologists to study. This exceptional archive is a combination of productivity and preservation potential. As an example of this, Al Traverse suggested that an average hectare of woodland in eastern North America produces at least 3,000 litres of pollen per year, that a gram of siltstone can contain in excess of four million sporomorphs, and a single microscope slide can contain thousands of specimens. This unparalleled archive of past life allows for a detailed understanding of morphology and its biological variability. In turn this has led to the recognition that a number of mass extinctions and carbon cycle perturbations are evidenced by increases in the abundance of malformed sporomorphs. These malformations are postulated to have occurred through abiotic stress impacting on normal reproductive development, with UV-B radiation and volatile metals being identified as the primary drivers. Whilst the case for elevated UV-B and thus stratospheric ozone is well developed, work on the role of metals in driving malformations has received less attention. Using an experimental framework this presentation will discuss evidence for the role of metals in driving sporomorph malformations.

Friday 12th December, Symposium, Portland Building PO 1.74, 16:15-16:45.

Physiological insights as a bridge between palaeontological and geochemical records

Erik A. Sperling

Stanford University, USA

Oxygen and temperature are the two most important environmental parameters in controlling habitable space for animals in the ocean, and changes in these parameters are often invoked as driving mechanisms for evolutionary radiations and mass extinctions. However, it is rare for only one parameter to change in isolation, and because oxygen and temperature interact synergistically in determining an animal's aerobic scope, it can be difficult to understand their relative importance or test the null hypothesis that environmental change is simply correlated with, rather than causally responsible for, major events in evolution. The recently developed Metabolic Index relates the oxygen supply to an organism to its oxygen demand, calibrated using experimental respirometry and biogeographic data. Here, using examples from the Permian–Triassic mass extinction,

the Cambrian radiation and the modern ocean, we demonstrate how this framework can be used to understand the biological impact of oxygen and temperature change across a variety of timescales. In particular, new experimental results from brachiopods and crinoids demonstrate that the Palaeozoic fauna was more hypoxia tolerant, but also more temperature sensitive, than extant representatives of the Modern fauna, with implications for the cause of the Permian–Triassic mass extinction and ecological patterns in Palaeozoic oceans.

Friday 12th December, Symposium, Portland Building PO 1.74, 16:45-17:15.

Abstracts of oral presentations

* Candidates for the President's Prize are marked with an asterisk
Underlined author denotes designated speaker.

Biodiversity dynamics during the initial Devonian radiation of ammonoids

Ninon Allaire[1,2,3], Claude Monnet[3], Dieter Korn[4], Diego Balseiro[2], Catherine Crônier[3]
[1]Université Claude Bernard Lyon 1, France; [2]Universidad Nacional de Córdoba, Argentina; [3]Université de Lille, France; [4]Museum für Naturkunde, Berlin, Germany

Ammonoids are an extinct group of externally shelled cephalopods that first appeared in the Emsian (Early Devonian, *c.* 410 Ma). To explore their early evolutionary dynamics and the abiotic drivers that shaped them, ammonoid biodiversity was investigated throughout the Devonian. The study focuses on the Anti-Atlas (Morocco), which provides the most complete stratigraphic succession with well-documented assemblages and high-resolution biozonation. Biodiversity estimates, based on both raw species richness and sampling-standardized data, reveal highly fluctuating patterns marked by successive phases of diversification and decline. Maximum richness occurred in the Late Givetian, driven by the successive radiations of Agoniatitina, Anarcestina and Pharciceratina. This peak was followed by two major extinction events at the Givetian/Frasnian and Frasnian/Famennian boundaries (the Frasnes and Kellwasser crises). Nevertheless, a significant rebound took place in the Late Famennian with the rise of Clymeniina. A network analysis of ammonoid assemblages and extinction/origination dynamics (polycohorts) underscores the successive diversification of six evolutionary faunas. Transitions between them define five major turnover intervals, each of which coincides with Devonian global events or crises (Daleje, Choteč, Kačák, Kellwasser and Enkeberg). These results highlight the strong influence of environmental changes on the evolutionary trajectories of early ammonoids.

Sunday 14th December, Session 5C, Portland Building PO 1.74, 11:45 – 12:00.

Investigating ichnological characteristics of Ordovician braid deltas

Hamilton Allport*, Neil S. Davies
University of Cambridge, UK

Due to high global sea levels during the Ordovician, fluvial sedimentary sequences from this time have been argued to be rare when compared with other geological periods, and detailed facies analyses of units of this age are less abundant than for earlier and later periods. A corollary of this absence is the paucity of identifiably fluvially-influenced shallow marine environments. As such, ecological and ichnological assessments of these environments from this period remain sparse. This study assesses the trace fossils found in three Laurentian and peri-Laurentian braid delta successions to create a detailed ichnological description of those environments. These three examples from the Middle and Late Ordovician of Ireland and Canada include both transgressive and regressive sequences, as well as siliciclastic and carbonate facies. By accounting for the taphonomic differences in these varied settings and environments, this study presents a rigorous assessment of the original, registered and observable ichnodiversity and ichnodisparity from different facies within these successions. The implications of this study are expanded beyond the Ordovician by considering how volatile fluvially-influenced nearshore environments prior to the evolution of land plants may have affected registered ichnodiversity in a pre-vegetation world.

Sunday 14th December, Session 5B, Richmond Building RB LT2, 11:00 – 11:15.

talks

Variable mechanical properties given by the presence/absence of pigment molecules in insect cuticle

Nidia Álvarez-Amada, Craig Williams
University of Manchester, UK

Insects produce one of the most interesting natural composite materials from a mechanical and bioengineer perspective. Insect cuticle is a chitinous exoskeleton which functions mainly as a protective barrier against external factors and provides body support, but is also the source and storage of striking colourations (*i.e.* pigmentary and/or structural colour). Similarly to the degree of sclerotization, other mechanical properties, such as thickness, morphology and elasticity are important contributors to the preservation potential of insect cuticle in the fossil record. We hypothesize that the diversity and variability of mechanical properties in insect cuticles are also intrinsically linked to colour-producing mechanisms, resulting in large scale taxonomic and biological biases. We acquired temporal XRD-CT 3D maps at Diamond Light Source's Dual Imaging and Diffraction beamline (DIAD); resolving the crystallographic composition of insect cuticle and detecting evolving molecular affinities within colour-producing mechanisms under conditions of mechanical stress. The results suggest that the combination of melanin with other large molecules in the bio-composite (*i.e.* chitin) weakens the intermolecular bonds which allows molecules to 'slide' against each other, resulting in regions of the cuticle containing melanin being less resistant to indentation and penetration stresses and subsequently more prone to fragmentation during sedimentary transport.

Saturday 13th December, Session 3A, Richmond Building RB LT1, 15:30 – 15:45.

The character of the semi-enclosed Baltoscandian Basin during the Furongian (late Cambrian) and Tremadocian (early Ordovician)

J. Javier Álvaro[1], Lars Holmer[2], Mansoureh Ghobadipour[3], Leonid Popov[3], Per Ahlberg[4]
[1]*Instituto de Geociencias CSIC- UCM, Spain;* [2]*Uppsala University, Sweden;*
[3]*National Museum Cardiff, UK;* [4]*Lund University, Sweden*

The black Alum Shale is a kerogenous formation, forming throughout Baltoscandia from the Miaolingian to the Tremadocian. The base is transgressive and diachronous. Its thickness is highly variable (10–170 m). The shale exhibits remarkable lithological uniformity. The unit hosts evidence for episodes of fissuring and faulting associated with the precipitation of submarine polymetallic ore deposits (Pb-Zn-Fe-bearing), encrusted by authigenic ikaite + aragonite crusts, subsequently transformed into secondary calcite. Hydrothermal discharges graded from highly reduced, acidic, metalliferous and hot (~ 150 ºC) to slightly alkaline, calcium-rich and warm (< 100 ºC), controlling the precipitation of authigenic carbonates. New studies in Västergötland in Sweden have revealed networks of subvertical fractures and fissures, with walls encrusted by polymetallic ore deposits and carbonate crusts. The carbonate interbeds of the Alum Shale are commonly slumped, brecciated and even karstified, with their contacts lined and crosscut by crusts. Some karstic infillings reflect the influence of acidic hot waters and not of subaerial exposure. The record of these synsedimentary fracture networks, which provided favourable conduits and pathways for hydrothermal fluids, points to seafloor instability and generalized extensional tectonics. These episodes seem related to the definitive end of the semi-enclosed character of the Baltoscandian Basin and the persistent anoxia on its seafloor.

Sunday 14th December, Session 6B, Richmond Building RB LT2, 14:30 – 14:45.

Taphonomic insights into fossil preservation and accumulation in Tham Khao Phak Kut cave, Peninsular Thailand

Holly Anderson[1], Prasopsook Sritangwong[2], Jirasak Charoenmit[2], Nattanakorn Songpracha[3], Kantapon Suraprasit[4]

[1]*University of Warsaw, Poland;* [2]*Department of Mineral Resources, Surat Thani, Thailand;* [3]*Department of Mineral Resources, Bangkok, Thailand;* [4]*Chulalongkorn University, Thailand*

We present the first systematic taphonomic study of cave deposits from the newly discovered fossil sites in southern Thailand, namely Tham Khao Phak Kut cave (TKPK) in Ao Luek District, Krabi Province. Two loci, one in each terminal chamber of the cave, named TKPK 1 and TKPK 2, are studied. A moderate accumulation of fossils, consisting mostly of isolated teeth and bone fragments of small- to large-sized animals, was documented from sedimentary remnants on the cave walls and ceilings of these loci. The two Pleistocene vertebrate assemblages include primates, rodents, carnivorans, perissodactyls, artiodactyls, chiropterans, proboscids and birds (Aves), mostly analogous to an extant fauna in the modern rainforests of Peninsular Thailand, with the exception of the presence of three locally extinct taxa: *Pongo* sp., *Hystrix indica*, and *Naemorhedus goral*. The large mammal faunas from both loci are quite similar in composition and are suggested to be of late Middle to Late Pleistocene in age based on comparisons with those from other well-dated sites. Tham Khao Phak Kut likely reflects the formation of a fossil assemblage with two primary taphonomic pathways: a prime-aged dominated macrofauna component initially produced by natural accumulation but subsequently gnawed by porcupines and transported to the cave by short-distance colluvial flow, and a microfauna component likely accumulated by small carnivores. This study not only represents the first record of orangutan fossils in Peninsular Thailand but also provides helpful information for future chronological and palaeoenvironmental studies of the Pleistocene Pongo-associated fauna in mainland Southeast Asia.

Saturday 13th December, Session 3A, Richmond Building RB LT1, 14:45 – 15:00.

Exploring the supposed freshwater Mesozoic xiphosurids

Jonatan Audycki[1]*, Russell D. C. Bicknell[2,3], Grzegorz Niedźwiedzki[4,5], Andreas Hecker[6], Błażej Błażejowski[7,8], Kenneth De Baets[1]

[1]*University of Warsaw, Poland;* [2]*Flinders University, Australia;* [3]*American Museum of Natural History, USA;* [4]*Uppsala University, Sweden;* [5]*Polish Geological Institute, Poland;* [6]*Jura-Museum, Germany;* [7]*Polish Academy of Sciences, Poland;* [8]*Polish Academy of Sciences Museum of the Earth, Poland*

Horseshoe crabs are aquatic chelicerates iconic for their apparent morphological conservatism since at least the Middle Jurassic. While modern forms are marine, some fossil representatives have been highlighted as having a fully freshwater ecology. The predominantly Triassic austrolimulids are the most striking Mesozoic example, their 'extreme' morphology considered connected to freshwater colonization. New austrolimulid material from the Triassic of Poland evidences a marine influence, casting doubts on the freshwater hypothesis, demanding a re-examination of suggested freshwater Mesozoic xiphosurids. Our geometric morphometry and palaeobiogeographic analyses of Triassic xiphosurids demonstrate that the Polish horseshoe crabs are strikingly similar to Australian and North American species. Such wide distribution is more consistent with marine dispersal than a fully freshwater habitat. Additionally, almost all xiphosurid localities are reconstructed within or proximal to shallow marine areas, supporting a marine connection.

Preliminary examinations of sedimentology, stratigraphy, associated fossils and estimated distance from shorelines support a brackish or marginal marine rather than fully freshwater habitat of many purportedly non-marine xiphosurids, necessitating their additional detailed investigations.

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Sunday 14th December, Session 6B, Richmond Building RB LT2, 15:15 – 15:30.

Otoliths don't lie: metabolic secrets of Eocene fishes

Emily Ball[1,2]*, Clive N. Trueman[1], Richard J. Twitchett[2], James D. Witts[2]
[1]*University of Southampton, UK;* [2]*Natural History Museum, London, UK*

Fossils may retain direct geochemical records of metabolic rate, providing new insights into ecophysiology and metabolic adaptation across deep time. We aim to assess the extent to which stable isotope compositions of fossil fish otoliths (ear stones) can be used to interpret species-level variations in metabolic (activity) level and ecological niche space (mode of life). We validate the approach by exploring variations in otolith isotope compositions within a contemporary otolith assemblage (40 species from UK seas). We show that otolith isotope compositions alone provide accurate descriptions of known metabolic rates and ecological niche space. We then apply the new approach to an assemblage of fossil fish otoliths from the Eocene London Clay Formation, UK (~54 Ma; 10 oto-species). Metabolic rates inferred from carbon isotope values varied systematically among oto-species, consistent with recovery of physiological rates. Combining carbon and oxygen isotope values allows us to predict the niche space and palaeoecology these fossil fish occupied. We conclude that carbon isotopes can be used as a proxy for metabolic rate in the otolith fossil record and we can infer niche space from isotope values. This approach opens many opportunities to explore larger ecological questions in the fossil record.

Saturday 13th December, Session 2A, Richmond Building LT1, 11:00 – 11:15.

New data on the Late Triassic/Early Jurassic vertebrate faunas of Zimbabwe

Paul M. Barrett[1,2], Michel Zondo[2,3], Lara Sciscio[4], Darlington Munyikwa[5], Timothy Broderick[6], Kimberley E. J. Chapelle[2,7], Atashni Moopen[2], Jonah N. Choiniere[2]
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[5]*National Museums and Monuments, Zimbabwe;* [6]*Maraki, Zimbabwe;*
[7]*Stony Brook University, USA*

Zimbabwe hosts several Karoo-aged basins filled with thick successions of terrestrial sediments that range from Permian to Early Jurassic in age. Although highly fossiliferous, they have not been as extensively explored as the main Karoo Basin (MKB) of neighbouring South Africa and Lesotho. Fieldwork targeting the Late Triassic–Early Jurassic faunas of the mid-Zambezi and Tuli basins – along the shore of Lake Kariba and in the Limpopo Valley, respectively – has yielded the first evidence of freshwater biomes from southern Africa, new records of archosaurs (phytosaurs, dinosaurs) and lungfish taxa, and clarified the stratigraphical relationships of these beds with the MKB. Together with the re-appraisal

of historically collected material held in Zimbabwean museum collections, this has revealed that, surprisingly, there are no shared dinosaur taxa between the Zimbabwean basins and the MKB, undermining previously proposed biostratigraphical links. All the specimens recovered thus far belong to new species, many of which are from early-diverging lineages.

Saturday 13th December, Session 3B, Richmond Building RB LT2, 15:15 – 15:30.

Evolution on rugged terrain: how complex fitness landscapes shaped the Cambrian Explosion

Charles Bates[1,2]*, Russell J. Garwood[2,3], Luke A. Parry[1], Thomas Smith[4], Frances S. Dunn[4]
[1]*University of Oxford, UK;* [2]*Natural History Museum, London, UK;*
[3]*The University of Manchester, UK;* [4]*Oxford University Museum of Natural History, UK*

Understanding the origin of morphological variation is a fundamental question in evolutionary biology. Several studies have quantified Kingdom-level patterns in morphological disparity, but none have tested the myriad processes proposed to underpin them. One such process is the roughening of fitness landscapes, proposed as an explanation for the burst in animal disparity seen in the Cambrian Explosion. We use TREvoSim, an individual-based eco-evolutionary simulator, to test this idea in ways not possible using the fossil record alone: we modulate fitness landscapes through the introduction and removal of fitness peaks, also altering the degree of ecospace fragmentation and the strength of selection. We compare the resultant disparity and the 'clumpiness' of morphospace occupation, for which novel metrics are introduced. Disparity increases with increasing fragmentation of ecospace regardless of the presence of selection, but morphospace occupation only becomes clumpier under selection, suggesting that a combination of the two could explain the patterns in disparity produced by the Cambrian Explosion. More broadly, our results suggest that morphological disparity is an emergent property of fitness landscape roughness, and therefore that the roughening of fitness landscapes is a viable mechanism for saltational jumps in morphological disparity throughout the history of life on Earth.

Saturday 13th December, Session 2B, Richmond Building RB LT2, 12:15 – 12:30.

Reconciling molecular clocks and the fossil record in placental mammals

Mary Kate Branigan[1]*, Graham E. Budd[1], Richard Mann[2]
[1]*Uppsala University, Sweden;* [2]*University of Leeds, UK*

Molecular clock studies use fossil ages as calibration for the origin of clades; however, their results often estimate significantly older ages than what the fossil record suggests. This is of particular interest for placental mammals: molecular clock analyses place their origin before the K–Pg boundary, even though the oldest unequivocal crown-group fossils are after. We explored this discrepancy in the light of the new Covariant Evolutionary Tempo (CET) model that links molecular evolution and diversification. We ran molecular clock analyses with two calibrations: a deep one employed by previous studies and one after the K–Pg boundary, then compared inferred rates of lineage creation and molecular substitution across the placental mammals. Consistent with the CET model, the younger calibration identified high correlated early rates of lineage creation and molecular change. The deep calibration obscures this early burst by stretching the tree into the Cretaceous. Overall estimated rates are consistent with estimated mean molecular rates in mammals, and even

the early elevated rates with the younger calibration are within a plausible range. Our data provide powerful support for the CET model and allows for fossil and molecular clock estimates for the origin of crown group placentals to be reconciled.

Saturday 13th December, Session 3B, Richmond Building RB LT2, 14:45 – 15:00.

talks

Climate was not the only driver explaining the asymmetry of the Great American Biotic Interchange

Lucas Buffan[1]*, Adrián Castro Insua[2], Fabien L. Condamine[1], Sara Varela[2]
[1]Université de Montpellier, France; [2]Universidade de Vigo, Spain

The Great American Biotic Interchange (GABI) refers to the admixture of North and South American faunas promoted by the closure of the isthmus of Panama. Among land mammals, this faunal exchange was asymmetric because it witnessed a greater ability of North American lineages to establish southwards, meanwhile many South Americans went extinct. Here, coupling a mechanistic eco-evolutionary simulator with palaeoclimatic reconstructions for the last five million years, we explore the extent to which palaeoclimate, alone, may have shaped such a biogeographic asymmetry. When climatic variables are the only constraints to virtual species' dispersal, our results indicate that (1) successful interchanges are more frequently achieved when simulations start from South America than from North America, contrasting with empirical observations. In addition, (2) our models fail at explaining the higher representation of temperate-adapted mammals in the fossil record of successfully exchanged mammals, particularly of North American origin, but (3) suggest that successful colonizers from North America occupy larger areas in South America than the other way around. Hence, our findings stress that spatio-temporal palaeoclimate dynamics are not sufficient to explain the imbalanced success of North American migrants in South America following the GABI, suggesting the implication of additional biogeographic and ecological filters.

Sunday 14th December, Session 5B, Richmond Building RB LT2, 12:15 – 12:30.

Chitinotax: an open-access global database bridging traditional and digital chitinozoan research in the Palaeozoic

Sonia C. Camina[1], Jeremy R. Young[2], Anthony Butcher[3], Stephen Stukins[4]
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Online databases have become essential tools for accessing reliable taxonomic, biostratigraphic and biodiversity data. In early-middle Palaeozoic marine biostratigraphy, chitinozoans are key microfossils, yet existing databases such as CHITINOVOSP and CHITINOS are outdated and/or inaccessible. CHITDB remains complete and active but is regionally-focused on the Baltic area. This underscores the imminent need for a comprehensive, complete and globally-accessible database dedicated to chitinozoans. Over several years, the first author has compiled an extensive dataset covering all valid chitinozoan taxa, including detailed taxonomy, synonymy, biostratigraphic ranges and geographic occurrences. This resource is continuously updated and has proven extremely useful. To make this tool widely available, Chitinotax is being developed as an open-access, user-friendly system utilizing the well-established Mikrotax online platform. It aims to serve as a definitive and consistent reference for chitinozoan taxonomy and biostratigraphy,

supporting both traditional research and emerging technologies. Future integration with AI-based identification tools is projected, enhancing accessibility and analytical capabilities. Ultimately, this database seeks to inspire and empower future generations to engage with chitinozoan research, making data easily accessible and bridging the gap between traditional research and the new digital era.

Saturday 13th December, Session 3C, Portland Building PO 1.74, 15:15 – 15:30.

Interspecific competition in Avalon (Ediacaran) communities

Shujie Chang[1,2]*, Nile P. Stephenson[1,2], Frances S. Dunn[3], Andrea Manica[1], Emily G. Mitchell[1,2]
[1]University of Cambridge, UK; [2]University Museum of Zoology, University of Cambridge, UK; [3]Oxford University Museum of Natural History, UK

Competition is a fundamental ecological and evolutionary process, yet its role in the earliest animal communities remains unclear. The Avalon assemblage (574–560 Ma) represents the earliest known animal communities, with exceptional *in situ*, near-census preservation of soft-bodied, sessile organisms in Newfoundland, Canada, and Charnwood Forest, UK, enabling ecological analyses. We focused on five of 23 surfaces with sufficient abundances (n >30) to detect interspecific competition, yielding 36 taxon pairs. These data, alongside a new rangeomorph phylogeny, were used to test the competition–relatedness hypothesis and investigate how competition structured communities. We quantified horizontal competition (spatial segregation) using spatial point-pattern analyses and vertical competition (tiering) using Schoener's D, with a sliding-window across size classes to track ontogeny. We found tiering occurred twice as frequently as spatial segregation and competition shaped community structure via limiting similarity. Among upright fronds, phylogenetic distance did not correlate with either horizontal or vertical competition intensity. Contrasting patterns between reclining and upright taxa suggest that reclining morphs exhibited niche differentiation consistent with historical competition, whereas upright groups showed community- and ontogeny-dependent flexibility in height and ongoing competitive interactions. These results suggest that competition was key to structuring Avalon communities, with a transition between horizontal and vertical competition.

Sunday 14th December, Session 6C, Portland Building PO 1.74, 15:45 – 16:00.

The Brioverian–Cambrian transition in the Armorican Massif: straddling the boundary between horizontality and verticality

Jules Charrondière[1]*, Didier Néraudeau[1], Marc Poujol[1], Baptiste Coutret[2], Arnaud Mazurier[3], Isabelle Bihannic[4], Damien Gendry[1], Alfredo Loi[5]
[1]University of Rennes, CNRS, France; [2]University of Alberta, Canada; [3]University of Poitiers, France; [4]University of Rennes, OSERen, France; [5]University of Cagliari, Italy

The Armorican Massif (Brittany and Normandy, northwest France) provides a comprehensive geological documentation of the Cambrian Agronomic Revolution (around -538 Ma), marked by the evolution of seabed exploitation by benthic organisms, which shifted from an exclusively horizontal configuration to one incorporating a vertical burrowing component. The Brioverian shales of Brittany, believed to be latest Proterozoic, document typical horizontal ecosystems developed on marine substrates at the end of the Precambrian. Further north, in Normandy, Early Cambrian outcrops show the rapid diversification of trace fossils and the development of vertical burrowing.

However, at a centimetre scale, microtomographic analyses and thin sections of slates reveal that Brioverian trace fossils can be slightly oblique, almost vertical, and announce the Cambrian verticality. This calls into question the clear-cut nature of the Ediacaran–Cambrian boundary and suggests a more gradual transition than previously thought. These ichnological considerations are combined with U-Pb radiochronology on detrital zircons to discuss the age of the fossiliferous ichnofacies and identify the different stages of Ediacaran and Cambrian ichnostratigraphy.

Sunday 14th December, Session 4B, Portland Building PO 1.74, 09:45 – 10:00.

Climatic niche conservatism and the macroevolutionary history of crocodile-line archosaurs

Alfio Alessandro Chiarenza[1], Alexandra Howard[2], Grace Varnham[3], Alexander Farnsworth[4], Paul Valdes[4], Philip D. Mannion[1]

[1]University College London, UK; [2]Texas A&M University, USA; [3]University of Cambridge, UK; [4]University of Bristol, UK

Understanding whether abiotic niche evolution reflects intrinsic physiological constraints or adaptation to novel climates is a major macroevolutionary question. We compiled a comprehensive dataset for crocodile-line archosaurs (Pseudosuchia), combining >130,000 vetted extant and fossil occurrences, 52 palaeoclimate reconstructions (Middle Triassic–Recent), and a time-scaled phylogeny of over 500 species. Ecological niche models calibrated on living crocodylians were projected onto palaeogeographies to map climatic suitability, then linked to evolutionary models fitted to node-specific temperature and precipitation optima. Results reveal a strong, deep-rooted phylogenetic signal in thermal, but not hydric, tolerance: thermophily arose in crocodile-line archosaurs by the Early Jurassic. Jurassic and early Cenozoic poleward excursions represent transient tracking of a conserved niche, whereas Cretaceous and Oligocene cooling pruned high-latitude lineages. Model comparisons favour stabilizing selection punctuated by rare adaptive bursts, rejecting unconstrained drift. Projected suitable areas latitudinally peak in the Ypresian, contract from the Chattian and rebound in the Langhian, following temperature oscillations. We conclude that intrinsic thermal limits, rather than ecological opportunity, have constrained the macroevolution of crocodile-line archosaurs. This thermal inflexibility has shaped pseudosuchian biodiversity and distribution, imposing strong limits on their capacity to respond to rapid climate shifts, an evolutionary constraint with clear implications under ongoing anthropogenic warming.

Sunday 14th December, Session 6B, Richmond Building RB LT2, 15:30 – 15:45.

Casting light on melanosome geometry and visual strategies in fishes

Daniel Cirtina*, Maria E. McNamara

University College Cork, Ireland

Melanosomes, pigment-containing organelles, contribute to diverse physiological functions in vertebrates. In fish, ocular melanosomes underpin visual adaptation to ambient light, yet their contribution to optical performance is understudied. To address this, we analysed melanosome geometry in ten tissues across twelve extant fish species, spanning jawless (Agnatha), cartilaginous (Chondrichthyes), ray-finned (Actinopterygii) and lobe-finned (Sarcopterygii) lineages. Scanning electron microscopy coupled with statistical analysis

reveals pronounced phylogenetic patterns. The eyes of ray-finned fish possess cylindrical melanosomes, widely considered to be diagnostic of the retinal pigment epithelium. Unexpectedly, cylindrical melanosomes are absent in cartilaginous fish eyes, which instead exhibit exclusively spheroidal melanosomes. These geometries relate to distinct mechanisms for light regulation: ray-finned fish rely on melanosome motility through retinomotor response, while cartilaginous fish rely on pupillary modulation. Melanosome geometry mediates trade-offs between sensitivity and spatial resolution, functioning alongside other retinal structures to optimise vision across different habitat light regimes and diel activity. Melanosomes of internal organs, however, show little geometric variation across tissues and taxa, reflecting strong evolutionary constraints. Extending this framework to fossil taxa provides calibration points for shifts in melanosome geometry through deep time. Our data highlight the role of pigment innovations in shaping sensory evolution and ecological expansion in early vertebrates.

Sunday 14th December, Session 5A, Richmond Building RB LT1, 11:45 – 12:00.

Can we reconcile molecular and morphological clock discrepancies in a group with a rich fossil record?

Johnny Clavo Yamahuchi[1]*, Philip C. J. Donoghue[1], Christine M. Janis[1], Luke T. Holbrook[2], Joseph N. Keating[1]

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Establishing evolutionary timescales is key to understanding the history of life. Traditionally, these timescales were based solely on the fossil record, but modern studies increasingly rely on molecular clocks, which are particularly valuable for groups with sparse fossil records. However, in clades with rich fossil records, there is often a discrepancy between the estimated divergence of groups and their first occurrence in the fossil record. Recently, new methods that incorporate more fossil data have been developed. Yet there is currently no consensus as to which method is most accurate. Here we evaluate multiple dating approaches in perissodactyls, a group with an exceptionally well-documented fossil record that has long served as a model in evolutionary studies. We compare divergence estimates from molecular clock analyses of living species, morphological-clock analyses of both living and fossil species, and total-evidence analyses combining molecular and morphological data. Preliminary results show general agreement in divergence times for crown-perissodactyls across methods. However, analyses incorporating fossils yield unexpected topologies, producing large discrepancies between age estimates for both crown-equiids and crown-ceratomorpha. These results underscore how conflicts between morphological evidence, stratigraphic data and clock models can generate discordant age estimates, even in groups with outstanding fossil records.

Saturday 13th December, Session 2B, Richmond Building RB LT2, 11:45 – 12:00.

talks

Exploring the transition from the lower to the upper stem groups of arthropods: gaps and facts

Peiyun Cong
Yunnan University, China; Oxford University Museum of Natural History, UK

Currently, stem arthropod fossils are informally categorized as the lower stem groups (Radiodonta, 'gilled lobopodians' and their relatives) and the upper stem groups (fuxianhiids, 'bivalved forms', 'megacheirans' and arguably Artiopoda). Within the lower stem arthropods, it is widely accepted that radiodonts arose from a lobopodian grade and are the sister group of Deuteropoda, a clade including the upper stem groups and crown arthropods. However, within the upper stem arthropods, the uncertainty in determining the most basal group of Deuteropoda has hindered the understanding of arthropod origin, notably the transition from radiodont-like ancestors to euarthropod-like descendants. This difficulty is, at least partially, imposed by morphological gaps between Radiodonta and the upper stem arthropods. Here I outline the main morphological gaps between Radiodonta and Deuteropoda based on recent discoveries on the morphology of these two groups and present new evidence that can potentially fill these gaps. I propose that the transition from the lower- to the upper-stem arthropods was a much more complicated stepwise process than previously thought. The origin and evolution of several arthropod key characters, such as biramous appendages, exoskeleton (*e.g.* tergite and sternite), and head segment homologies, are discussed in this new light.

Sunday 14th December, Session 7, Richmond Building RB LT1, 16:45 – 17:00.

Prototaxites and friends: a unique extinct eukaryotic lineage

Laura Cooper[1]*, Coretin Loron[1], Michael Krings[2,3], Alexander J. Hetherington[1]
[1]University of Edinburgh, UK; [2]SNSB-Bayerische Staatssammlung für Paläontologie und Geologie, Germany; [3]Ludwig-Maximilians-Universität, Germany

A diversity of organisms from the Silurian–Devonian have been grouped within the Nematophytes, an informal group of fossils with a tubular microstructure. The most famous of these organisms is *Prototaxites*, some species of which are known from columnar 8 m tall fossils. This makes *Prototaxites* the largest continuous organism on the terrestrial surface until the appearance of large trees in the mid-Devonian. Additionally, *Prototaxites* and other nematophyte fossils are highly prevalent at many Devonian localities. Therefore, nematophytes had a considerable ecological impact during this period of revolutionary change to the Earth's surface. The taxonomic affinity of *Prototaxites* and other nematophytes has been debated extensively for over 150 years, with all major eukaryotic groups, with the exception of the Fungi, excluded. We demonstrate that the exceptionally-preserved nematophytes *Prototaxites* and *Nematoplexus* from the Rhynie chert are incompatible with a fungal classification owing to differences in anatomy to extinct and extant Fungi, and a distinct molecular fingerprint when contrasted with those of diverse contemporaneous taxa. This suggests that these nematophytes should be interpreted as members of an extinct higher-level eukaryotic lineage, and therefore that early terrestrial ecosystems should be reconsidered in the light of the impact of these morphologically and biochemically distinct organisms.

Sunday 14th December, Session 5B, Richmond Building RB LT2, 11:45 – 12:00.

The world's most diverse Early Ordovician fauna?

John C. W. Cope
University of Bristol, UK

The recent (2023) description of the small but varied tergomyan fauna from a small quarry in the Early Floian (Early Ordovician) of the Llangynog Inlier, Carmarthenshire, South Wales, UK, concluded the description of all the principal fossil groups from this locality. Bulk collecting over a decade yielded more than 60 species of fossils, making this probably the most diverse record from a single locality for fossils of this age. It has also provided one of the earliest examples of Sepkoski's Modern Fauna as its molluscan component makes up the largest part of its fauna (*c.* 72 %). Principal amongst this element is the bivalve fauna consisting of 20 species that is by far the most diverse bivalve fauna of this age and includes the earliest examples of several bivalve groups. Additionally, the quarry has also yielded a significant number of rarities, including the earliest examples of parablastoids, gorgonians and a calcified red alga. In view of the amount of material collected it is remarkable that some 11 species are represented by a single specimen. Other localities in South Wales of the same age lack the diversity of the fauna. Possible explanations for the diversity are considered.

Sunday 14th December, Session 4A, Richmond Building RB LT1, 09:45 – 10:00.

The unexpected role of sulphate-reducing bacteria in the replication of organic matter in aluminosilicates

Nora Corthésy[1]*, Camille Thomas[2], Farid Saleh[1]
[1]Universiy of Lausanne, Switzerland; [2]University of Bern, Switzerland

Microbes, through decay and mineralization, control what is preserved in the fossil record. While their role in replicating anatomies via phosphatization and pyritization is well established, it remains unclear whether soft tissue replication by aluminosilicates is mediated by microorganisms. Here we observed a black aluminosilicate film on shrimp decaying on kaolinite clay beds, faithfully replicating anatomical features. Shrimp tissues and sediments were sampled before and twice during the formation of the black film, and bacterial communities were identified using 16S rRNA sequencing. A marked increase in sulphate-reducing bacteria during film formation suggests that these microbes facilitate aluminosilicate precipitation, in addition to their role in pyrite formation. Sulphate reduction can generate bicarbonate, which could increase local alkalinity and promote silicon dissolution from the surrounding clays. When aluminium is abundant, as in many Cambrian Lagerstätten, new aluminosilicates can in turn precipitate. In iron-limited environments, sulphate-reducing bacteria may mediate organic templating in aluminosilicates rather than pyrite. This may explain the prevalence of aluminosilicates in sites where pyrite is not abundant, and vice versa. Overall, this work identifies a mechanism responsible for divergence in preservation modes of Burgess Shale-type assemblages, while highlighting a previously unrecognized role of sulphate-reducing bacteria in exceptional fossil preservation.

Saturday 13th December, Session 3A, Richmond Building RB LT1, 15:15 – 15:30.

talks

Larger foraminifera as archives of intra-annual temperature variation

Laura J. Cotton[1], David Evans[2], Max Fursman[3], Wolfgang Müller[3], Willem Renema[4], Paul N. Pearson[5]

[1]*Natural History Museum Denmark, Denmark;* [2]*University of Southampton, UK;* [3]*Goethe University Frankfurt, Germany;* [4]*Naturalis Biodiversity Center, the Netherlands;* [5]*University College London, UK*

Corals, otoliths, molluscs and foraminifera all produce growth-banded shells, which can be subsampled to produce records of intra-annual variation in Earth's past. However, foraminifera remain under-used for this purpose, with only a handful of studies to date. In particular, the larger foraminifera remain a largely untapped archive of past intra-annual changes. Here we use laser ablation ICPMS to generate continuous Mg/Ca records along the spiral whorl of *Nummulites* from the early Oligocene of Tanzania. Using *in situ* temperature logger data in a modern tropical setting, the variability of this Mg/Ca palaeothermometer was calibrated utilizing corresponding Mg/Ca profiles from related modern species. Our results constrain a mean annual temperature of 29.7±3.9°C, comparable with the oxygen isotope and TEX86 sea surface temperatures in previous studies from Tanzania, and intra/inter-annual temperature variability of ±2.3–3.0°C. This is similar to both modern values for the region and sparse existing Oligocene seasonal data from the USA. Our records thus contribute to unravelling Oligocene climate, and highlight the potential of larger foraminifera in filling the key seasonality gap in our understanding of past climates.

Saturday 13th December, Session 3C, Portland Building PO 1.74, 14:45 – 15:00.

Vegetation-induced sedimentary structures (VISS): their biogeomorphological, sedimentological and evolutionary significance

James Craig*, Neil S. Davies, William J. McMahon

University of Cambridge, UK

Vegetation-induced sedimentary structures (VISS) provide tangible evidence of plants mediating sedimentation and erosion in ancient environments, because they represent primary sedimentary structures formed from direct plant-sediment or plant-hydrodynamic interactions. VISS are pervasive in modern landscapes but under-reported from the geological record. We review the morphological diversity and formative mechanisms of ancient VISS, illustrating examples from a range of sedimentary and fossil contexts to aid future identification. Several instances of VISS are recognized without concomitant fossil vegetation, providing expanded evolutionary records from environments where fossil preservation was unfavourable. The small spatiotemporal scale of VISS renders them high-resolution records of local-scale biogeomorphic processes, and we further explain how they provide small-scale windows onto larger-scale biogeomorphology. The stratigraphic distribution of VISS is discussed in relation to plant evolution; from their first appearance in Lower Devonian strata, their expansion through to the Pennsylvanian in line with the progressive evolution of rooting, arborescence and forestation, and their occurrences through the Mesozoic and Cenozoic.Particular attention is paid to latest Pennsylvanian–Permian strata, which record a transition from lycopsid-dominated 'coal swamps' to conifer-dominated drylands. Taphonomic conditions discourage plant preservation in drylands and vegetation appears superficially scarce, but VISS reveal early conifers as important biogeomorphic agents.

Sunday 14th December, Session 5B, Richmond Building RB LT2, 11:15 – 11:30.

Investigating the functional morphology of iguanodontian thumb spikes

Emily Driscoll*, David J. Button, Joseph N. Keating
University of Bristol, UK

The conical thumb spike seen in many iguanodontian dinosaurs is a quintessential example of a unique and enigmatic structure that is absent from extant biodiversity. Despite rampant speculation since the discovery of iguanodontians in the nineteenth century, the function of this spike has remained a mystery for 200 years. Here we apply a multifaceted approach to investigate the four previously-suggested functional drivers for thumb spike morphology: use as a stabbing weapon; for cracking fruit; for raking foliage during foraging; and inter- or intra-specific display. First, we quantified the relative shape and evolution of the spike using geometric morphometrics and ancestral state reconstructions. Second, functional analyses investigated the forelimb range of motion to falsify hypothesized uses, and the spike's biomechanical performance under simulated functional scenarios using finite element analysis. Overall, shape analysis and ancestral state reconstructions reject cracking and raking drivers of spike evolution, and stabbing for predatory defence seems unlikely due to limited forelimb mobility. Intraspecific combat and ornamental signalling remain the only hypothesized drivers of spike evolution plausible under all analyses. We highlight how the technological revolution in palaeontology allows us to revisit classic behavioural hypotheses, here quantitatively narrowing down potential explanations for a centuries-old mystery for the first time.

Funded by the University of Bristol MSc project fund and Bob Savage Memorial Fund.

Saturday 13th December, Session 2A, Richmond Building LT1, 11:15 – 11:30.

Description of one of the oldest crinoids shows a unique mix of crinoid and edrioasteroid features

Christophe Dupichaud[1]*, Tom Guensburg[2], Forest Gahn[3], Rich Mooi[4], Martina Nohejlová[5], Bertrand Lefebvre[1]
[1]*Université Claude Bernard Lyon 1, France;* [2]*Field Museum, USA;* [3]*Brigham Young University, USA;* [4]*California Academy of Sciences, USA;* [5]*Czech Geological Survey, Czechia*

A new occurrence of stem crinoid has been found in the Saint-Chinian Formation, late Tremadocian (Ordovician of France). This specimen is preserved as a mould encased in an alumino-siliceous concretion, resulting in a slightly flattened, but almost complete preservation in 3D. Latex casting and 3D segmentation allowed for a thorough description of a new crinoid genus. This stem crinoid harbours a unique mix of traits from the earliest crinoids (unbranched pinnule-less arms, calcified rows of floor plates, and a stem made of pentamerous rings), more derived disparid crinoids (calyx composed only of infrabasal and radial plates), and edrioasteroids (large floor plates adorned by squared primary cover plates and secondary cover plates). Those morphological specificities being found in one of the oldest crinoid occurrences may hint at the evolution of the class Crinoidea from edrioasteroids.

Sunday 14th December, Session 4B, Portland Building PO 1.74, 10:15 – 10:30.

talks

Novel insights into fossil ecdysozoans from the Sirius Passet Lagerstätte (Cambrian Series 2, Stage 3, North Greenland)

Thomas P. Farrell[1,2*], Gregory D. Edgecombe[2], Tae-Yoon S. Park[3,4] Jakob Vinther[1]
[1]*University of Bristol, UK;* [2]*Natural History Museum, London, UK;* [3]*Korea Polar Research Institute, Republic of Korea;* [4]*University of Science and Technology, Republic of Korea*

The Cambrian-aged Sirius Passet Lagerstätte hosts a wealth of exceptionally-preserved, soft-bodied animal fossils, offering a crucial window on to animal evolution during the Cambrian Explosion. However, its remote location in North Greenland, only 800 km from the North Pole, has limited collecting efforts. Much collected material remains undescribed, leaving its published diversity low compared to other Cambrian Konservat-Lagerstätten. Ecdysozoans are well-represented in Sirius Passet by arthropods, while ecdysozoan worms (*e.g.* 'Cycloneuralia') make up a smaller portion of its described diversity. However, the latter include unusually robust palaeoscolecids and unique, giant stem-group loriciferans. Here we survey the ecdysozoan worms of Sirius Passet with new fossil data including three new worms: an aberrant palaeoscolecid, a priapulidan, and a cambroclave animal. Our complete cambroclave specimens preserve soft tissues which confirm the group's identity as macroscopic scalidophoran worms and reveal a close affinity to the meiofaunal kinorhynchs and loriciferans. Together, these new taxa expand the diversity and disparity of the fauna in Sirius Passet and emphasize its uniqueness among Cambrian Lagerstätten.

Sunday 14th December, Session 6C, Portland Building PO 1.74, 15:00 – 15:15.

Dynamics and drivers of the first radiation of ray-finned fish in a spatially controlled framework

Joseph Flannery-Sutherland, Sam Giles
University of Birmingham, UK

Ray-finned fish (Actinopterygii) first became prominent components of vertebrate ecosystems in association with the end-Devonian Hangenberg extinction event, accruing substantial diversity through the Palaeozoic until the emergence of their major extant lineages in the Permian and Triassic. The timing of their initial diversification remains contentious, however, due to conflict between phylogenetic and taxonomic signals, while the drivers of their wider rise to prominence are unclear. To overcome the issues of spatiotemporally and taxonomically uneven sampling which plague their fossil record more generally, we analyse a taxonomically comprehensive occurrence database of all known early actinopterygians in a spatially controlled framework. We use analytical tools rooted in the birth–death process that underpin phylogenetic diversification rate analyses, but without the requirement of a resolved tree. We obtain diversification-rate estimates for early actinopterygians which are compatible with both their total fossil record and the statistical requirements of their underlying yet incompletely known phylogeny. We then infer the drivers of their Palaeozoic radiation using AI-extensions to this birth–death framework. We use these results to elucidate the stratigraphic relationship between the Hangenberg event and the first explosive radiation of actinopterygians, along with the biotic and abiotic controls on their rise to prominence.

Sunday 14th December, Session 5C, Portland Building PO 1.74, 11:00 – 11:15.

Tomographic analysis of an exceptionally-preserved bilaterian larva from the Cambrian of Mongolia

Kirsten Flett[1]*, Michael Steiner[2,3], Philip C. J. Donoghue[1]
[1]*University of Bristol, UK;* [2]*Shandong University of Science and Technology, China;*
[3]*Freie Universität Berlin, Germany*

The origin of animal bodyplans was a consequence of developmental evolution. Insights into these episodes of evolution are constrained because the development of living animals is derived and there is a paucity of fossils preserving early developmental stages. Here we present the results of a high-resolution tomographic investigation of post-embryonic developmental stages of a metameric bilaterian from the Cambrian Salanygol Formation of Mongolia. Using synchrotron radiation X-ray tomographic microscopy (srXTM) and computed tomography we analysed eight specimens. These exceptionally-preserved phosphatized fossils co-occur with isolated sclerites of camenellan tommotiids, to which they have been attributed. These fossils are entirely soft-bodied developmental stages and are preserved to a cellular level of resolution, though this appears limited to a single layer of hemispherical to cuboid epithelial cells that exhibit variation in the nature of their preservation, though apparently limited to the cell walls which are often infilled by later diagenetic cements. The tomographic data clarify uncertainties concerning the external anatomy of developmental stages and constrain interpretations of their internal anatomy. We consider the implications of these results for their proposed camenellan affinity, as well as their evolutionary implications.

Sunday 14th December, Session 6C, Portland Building PO 1.74, 15:15 – 15:30.

Range size or thermal tolerance: exploring climatic and environmental controls on bivalve biogeography

Sarah C. Gale[1]*, Katie S. Collins[2], Shan Huang[1]
[1]*University of Birmingham, UK;* [2]*Natural History Museum, London, UK*

Here we examine changes in the global distribution of bivalve species from seven Pliocene sites between their time of deposition and the present, and find patterns of regional extinction that suggest wide-ranging species may not only conform to the expected pattern of lower extinction risk globally, but also appear to have a lower risk of local extinction as well – suggesting these species are not simply surviving in refugia, but have always been more resilient overall. These patterns may be useful in understanding extinction vulnerability amongst marine bivalves across sudden climatic change – in this case the Plio–Pleistocene transition around 2.3 million years ago – and applying this to modern climatic change. The modern marine Bivalvia are under-monitored compared to many terrestrial species, with very few having undergone formal IUCN assessment for extinction risk. We identify groups which we may expect to become exceptionally resilient or vulnerable in the near future using the fossil record of their lineages. We then compare species distribution and realized thermal niche for taxa since the Pliocene, and explore the likelihood of persistent bivalve groups being efficient re-invaders, or simply being exceptionally resilient to changes in climate. We also explore ecological functions as correlates of extinction risk, besides thermal tolerance.

Sunday 14th December, Session 5C, Portland Building PO 1.74, 12:00 – 12:15.

talks

A decade of spinosaurids: is the UK a centre for a golden age in spinosaurid research?

Neil J. Gostling[1], Chris T. Barker[1], Darren Naish[1], Jeremy Lockwood[2]
[1]University of Southampton, UK; [2]Natural History Museum, London, UK

Spinosaurids – large to gigantic, semiaquatic, long-snouted megalosauroid theropods – are among the most controversial of dinosaurs. Discovered in 1983, Baryonyx from the Lower Cretaceous Wealden Supergroup of Surrey, UK, revealed western Europe is globally important in our understanding of these dinosaurs. Recent finds that span the Valanginian to upper Barremian deposits of the Wealden succession include *Ceratosuchops* and *Riparovenator* from the Wessex Formation, and fragmentary remains of a giant possible spinosaurine from the Vectis Formation of the Isle of Wight. Along with studies of isolated teeth, suggesting that additional spinosaurid lineages await documentation in other parts of the Wealden, these discoveries imply that spinosaurids originated in western Europe. As a multidisciplinary team, we seek to understand these animals in an evolutionary and biomechanical framework, including hydrodynamics and feeding ecology. We are exploring the origins and dispersal pattens of Spinosauridae using time-calibrated Bayesian inference analyses, integrating important South American specimens into an updated character matrix. We will evaluate the impact of these operational taxonomic units on tree topologies and divergence times to compare these results with previously proposed palaeobiogeographical hypotheses and investigate the phylogenetic positions of the Wealden spinosaurid material. With more finds and new taxa, Southern England is a spinosaurid hot spot!

Sunday 14th December, Session 4A, Richmond Building RB LT1, 09:15 – 09:30.

Curved tracks from straight toes: kinematics distorting morphology in tridactyl penetrative tracks

Benjamin Griffin, Tash Prescott, Andreás Jannel, Peter Falkingham
Liverpool John Moores University, UK

Tridactyl dinosaur tracks occasionally present highly curved impressions of digits II and IV (the side toes). This curvature is not tied to anatomy of the trackmaker, but to the complex foot–sediment interaction during track formation. If curving digit impressions are a result of specific foot kinematics, they may offer insight into the locomotion and stability of dinosaurs in deformable substrates. To determine how toe curvature occurs in fossil tracks we conducted a series of simulations with the discrete element method. Using a simplified functionally tridactyl foot model, in which all toes are straight cylinders, we tested a variety of foot and toe motions including foot sliding, adduction and abduction of the outer digits, and entry angle of the foot model. Virtual surface and sub-surface layers were digitally exposed, and trace morphology was compared qualitatively and quantitatively. Our models show that abduction of outer toes during descent through sediment increases the likelihood of forward-directed curvature. Outward-directed curvature tends to occur with toe adduction when the foot is angled so the digits enter the sediment first. Examination of bird-like wider-angled toe models were found to be no more likely to produce toe curvature than narrower-toed more dinosaurian models.

Saturday 13th December, Session 1, Richmond Building LT1, 09:45 – 10:00.

Early Cenozoic mammal radiation coincides with increased terrestrial habitability

Nicholas Hadjigavriel, Alexander M. Dunhill, Khushboo Gurung, Benjamin J. W. Mills
University of Leeds, UK

Environmental variables like temperature, atmospheric oxygen, land availability and food availability constrain the ecological niches of terrestrial animals, and likely had a direct effect on their evolution and distribution over geological time. In this study we develop an agent-based palaeoecological model, which we couple to an Earth system model to reconstruct how Earth's habitability for terrestrial mammals has changed over the late Mesozoic to Cenozoic eras. This allows us to investigate whether there was an environmental component to the early Cenozoic mammal radiation. Our findings indicate that Earth's habitability for terrestrial mammals was maximised during the Cretaceous–Palaeogene interval, due to the combination of elevated plant net primary productivity (NPP), expansion of continental land areas, minimal glaciation, and elevated atmospheric oxygen levels. We propose that the rapid diversification of mammals during this period, while clearly enabled by the extinction of non-avian dinosaurs, was also influenced by the enhanced habitability of Earth's surface during this time. Similar environmentally-driven changes in terrestrial habitability may also play a significant role for other geological periods and events.

Saturday 13th December, Session 3B, Richmond Building RB LT2, 15:00 – 15:15.

Phylogenetic inference from an incomplete fossil record

Niklas Hohmann[1]*, Rachel C. M. Warnock[2], Emilia Jarochowska[1]
[1]*Utrecht University, the Netherlands;* [2]*FAU Erlangen-Nürnberg, Germany*

Temporal and morphological data derived from fossils are a crucial component of the construction of time trees. However, the non-uniform incompleteness of the fossil record still poses a huge challenge for time tree inference. Sequence stratigraphy predicts the location and duration of gaps in the stratigraphic record, showing that this incompleteness is highly structured and can be understood using expert geological knowledge. We explore the effects of the incompleteness of the fossil record on the precision and accuracy of phylogenetic inference by combining forward models of carbonate platform growth with simulations under the fossilized birth–death model, and try to recover the 'true' evolutionary history from the resulting synthetic fossil record. We find that when accounting for prior knowledge of sampling, the structure of the fossil record does not bias phylogenetic inference. Incorporating geological expert knowledge on the positions and durations of gaps in the form of informative priors improves phylogenetic inference. Interestingly, we find that geological parameters can be recovered from phylogenies. Our results demonstrate that it is possible to incorporate geological knowledge into phylogenetic inferences, and that a detailed understanding of stratigraphic architectures improves phylogenetic reconstructions.

Saturday 13th December, Session 2B, Richmond Building RB LT2, 12:00 – 12:15.

talks

Reconstructing spore evolution recalibrates the timescale of land plant diversification

Jack Hooper[1]*, Annabel Worth[1], Charles H. Wellman[2], James Clark[3], Philip C. J. Donoghue[1]
[1]University of Bristol, UK; [2]University of Sheffield, UK; [3]University of Bath, UK

The origin and evolution of land plants precipitated fundamental changes to the Earth system and enabled the diversification of life on land. Their early evolution is documented by a rich fossil record of sporopollenin-walled spores that is difficult to interpret because the evolution of plant spore characteristics is unresolved. We employ a suite of ancestral state estimation methods to elucidate the pattern of spore character evolution among land plants. We find that the ancestral embryophyte underwent monoplastidic meiosis and produced unenveloped spores with a three-layered sporoderm. We infer that trilete spores, traditionally considered a feature of vascular plants, were produced by the crown-embryophyte. We recalibrate the molecular timescale of early land plant evolution based on a reinterpretation of the fossil record in this light. We find that crown-embryophytes originated in the Late Ordovician (457–450 Ma) and that both crown-tracheophytes (432– 428 Ma) and crown-bryophytes (445–429 Ma) diverged in the lower Silurian. Our results call into question the hypothesized link between crown embryophytes and the onset of late-Ordovician glaciation.

Saturday 13th December, Session 3C, Portland Building PO 1.74, 14:30 – 14:45.

Ocean circulation modelling linked to Lagrangian particle transport to explore connectivity of Mesozoic methane seep communities

Stephen J. Hunter[1], Crispin T. S. Little[1], Steffen Kiel[2], Alan M. Haywood[1]
[1]University of Leeds, UK; [2]Swedish Museum of Natural History, Sweden

In recent years a range of sophisticated methods have been developed that use physical first principles to model palaeoclimates and linked ocean circulation systems. These have been commonly applied to Cenozoic time periods, but less so for the Mesozoic and Palaeozoic, partly because the models rely on robust palaeogeographic reconstructions. In this study we use a MITgcm ocean model to simulate global ocean conditions for the latest Jurassic to early Cretaceous time periods and link this to a Lagrangian particle transport model. Lagrangian particle transport has been used in modern oceanography to predict the movement of passively floating objects, such as plastic pollution and marine animal larvae. Here we use it to predict the transport of larvae between known latest Jurassic to early Cretaceous methane seep communities, which can be considered as benthic 'islands' on the contemporary seafloor. We then test the veracity of the models with cluster analysis of the faunas from the same seep communities. Whilst our test case uses a relatively specialized marine palaeocommunity, the methodology could be applied to many other time periods and communities to explore palaeobiogeographic questions.

Sunday 14th December, Session 6B, Richmond Building RB LT2, 14:45 – 15:00.

Insights into the locomotor modes of giant extinct kangaroos from vertebral morphology

Megan Jones[1,2,3]*, Andrew Pask[3], Axel Newton[3], Katrina Jones[1,2]
[1]University of Bristol, UK; [2]The University of Manchester, UK; [3]University of Melbourne, Australia

Prior to the Australian Pleistocene megafaunal extinctions, kangaroos reached much greater body sizes than we see today, sometimes exceeding twice the weight of the heaviest extant kangaroo. This raises the question of what gaits giant kangaroos used. Were they able to hop? Could they use a pentapedal slow gait? Research to date has focused on hindlimb morphology, but the spinal column also has biomechanical significance in locomotion. Here we perform 3D geometric morphometric analyses of the vertebrae of extant (n=82) and extinct (n=41) kangaroos, to test how vertebral morphology varies by locomotor mode among living species, and compare it to the megafaunal species. We find that among living kangaroos, arboreal species display divergent morphologies throughout the spinal column; meanwhile, pentapedal species are primarily distinguished from more generalist kangaroos in the proximal tail. We also find that the megafaunal kangaroos possess novel vertebral morphologies, unlike any seen today. The lumbar vertebral morphology of the short-faced sthenurines possibly suggests increased resistance to ventral bending. Meanwhile, their proximal tail vertebrae more closely resemble the tails of the arboreal kangaroos than today's large kangaroos, supporting prior suggestions that the sthenurines may have used bipedal striding, rather than pentapedal walking, as their primary slow gait.

Saturday 13th December, Session 2A, Richmond Building LT1, 11:45 – 12:00.

Big birds, big data: palaeognath phylogeny tested using morphology, DNA and ancient collagen

Joseph N. Keating[1], Edmund R. R. Moody[2], Andrew Kitchener[3], Michael Buckley[4]
[1]University of Bristol, UK; [2]Universitat de Barcelona, Spain; [3]National Museums of Scotland, UK; [4]The University of Manchester, UK

Palaeognaths, the sister group to all other living birds, are key to understanding avian evolution, yet their relationships remain debated. Morphological studies group all flightless species together, placing volant tinamous as their sister lineage. In contrast, most molecular studies place ostriches as sister to all other palaeognaths, with tinamous nested amongst flightless lineages. Ancient DNA and palaeoproteomic studies have complicated matters further by placing elephant birds with kiwis and moas with tinamous, contradicting both morphology and biogeography. Here we present new ancient collagen sequences from elephant birds and moas, demonstrating the value of palaeoproteomics for phylogenetic inference. Our total-evidence approach, integrating morphology, DNA and ancient collagen, supports a novel topology: Rheiformes and Casuariiformes are sister to a clade containing elephant birds, kiwis, tinamous and moas. Comparative tests across all 10,395 possible topologies identified 21 additional plausible trees, underscoring high phylogenetic uncertainty. While some relationships are robust (ostriches as sister to all others; tinamous as sister to moas), most remain ambiguous, likely due to rapid radiation following the K–Pg extinction and incomplete lineage sorting. Our findings underscore the need for expanded sequencing of extinct lineages to fully resolve palaeognath evolutionary history.

Saturday 13th December, Session 1, Richmond Building LT1, 10:15 – 10:30.

talks

Flammability and functional traits in conifers: evolutionary perspectives from the fossil record

Rebecca A. Koll[1], Claire M. Belcher[1], Cindy V. Looy[2], William A. DiMichele[3]
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Wildfire has been a fundamental force in shaping terrestrial ecosystems, with plant traits both responding to and influencing fire behaviour. Yet, the evolutionary origins and trajectories of flammability-related traits remain poorly resolved, particularly in conifers, one of the most widespread and ecologically significant plant lineages. With global change driving more frequent and severe fires, questions of trait conservation, plasticity and adaptive capacity are increasingly critical for predicting biodiversity responses and ecosystem resilience. This study integrates fossil evidence with experimental analyses of modern conifers to examine the role of leaf- and shoot-level traits in shaping fire behaviour across deep time. Fossil trait reconstructions illuminate the persistence and loss of key morphologies during major climatic transitions, while complementary experiments with extant species assess the functional significance and variability of traits under environmental stress. By bridging palaeobotany and experimental ecology, this research highlights the interplay between climate variability, plant functional traits and fire regimes in shaping evolutionary fitness. Viewed through a deep-time lens, this work provides new insight into the evolutionary pressures exerted by fire, the circumstances under which flammability traits arise or are lost, and the role of disturbance in shaping the long-term trajectories of plant lineages.

Sunday 14th December, Session 7, Richmond Building RB LT1, 17:00 – 17:15.

Multi-scale community dynamics revealed by Bayesian network analysis in the Ediacaran Shibantan biota, South China

Yarong Liu[1,2,3]*, Emily G. Mitchell[3,4], Xunlai Yuan[1], Zhe Chen[1]
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The Ediacaran Period marks the emergence of the earliest complex ecosystems, offering key insights into metazoan evolution. The Shibantan biota of South China, preserved in carbonate rocks with both body and trace fossils, provides a unique record of ecological transitions near the White Sea–Nama boundary. Sedimentological evidence indicates an environment of enhanced hydrodynamic energy and intensified storm disturbance from the lower to middle parts of the Shibantan Member. To explore species interactions and community dynamics, we applied Bayesian network analysis to infer probabilistic dependencies among taxa and identify key interactions structuring the community. High-resolution analysis of a 2 m interval in the lower part reveals coexistence of typical White Sea taxa with Shibantan-specific taxa, reflecting short-term fluctuations in community composition. At a broader scale, comparison of intervals separated by ~70 m shows restructuring of species composition and diversity, including increased proportions of tubular fossils and declining body fossil diversity. Concurrently, rising trace fossil diversity and behavioural differentiation indicate intensified biotic disturbances. Multi-scale probabilistic modelling demonstrates that the Shibantan assemblage captures both short-

term coexistence and broader community restructuring, providing insights into biotic–environmental feedbacks during a formative stage of early complex ecosystem evolution.

Saturday 13th December, Session 2C, Portland Building PO 1.74, 11:15 – 11:30.

3D morphologies of early Cambrian arthropods from Chengjiang biota

Yu Liu[1], Xianguang Hou[1,2]

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The 'Cambrian Explosion' represents one of the most important events in the evolution of metazoans. Evidence of this event has been found in various Lagerstätten from all over the world, among which the Chengjiang biota, located in Yunnan Province, southwest China, provides unparalleled fossils of over 300 species from the early Cambrian. More than 80 Chengjiang species belong to the most abundant animal group throughout the entire span of geological time: the Arthropoda. Knowing the morphologies of these animals is fundamental to understanding their evolutionary history and ecological traits, which then reflect the co-evolution of these widespread animals and the environment they used to live in. For a long time, due to limitations of methods, researchers have been able to extract only little information, mostly from the surface of the fossils. Little has been known about the important soft-body structures on the ventral side of the Chengjiang arthropods. In recent years, my team has conducted in-depth research on various Chengjiang arthropods from multiple perspectives such as 3D morphology, ontogeny and phylogeny by using micro-CT scanning, computer-based 3D rendering, and virtual anatomical dissection techniques. New information that had long been overlooked has now been discovered and certain progress has been made.

Saturday 13th December, Session 1, Richmond Building LT1, 10:00 – 10:15.

New multidiciplinary insights into trilobite respiration

Sarah R. Losso[1], Federica Vallefuoco[2], Igino Foglia[2], Léo Laborieux[3], Ana Belén Muñoz-García[2], Javier Ortega-Hernández[1]

[1]Harvard University, USA; [2]University of Naples Federico II, Italy; [3]University of Michigan, USA

Trilobites had biramous appendages with an inner endopodite (walking leg) and outer exopodite (gill) connected to the body through the protopodite (limb base). Whereas endopodite and protopodite were involved in both locomotion and feeding, the exopodite has been subject to various functional interpretations including respiration, ventilation and swimming. Evidence from sites with exceptional fossil preservation indicate that trilobite exopodites show substantial variability in terms of the number and size of their articles, lamellae and setae, but the implications of this morphological diversity have never been investigated. We created 3D models of two species with diverse exopodite morphology, *Olenoides serratus* and *Triarthrus eatoni*, to calculate lamellae surface area and test fluid flow patterns. Additionally, lamellae surface area was calculated from nine other species to compare gill surface area per biomass with modern taxa. Trilobites exhibit similar gill surface area as modern crabs and shrimp, but environment, behaviour and activity level are known to impact this in the extant species. Computational fluid dynamics of these exopodites shows that decreases in flow rate between lamellae does not significantly increase oxygen diffusion into the gills. The broad exopodite articles in *O. serratus* generate more lift and drag than the narrow morphology seen in *T. eatoni*.

Sunday 14th December, Session 6A, Richmond Building RB LT1, 15:45 – 16:00.

talks

Dinosaur of the round table: redescribing *Camelotia borealis* highlights its importance to our understanding of sauropod origins

Jack Lovegrove[1,2]*, Samantha L. Beeston[2], Philip D. Mannion[2], Paul Upchurch[2], Paul M. Barrett[1,2]
[1]*Natural History Museum, London, UK;* [2]*University College London, UK*

Camelotia borealis was named in 1985, but the holotype was collected nearly a century earlier from the Late Triassic Westbury Formation in Somerset. The Late Triassic is considered a key period in the evolution of dinosaurs. *Camelotia* is known from well-dated marine strata, unlike most British Late Triassic dinosaurs which are known from 'fissure' deposits with controversial dating. *Camelotia* is also significant for its large size for a Triassic dinosaur and its consistent recovery as close to the origin of sauropods. Our understanding of sauropodiform evolution has advanced considerably, driven primarily by new taxa from the Southern Hemisphere. Uncertainties over *Camelotia*'s phylogenetic position suggest it is ripe for redescription. Surface scanning of the material has enabled its anatomy to be described in detail. This description highlights the presence of several derived sauropod traits in *Camelotia*. Phylogenetic results based on a data matrix (80 taxa, 419 characters) recover *Camelotia* as a lessemsaurid. The recovery of two European taxa as lessemsaurids suggests that the Northern Hemisphere may be more important to sauropod origins than an uncritical reading of the fossil record suggests.

JL is funded by the NERC (NE/S007729/1) and a Palaeontographical Society Richard Owen Research Fund grant.

Sunday 14th December, Session 4A, Richmond Building RB LT1, 09:30 – 09:45.

The Chimaera Beds Lagerstätte: taphonomic window for Burgess Shale-type preservation of marine invertebrates still open during the Cretaceous

Javier Luque[1,2,3], Germán Bonilla[4], Duván García[4], Sebastián Gómez-Coronado[4], Javier Ortega-Hernández[2], Farid Saleh[5]
[1]*University Museum of Zoology, University of Cambridge, UK;* [2]*Harvard University, USA;* [3]*Museo Geológico e Investigaciones Asociadas, Colombia;* [4]*INCLAY Geología Especializada, Colombia;* [5]*University of Lausanne, Switzerland*

Deposits with exceptional preservation (Konservat Lagerstätten) of the Burgess Shale-type (BST) are characterized by the conservation of organisms as carbonaceous films with accessory authigenic minerals in a siliciclastic matrix. Such deposits are common in lower Phanerozoic rocks, principally in the Cambrian and Ordovician. Afterwards, preservation in carbonaceous compressions is rarer, with exceptionally-preserved fossils often found phosphatized and/or pyritized. Several works have shed light on the taphonomic window of BST deposits, yet little is known for post-Palaeozoic BST marine deposits, especially from modern tropical latitudes. We present the Chimaera Beds Lagerstätte (CBD) from the Cenomanian-Turonian (95–90 Ma) of Colombia, which preserves in exquisite detail hundreds of marine invertebrates with soft to poorly-biomineralized tissues (*e.g.* antennae, setae, guts, muscles, eyes, neural tissues). The preservation of arthropods in the CBD exhibits many similarities with BST preservation. Non-weathered fossils are preserved as carbonaceous compressions in a kaolinite-rich matrix (kaolinite constituting ~50 % of the rock sample). Weathered samples are depleted in carbon and show a similar signature to the surrounding matrix. The CBD is the first Cretaceous tropical Lagerstätte with documented exceptional BST preservation, has broad implications for our understanding of BST preservation mode throughout the Phanerozoic, and opens new avenues to explore such deposits in modern tropical settings.

Saturday 13th December, Session 3A, Richmond Building RB LT1, 14:30 – 14:45.

Reinterpretation of *Jianshania furcatus*

Lorenzo Lustri, Yu Liu
Yunnan University, China

Jianshania furcatus is an enigmatic arthropod from the early Cambrian Chengjiang biota, originally described more than two decades ago but still poorly understood in terms of its anatomy and phylogenetic affinities. We reinvestigated the original material using micro-computed tomography, a well-established methodology for examining Chengjiang fossils. These new analyses reveal previously inaccessible anatomical details. Particular attention is given to the organization of the prosomal appendages and trunk tagmosis, which provide critical evidence for assessing the systematic placement of the species. Our observations suggest that *Jianshania* may represent a close relative of early chelicerate lineages. These chelicerate affinities allow us to reconsider the evolutionary polarity of several important morphological traits, particularly the development of a chelicerate-like tagmosis, and they contribute to ongoing understanding of character evolution in early euarthropods. These results highlight the significance of *Jianshania* for reconstructing the origins of major clades within the chelicerate. This study further underscores the value of micro-computed tomography as a tool for re-examining Chengjiang fossils, which continue to yield critical insights into the anatomy, disparity, and evolutionary history of Cambrian euarthropods.

Sunday 14th December, Session 6C, Portland Building PO 1.74, 14:45 – 15:00.

The Covariant Evolutionary Tempo Model

Richard Mann[1], Graham E. Budd[2]
[1]University of Leeds, UK; [2]Uppsala University, Sweden

We present the Covariant Evolutionary Tempo (CET) Model, which links rates of diversification, molecular evolution and morphological innovation within a framework of a continuously changing evolutionary 'tempo'. We will show that this model predicts that diversity is dominated by a small number of extremely large 'supertaxa' clades and that these large clades are expected to be characterized by explosive early radiations accompanied by elevated rates of molecular evolution and morphological change. Slowly-evolving and species-poor 'living fossil' clades naturally emerge as a counterpoint to the large clades. Our analysis shows that extant organisms are likely to have evolved from species with unusually fast evolutionary rates, making them appear ''old' when viewed in terms of molecular disparity. Given a strong correlation between rates of diversification and molecular change, we show that the amount of molecular change along a particular lineage is essentially independent of its height, which weakens the molecular clock hypothesis and gives reason to reconsider recent estimates for the ages of major clades based on molecular data.

Sunday 14th December, Session 5C, Portland Building PO 1.74, 11:15 – 11:30.

talks

First report of whitlockite in the dental plates of crown Holocephalii

Esther Manzanares[1], Zerina Johanson[1], Jens Najorka[1], Joseph Razzelliot[1], Charlie J. Underwood[2], Richard J. Twitchett[1]

[1]*Natural History Museum, London, UK;* [2] *Birkbeck, University of London, UK*

Extant holocephalans present a unique set of dental plates that grow throughout life, in contrast to the constant tooth replacement of elasmobranchs. These dental plates are mainly composed of trabecular dentine of hydroxyapatite that surrounds elements of hypermineralized whitlockite. In this work we have tested whether this unique mineral is preserved in the fossil record of holocephalans. Using a series of techniques, including EDS mapping, Raman and X-ray diffraction analyses, we tested for the presence of whitlockite in the tritoral pads and ovoids in the extant *Harriota raleighana* and in a range of extinct holocephalans from the Palaeocene of the UK from the NHM collections. These specimens were collected at sites well known for high-fidelity preservation, and have clearly preserved tritoral tissue, suggesting that whitlockite has some preservation potential. Our study confirms the presence of whitlockite in the tritorial pads and ovoids of both extant and extinct crown Holocephali dental plates, extending its evolutionary record back to the Palaeocene. Demonstrating that whitlockite can be preserved in the fossil record opens up the possibility of testing hypotheses related to when and why it was incorporated into the holocephalan skeleton, and its role in the evolution of durophagy.

Sunday 14th December, Session 5A, Richmond Building RB LT1, 12:15 – 12:30.

Conserving and communicating palaeontology: novel methods from Charnwood Forest Geopark

Jack J. Matthews

Charnwood Forest Geopark, UK; Oxford University Museum of Natural History, UK; Loughborough University, UK

The geoconservation of palaeontological geosites and the effective communication of fossil stories with the public remain complex endeavours. In Charnwood Forest, UK, the Ediacaran rocks contain some of the oldest animal fossils in the world, and the conservation and management of this geoheritage has been a challenge, with the need to balance protection, research, public access and site aesthetics. An innovative intervention was required that could mitigate multiple threats such as fossil theft and inadvertent damage by the public, but that also respected the landscape character and other heritage in the area. This presentation will outline how Charnwood Forest Geopark and partners have collaborated to implement a bespoke fossil protection solution that utilizes traditional construction techniques. The presentation will further outline the complexities of obtaining permissions for geoconservation interventions, and the importance of communication in conservation work. Furthermore, examples will be provided of how high-quality interpretation can be provided without the need for geosites to be visited. These examples from Charnwood Forest Geopark are a valuable case study in how to protect and interpret fossil geoheritage where a geosite is not suitable for visitation by the general public.

Saturday 13th December, Session 2B, Richmond Building RB LT2, 11:15 – 11:30.

The functional performance of spiral feeding structures in Palaeozoic echinoderms

James McDermott[1,2,3*], Louis Dudit[4], Zekun Wang[1], Frances S. Dunn[3], Ferdinand Marlétaz[2], John A. Cunningham[5], Imran A. Rahman[1,3]

[1]*Natural History Museum, London, UK;* [2]*University College London, UK;* [3]*Oxford University Museum of Natural History, UK;* [4]*University of Zurich, Switzerland;* [5]*University of Bristol, UK*

Spiral patterning can be seen across the animal kingdom, from the shells of molluscs to the tusk of the narwhal. The fossil record shows spiral and non-spiral radial symmetry in the echinoderm body plans that emerged in the Cambrian, many of which persisted for tens of millions of years. However, the function of these distinct symmetries remains uncertain, with some suggesting that spiral feeding structures could enhance food gathering and others suggesting that spirality is a plesiomorphic trait. To address this, we investigated feeding performance in diverse early echinoderms with spiral and non-spiral feeding structures, placing these results in a phylogenetic context to better understand the evolutionary history of spirality. Computational fluid dynamics was used to quantitatively analyse flow patterns around feeding structures. Additionally, ancestral state reconstruction was used to determine whether spiral symmetry was the ancestral form of radial symmetry in echinoderms or a derived trait. The results provide insight into the function and evolution of spiral symmetry in early echinoderms, with implications for understanding spiral structures in animal body plans more widely.

Sunday 14th December, Session 6A, Richmond Building RB LT1, 15:15 – 15:30.

A climbing carnivorous eutriconodont mammal exceptionally preserved from the Middle Jurassic of Skye, Scotland

Luke E. Meade[1], James R. G. Rawson[1], Elsa Panciroli[2], Stig Walsh[2], Richard J. Butler[1], Roger B. J. Benson[3]

[1]*University of Birmingham, UK;* [2]*National Museums Scotland, UK;* [3]*American Museum of Natural History, New York, USA*

During the Middle Jurassic, key groups along the lineage to therian mammals (marsupials and placentals) diversified taxonomically and ecologically. However, their articulated fossil remains are rare, coming from sites of exceptional preservation like the Yanliao Biota of Northeast China and the stratigraphically older Kilmaluag Formation of the Isle of Skye, Scotland (~166 Ma). Here we present the articulated anterior half of a new taxon from the Kilmaluag Formation that represents the earliest well-preserved eutriconodont mammal. The skull is complete and has a distinctive molar morphology similar to *Dyskritodon*, though with features that may align it with Volaticotherini. Provocatively, the isolated head of the cynodont *Stereognathus* is preserved ahead of the eutriconodont's open jaws, associated with its hand. Localized lower density material comprising small broken bone fragments and amorphous mineralization in the trunk region potentially represents preserved stomach contents. We investigate the relationship between hand morphology and climbing in a phylogenetically broad sample of extant mammals using multivariate phylogenetic regressions, as part of further investigation into locomotory adaptation in early mammals. Additionally, preservation of the hyoid apparatus, middle and inner ear, and a suite of osteological detail promises to reveal insights into mammalian morphological evolution in a poorly-represented time interval.

Sunday 14th December, Session 4A, Richmond Building RB LT1, 09:00 – 09:15.

talks

Constraining the lifespans of early animals of the Ediacaran

Emily G. Mitchell[1,2], Alayva Dhughana[3]
[1]*University of Cambridge, UK;* [2]*University Museum of Zoology, University of Cambridge, UK;* [3]*Durham University, UK*

Lifespans fundamentally impact life-history traits. These traits influence the tempo of biological cycles such as nutrient cycling and macro-evolutionary patterns over geological time. Yet, the lifespans of the first animals, found during the Ediacaran Period (approx. 580–539 Ma), are not well constrained, limiting our understanding of ecological and evolutionary change of early animals. In this study we use the metabolic theory of ecology to estimate the maximum lifespans and evolutionary rates of ten key Ediacaran taxa, constraining maximum lifespan variation for different environmental temperatures and modularity. We find a large range of different maximum lifespans for Ediacaran taxa (0.53–30.2 years), with longer lifespans in colder environments and for modular organisms (up to 40.4 years). Evolutionary rates were most impacted by environmental temperature, with the fastest evolutionary rates found in small, warm-water taxa. Ediacaran organisms pre-date macro-predation so do not suffer this key downside of small body size. Therefore, these small, warm-water taxa kept the advantages of these higher evolutionary rates, without the predatory downside. The release from predation coupled to these fast evolutionary rates could help to explain the large morphological and taxonomic diversity found in the shallow-water Ediacaran assemblages, in contrast to the colder, deep-water assemblages.

Saturday 13th December, Session 1, Richmond Building LT1, 09:30 – 09:45.

Regional variation drove disparity in functional diversity and ecosystem structure in the Late Cretaceous

Cassius Morrison[1]*, Franco Aspromonte[2], Zak Lewis[3], Josh Wasserlauf[4], Ezekiel O'Callaghan[5], Robert Mayer[6], Harry Jones[7], Jordan Mallon[8], Diego Pol[9]
[1]*University College London, UK;* [2]*Universidad Nacional de La Plata, Argentina;* [3]*University of Bristol, UK;* [4]*McGill University, Canada;* [5]*Northern Arizona University, USA;* [6]*University of Oklahoma, USA;* [7]*University of Birmingham, UK;* [8]*Canadian Museum of Nature, Canada;* [9]*Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Argentina*

There is persistent debate concerning the apparent reduction in dinosaurian species diversity leading up to the Cretaceous–Palaeogene extinction. Gaps in the fossil record make it difficult to assess the absolute taxonomic diversity of dinosaurs. This difficulty is compounded by disproportionate sampling of Late Cretaceous North America to understand terminal Cretaceous biotas. We apply novel approaches to investigate the dinosaurian functional diversity and ecosystem structures of two continents leading up to the Cretaceous–Palaeogene extinction. Functional diversity (using ecomorphological traits including dietary guild, mass and locomotion of taxa) and food web reconstructions were used to compare ecosystem functionality in the latest Cretaceous of North and South American faunal assemblages. Our findings show that while there is support for a weakening of dinosaurian functionality and ecosystems in North America, this is not true for South America which shows greater regional variation. Long-term trends for the Cretaceous of South America show that changes in functional diversity relate to both climate and clade dispersals. Here we suggest that new metrics should be investigated to assess dinosaurian functional diversity and ecosystem resilience prior to the K–Pg and the need for regional analyses instead of global patterns that are unlikely to identify precise

patterns in all regions.

Saturday 13th December, Session 3B, Richmond Building RB LT2, 15:30 – 15:45.

Changes in metazoan functional diversity across the first Phanerozoic mass extinction: the Cambrian Sinsk Event

Adam Murphy[1]*, Amelia M. Penny[1], Andrey Zhuravlev[2], Rachel A. Wood[1]
[1]University of Edinburgh, UK; [2]Russian Academy of Sciences, Russia

The Sinsk Event (~513.5 Ma) is the first Phanerozoic mass extinction, marking the end of the canonical Cambrian Radiation. We reconstruct taxonomic and functional diversity patterns of skeletal metazoans from the Siberian Platform during the Cambrian Radiation and across the Sinsk Event from ~529 to 508 Ma, to investigate the changing occupation of functional space and the evolution of functional traits during the radiation, and the role of these in extinction selectivity at the Sinsk extinction and subsequent recovery. During the radiation, functional richness increased before taxonomic richness as new groups with novel traits emerged and diversified. Taxonomic richness declined sharply at the Sinsk, but thereafter increased rapidly while functional richness continued to decline until ~508 Ma, indicating a post-extinction decoupling. While there is limited evidence of extinction selectivity at the Sinsk, certain functional traits are associated with post-extinction recovery from ~511 to 508 Ma. Groups with novel functional traits associated with motility, diversified feeding modes and broad water depth tolerances diversified rapidly, whilst sessile, inshore filtrators and heavily-calcified taxa that had been dominant prior to the extinction either failed to recover or became extinct. The Sinsk Event therefore marks a significant transition in marine ecosystem function.

Saturday 13th December, Session 2C, Portland Building PO 1.74, 11:00 – 11:15.

Two new exceptionally-preserved biotas from North Dakota reveal cryptic Ordovician shelf ecologies

Giovanni Mussini*, Nicholas J. Butterfield
University of Cambridge, UK

The Ordovician saw one of the greatest evolutionary radiations in Earth history, precipitating the assembly of modern marine ecologies in the aftermath of the Cambrian Explosion. However, Ordovician non-mineralized faunas are rare and mostly sample ecologically marginal settings. We describe small carbonaceous fossils (SCFs), including semi-articulated elements preserving submicrometric detail, from epicontinental deposits of the Deadwood and Winnipeg formations (North Dakota, USA). These SCFs, associated with biostratigraphically informative conodonts and graptolites, record two successive biotas of Cambrian–Tremadocian and Darriwilian ages. These fossils open a window on normal marine Ordovician shelf habitats, revealing taxa and functional morphologies unrecorded by coeval macrofossils: specialized grazing and predatory molluscan radulae, crustaceomorph molars, the oldest known eurypterids, and microphagous priapulid worms. Together, the Deadwood and Winnipeg SCFs demonstrate an Ordovician co-occurrence of cryptic taxa and feeding adaptations, reminiscent of the most ecologically modern Cambrian biotas, alongside classic later-Palaeozoic forms like colonial zooplankton and biomineralized vertebrates. By contrast, they do not record the classic Burgess Shale-style taxa typical of marginal or deeper-water Ordovician assemblages. These results

demonstrate a lasting presence of cryptic, modern-style shelf faunas throughout the earliest Palaeozoic, suggesting that exceptional Ordovician macrofossil sites are unrepresentative of the broader state of their coeval biosphere.

Sunday 14th December, Session 4B, Portland Building PO 1.74, 10:00 – 10:15.

Clade-level constraints to ecological diversification of Phanerozoic marine animals

Philip M. Novack-Gottshall
Benedictine University, USA

Why are some animal clades ecologically more diverse than others? Has this pattern held true throughout their history? I address these questions using a standardized 39-trait ecospace (functional trait) database for *c*. 50,000 Phanerozoic marine animal genus life habits. This allows quantitative comparisons (using ecological richness and disparity) of how major clades (phyla and classes) have varied throughout geological history. Most clades maintain consistent levels of Phanerozoic ecological diversity. Molluscs and arthropods (and to a lesser extent, their classes) are persistently diverse. However, variability is evident for many important clades. At their origins, chordates had low richness and disparity, but diversified significantly during the Devonian radiation of fishes and again after the Permian extinction. Echinoderms achieved peak richness during the Palaeozoic, but increased disparity during post-Palaeozoic diversification of divergent echinoids and asterozoans. Overall, there is little impact of mass extinctions in resetting clade trajectories at these broad scales. Low correlation with genus richness suggests functional experimentation is largely independent from small-scale diversification. These patterns suggest inherent constraints to ecological innovation across marine taxa, largely set during clade origins, and little impacted by mass extinctions and subsequent turnover within subclades.

This research has been supported by NSF grant #2322080.

Sunday 14th December, Session 7, Richmond Building RB LT1, 16:30 – 16:45.

Hallucigenia's diet illuminates the ecology of cambrian lobopodians

Javier Ortega-Hernández[1]
[1]*Harvard University, USA*

The armoured lobopodian *Hallucigenia sparsa* embodies the seemingly uncanny nature of the animals that evolved during the Cambrian Explosion over 500 million years ago. Initially regarded as an evolutionary oddball, the exceptional preserved anatomy of *H. sparsa* has been substantially revised, leading to a better understanding of its relationships with other lobopodians and phylogenetic affinities with extant panarthropod phyla. However, the ecology and behaviour of *H. sparsa* remain largely enigmatic owing to the difficulties of interpreting its functional morphology and the perceived lack of modern analogues. Restudy of an extraordinary composite fossil assemblage from the middle Cambrian Burgess Shale demonstrates swarm-like behaviour of several diminutive *H. sparsa* individuals scavenging on a dead ctenophore. The lack of grasping, masticatory or piercing mouthparts in *H. sparsa* points to suction feeding as a viable strategy to consume the gelatinous carcass. Reassessment of the functional morphology of *H. sparsa*

reveals analogues with extant pycnogonids, including an elongate anterior end with a terminal mouth, enlarged oral chambers followed by cuticular denticles in the foregut. These observations suggest that suction feeding is ancestral for the onychophoran stem lineage and highlights the critical ecological role of hallucigeniid lobopodians in degrading soft-bodied carcasses in Cambrian benthic ecosystems.

Sunday 14th December, Session 4B, Portland Building PO 1.74, 09:30 – 09:45.

The terminal Ediacaran Quanjishan macrofossil assemblage from the Qaidam Basin, Northwest China

Ke Pang[1,2], Chengxi Wu[1,3], Xiaopeng Wang[1,3], Yarong Liu[1,3], Hanzhi Qu[1,4], Mingyang Qiu[1], Guangjin Li[1], Alexander G. Liu[3]

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Ediacara-type macrofossils characterize the late Ediacaran Period, and are pivotal in understanding the early evolution of animals on the eve of the Cambrian Explosion. The Quanjishan macrofossil assemblage has been discovered in siliciclastic rocks of the Zhoujieshan Formation, Quanji Group, in the Qaidam Basin, Northwest China. The fossil assemblage is dominated by the terminal Ediacaran candidate index fossil *Shaanxilithes* and the iconic and long-ranging soft-bodied rangeomorph *Charnia*, including specimens described as *Charnia masoni*, *Charnia gracilis* and *Charnia* sp. Most *Charnia* specimens possess a small petalodium with ≤8 first-order branches per row, some of which are comparable to juvenile fronds from other Ediacaran localities. The Quanjishan Charnia specimens display both two- and three-dimensional preservation, offering new opportunities to explore taphonomic pathways of Ediacaran fronds. Sedimentary characteristics suggest that the Quanjishan *Charnia* lived in shoreface and offshore marine depositional environments, under low-to-moderate energy hydrodynamic conditions. Co-occurrence with *Shaanxilithes* constrains the Quanjishan assemblage to be ~550–539 Ma in age, representing one of the youngest occurrences of *Charnia* and a potential example of the Nama biotic assemblage. Recent excavation has additionally uncovered several new, albeit rare, frondose taxa from the Zhoujieshan Formation, indicating further taxonomic diversity within this terminal Ediacaran assemblage.

Sunday 14th December, Session 4B, Portland Building PO 1.74, 09:15 – 09:30.

The evolutionary history of radiodonts, great predators of the Early Palaeozoic seas

Gaëtan Potin*, Allison C. Daley

University of Lausanne, Switzerland

Radiodonts, stem lineage arthropods from the Cambro–Ordovician, are well known for their predatory palaeoecology, as well as their large body size and distinct morphology. All radiodonts are predators; however, they can be distinguished between raptorial predators, benthivores and suspension feeders. More than 3,000 specimens have been published, with over 40 known species distributed globally. Many recent studies have described new taxa and tend to focus on isolated genera or families, but few studies have explored the broad evolutionary and palaeoecological trends that characterize the whole Radiodonta

clade. Their anatomy, taxonomy and global and temporal distributions have the potential to inform us about major events in evolutionary history. In this study, a database listing all published occurrences of radiodonts was generated, and analysed using statistical approaches. Radiodont diversity, the relative proportions of families, and their feeding strategies changed through time, influenced by major events and palaeogeographic domains. There still exist some uncertainties, such as the Furongian gap and the possible Devonian specimen. However, after 130 years of radiodont research, the evolutionary history of the most emblematic group of the early Palaeozoic can be better understood.

Sunday 14th December, Session 6C, Portland Building PO 1.74, 14:30 – 14:45.

Diverse mycelial microfossils from the early Ediacaran Doushantuo Formation, South China

Hanzhi Qu[1,2,3]*, Corentin Loron[3], Ke Pang[1,2], Tian Gan[4,5,6], Sean McMahon, Taiyi Luo[4], Qing Ouyang[1,2], Xunlai Yuan[1,2], Shuhai Xiao[7]

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Mycelial organization, characterized by dense filamentous networks, is present in many groups of filamentous organisms, including fungi and actinobacteria. However, the diversity of mycelial organisms and their roles in bio-weathering on Earth during the Neoproterozoic have been largely overlooked, partly due to the scarcity of their fossil record. Here we analyse mycelial microfossils from the early Ediacaran Doushantuo Formation in the Weng'an region, Southwest China, to clarify their diversity. Fungal filaments from the sheet cavities in the basal cap dolostone are characterized by dichotomous branching, anastomosis, and the association with spheres. Their different filament diameters suggest they could probably be two species. Compared with a lichen-like fossil from the upper phosphorite bed, which exhibits symbiotic features evidenced by filaments encircling coccoidal cells, this filament-sphere association may represent a more primitive symbiosis. In addition, trichome-like filaments are found preserved together with the fungal filaments and interpreted as possible actinobacteria based on their thinner diameter (~1 μm), rare branching, and the lack of association with spheres. Altogether, the collective appearance of mycelial microorganisms in the early Ediacaran indicates that they were more diverse than previously assumed, and that their bio-weathering processes after the termination of the 'Snowball Earth' cannot be ignored.

Sunday 14th December, Session 6C, Portland Building PO 1.74, 15:30 – 15:45.

Decoupled evolution of melanosome geometry and chemistry in amphibians and reptiles

Aaron Quigley[1]*, Beatriz Carazo del Hoyo[1], Daniel Cirtina[1], Valentina Rossi[1], Catherine McCarney[2], Jane Brennan[2], Soudeh Ziapour[2], Maria E. McNamara[1]

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Melanosomes are melanin-rich organelles in the integument, eyes and internal organs of vertebrates, with tissue-specific morphology and chemistry. The relationship between

these melanosome attributes, *i.e.* geometry and chemistry, and the associated functional implications, are poorly understood. To investigate this, we analysed melanin in various tissues from extant amphibians and reptiles. Our results demonstrate consistent tissue-specific variation in melanosome geometry in both groups. For homologous tissues, reptilian melanosomes are usually smaller and more elongate than their counterparts in amphibians, suggesting conserved functions for melanin in these tissues. In certain tissues (heart, ventral skin and gonads), however, reptilian melanosomes are larger and more spherical than in amphibians, suggesting divergent functions. Synchrotron-XRF analyses reveal that melanosomes from certain tissues are similar in chemistry in amphibians and reptiles despite differences in geometry. In contrast, melanosomes from other tissues, *e.g.* dorsal skin, are similar in geometry in both vertebrate groups but not chemistry. These data confirm decoupling of melanosome geometry from the melanosomal metallome in amphibians and reptiles. Preliminary synchrotron-XRF analyses of fossil amphibians and reptiles reveal a strong sedimentary signal. Ongoing analyses of fossil specimens will clarify whether melanosome characteristics in extant taxa have deep origins or are recent innovations.

Saturday 13th December, Session 2A, Richmond Building LT1, 12:15 – 12:30.

The community ecology of the Early Ordovician Fezouata Shale biota of Morocco

Jared Richards[1]*, Karma Nanglu[2], Javier Ortega-Hernández[1]
[1]Harvard University, USA; [2]University of California, Riverside, USA

The Great Ordovician Biodiversification Event (GOBE) consisted of a series of evolutionary radiations at low taxonomic levels that increased net biodiversity and ecological complexity throughout the Ordovician. Most research into the GOBE is informed by the conventional shelly fossil record consisting of biomineralized remains. The Fezouata Shale contains the best preserved and most fossiliferous Early Ordovician sites by far, consisting of a diverse assemblage of high-quality biomineralizing and non-biomineralizing taxa. Using information from 9,211 specimens encompassing 90 genera collected from 28 sub-localities from the Draa Valley of Morocco, we performed the first in-depth quantitative and comparative examination of the Fezouata Shale's community ecology. Rank-abundance curves suggest that the sub-localities of the Fezouata Shale are ecologically uneven, each having a subset of genera that are highly abundant. We also find evidence for two major, ecologically distinct assemblages within the Fezouata Shale biota. The first contains significantly more graptolites and is dominated by benthic and nektonic scavengers and predators, while the second is dominated by suspension feeders such as brachiopods and benthic echinoderms. The broader ecological structure of the Fezouata Shale, one dominated by benthic clades such as echinoderms, arthropods and molluscs, is reminiscent of invertebrate-dominated, cold water marine ecosystems today.

Saturday 13th December, Session 2C, Portland Building PO 1.74, 11:45 – 12:00.

talks

Reevaluating the Cambrian chelicerate *Molaria*

Edna Rodríguez-Sánchez[1]*, Ailin Chen[2], Yu Liu[3], Javier Ortega-Hernández[1]
[1]*Harvard University, USA;* [2]*Yuxi Normal University, China;* [3]*Yunnan University, China*

The unusual combination of characters in the Cambrian arthropod *Molaria* has kept its taxonomic affinities uncertain since its original description at the beginning of the twentieth century. *Molaria spinifera* was first described in 1912 from 20 Burgess Shale specimens and was last revised in 1981 on the basis of over 100 specimens. A second species, *M. steini*, was described in 2017 from 30 Sirius Passet specimens. Here we revise the morphology, phylogenetic position, spatiotemporal distribution and autecology of this enigmatic Cambrian genus. We restudied the type material of *M. spinifera* from the Burgess Shale and describe a new species of *Molaria* from the early Cambrian (Stage 4) Guanshan biota of China. Using polarized light and micro-computed tomography, we document fine exoskeletal, internal and appendicular features. The combined evidence, including fine details of the ventral biramous appendages, suggest an affinity with the chelicerate stem lineage. We further show the broad early-middle Cambrian diversification of *Molaria* across Laurentia and Gondwana. Finally, variation in *Molaria* body length suggests that habitat and lifestyle influence body size. These biogeographic and ecologic patterns correspond to other Cambrian arthropods and underscore the relevance of *Molaria* to understanding early arthropod evolution.

Saturday 13th December, Session 2C, Portland Building PO 1.74, 12:15 – 12:30.

Polar adaptations in the life histories of Australia's earliest mammals revealed via synchrotron X-ray tomography

Andre Rowe[1], Elis Newham[1,2], Nuria Melisa Morales-Garcia[1], Pamela G. Gill[1], Emily J. Rayfield[1]
[1]*University of Bristol, UK;* [2]*Queen Mary University of London, UK*

Despite recent studies on lifespan and growth in several Jurassic mammals, their life histories across the Mesozoic, particularly in extreme climates, remain poorly understood. Here we examine life history and physiology in the Flat Rocks fauna from Western Australia, which lay within the Antarctic Circle during the Early Cretaceous. This assemblage offers a rare view of southern Gondwana mammals living under dynamic, harsh polar climates, and includes key groups such as Australosphenida (*e.g. Bishops*, *Ausktribosphenos*) and the earliest monotremes (*Teinolophos*). Using propagation phase-contrast synchrotron microtomography, we analysed dental cementum histology to reconstruct lifespan and growth. Cementum increment counts show that individuals of both *Bishops* and *Teinolophos* could reach ages of up to nine years, within the known range of Jurassic mammals. However, these taxa show contrasting growth trajectories, suggesting differing adaptive strategies to polar environments. Estimating basal metabolic rates from this dataset extends evidence of relatively low metabolic rates in crown mammals well into the Cretaceous. These results support a scenario in which elevated metabolic rates arose later in mammalian evolution, closer to the emergence of Theria, and highlight the importance of high-latitude faunas for understanding early mammal physiology.

Saturday 13th December, Session 3B, Richmond Building RB LT2, 14:30 – 14:45.

Breaking the bottleneck: fully automated CT segmentation of fossils using deep learning

Arindam Roy[1], Poulami Ghosh[1], Roger B. J. Benson[2], Ben Scott[3], Arianna Salili-James[3], Sanson T. S. Poon[3], Susannah C. R. Maidment[1,3], Richard J. Butler[1]

[1]*University of Birmingham, UK;* [2]*American Museum of Natural History, New York, USA;* [3]*Natural History Museum, London, UK*

Artificial Intelligence (AI) is fundamentally transforming palaeontological research by automating analyses and revealing hidden patterns in complex datasets. Computed tomography (CT) is widely used as a standard tool for imaging fossils, but a major bottleneck is the manual segmentation of CT datasets, which is slow, potentially subjective, and labour-intensive. To this effect, for the first time, we developed two pipelines fusing SimCLR v1 (a Simple Framework for Contrastive Learning of Visual Representations) and MoCo v2 (Momentum Contrast) with U-Net (a convolutional neural network for image segmentation) to fully automate fossil CT data segmentation. Our dataset included 10,495 CT-images of amphibians, squamates, reptiles, dinosaurs and mammals from the Middle Jurassic Kilmaluag Formation, Scotland. Both approaches achieved high performance scores (Dice-Sorensen's coefficient >90 % and Jacquard's similarity index >85 %) indicating robust segmentation. While SimCLR v1+U-Net was able to rapidly distinguish 'bone' from the encasing 'rock matrix' at moderate detail, MoCo v2+U-Net showed proficiency in capturing subtle morphology, making the former suitable for fast and the latter for high-granularity segmentation. By integrating advanced AI methods into fossil imaging workflows, we demonstrate how deep learning can accelerate and enable large-scale comparative studies, and open new opportunities for quantitative analyses of fossil morphology and diversity.

Funding: EU Horizon Europe - Marie Sklodowska-Curie Actions Postdoctoral Fellowship and EPSRC (UKRI).

Saturday 13th December, Session 1, Richmond Building LT1, 09:00 – 09:15.

An exceptionally preserved polar window on the Cambrian–Ordovician transition

Farid Saleh, Pierre Gueriau (to be presented by **Allison C. Daley**)
University of Lausanne, Switzerland

The Cabrières Biota, an exceptionally-preserved Early Ordovician assemblage from southern France, has sparked intense debate since its description in 2024. Early scepticism questioned whether its fossils represent true body fossils or merely traces, casting doubt on both its diversity and its status as a Lagerstätte. Here we present a comprehensive collaborative study involving more than 50 researchers and students, numerous field campaigns, thousands of collected fossils, and multiple works forthcoming in a special volume. This international effort across sedimentology, ichnology, taphonomy and palaeontology demonstrates that the Cabrières Biota is a highly diverse ecosystem with more than 100 genera, including algae, sponges, cnidarians, arthropods, echinoderms, graptolites, annelids, brachiopods and molluscs, among others. Remarkably, some taxa were previously known only from much older deposits such as the Early Cambrian Chengjiang biota. These organisms inhabited a storm-dominated deltaic environment, and a unique combination of preservation modes including pyritization, silicification and carbonaceous material has captured an unprecedented snapshot of an Early Ordovician polar ecosystem. Beyond resolving controversies about the taxonomic composition of the

Cabrières Biota, this work provides a new window into a key transition in Earth's history, bridging the Cambrian Explosion and the Great Ordovician Biodiversification Event, and offering new insights into the evolution of early complex ecosystems.

Sunday 14th December, Session 7, Richmond Building RB LT1, 17:15 – 17:30.

Histology-guided analyses show fossil shark teeth can serve as geochemical time capsules

Synnøve M. Saugen[1], Jay M. Thompson[2], Heather A. Lowers[2], Jørn H. Hurum[3], Thijs R. A. Vandenbroucke[1], Poul Emsbo[2]

[1]Ghent University, Belgium; [2]US Geological Survey, USA; [3]Natural History Museum, Oslo, Norway

Whether rare earth elements (REEs) and other geochemical signatures in fossil shark teeth represent primary signals or diagenetic alteration remains an open question. Here we show that the triple-layered structure of neoselachian enameloid strongly influences geochemical behaviour. Using combined histological imaging and *in situ* geochemical analyses, we document systematic REE and isotopic zoning aligned with enameloid microstructures in shark teeth from the Grippia Bonebed of Spitsbergen, Norway. This alignment of REE and elemental zoning with enameloid histology demonstrates that conventional screening protocols, which simply distinguish between enameloid and dentine, are overly simplistic. Notably, direct U-Pb dating of parallel bundled enameloid (PBE) yields the stratigraphical age of the bonebed, confirming that PBE preserves pristine geochemistry. In contrast, tangled bundled enameloid (TBE) exhibits a much more intricate system that interferes with the dentine. Both the TBE and the dentine gave much younger ages, indicative of open-system behaviour. These results demonstrate that careful histological mapping is essential to identify reliable substrates for geochemical analysis. Thus, histological and geochemical mapping of shark enameloid can provide a high-fidelity chemical archive, challenging the assumption that the chemical composition of fossil shark teeth necessarily reflects diagenesis.

Sunday 14th December, Session 5A, Richmond Building RB LT1, 12:00 – 12:15.

Osedax-like borings, soft tissue preservation, and more, in Jurassic and Cretaceous marine vertebrate remains from Japan and UK

Christina Shears-Ozeki[1]*, Robert G. Jenkins[2]

[1]Kyoto University, Japan; [2]Kanazawa University, Japan

Doctoral research aimed to identify whether Jurassic and Cretaceous marine vertebrates, particularly reptiles, had similar decompositional stages to those seen in modern whalefalls, the decomposers responsible, and any exceptional preservation. Seven types of fossil marine specimens from Japan and the UK (Toarcian ichthyosaurs, an Oxfordian shallow marine deposit, Coniacian and Santonian elasmosaurids, and a Campanian mosasaur) were investigated. The specimens were analysed using optical microscopes (binocular and petrological), scanning electron microscopy (SEM), and energy dispersive X-ray analysis (EDX), unlike other studies that typically use CT scanning. Bacterial mats, molluscs and various millimetre- and micrometre-sized borings (attributed to *Osedax*, bacteria and fungi) were evident. Exceptional soft tissue preservation, such as a venule-like tube, borings inclusive of probable bacterial producers, and networks of spherules, possibly of bacterial origin and likely associated with the bacterial mats, were also observed. The results were

compared to previous studies and to an experimentally deployed Minke whale carcass, as a modern analogue. The research indicated that even Lower Jurassic marine vertebrates degraded in similar ways to extant whales, and inferred that *Osedax*-like organisms had already evolved by this time, suggesting a need to recalibrate the molecular clock from the Upper Cretaceous to the Lower Jurassic.

Sunday 14th December, Session 5A, Richmond Building RB LT1, 11:15 – 11:30.

Life in the deep – morphological plasticity in benthic foraminifera across environmental changes of the Palaeogene

Yujie Shi[1,2], Monsuru Adebowale[1], Madhura Gosh[1,3], Ellen Thomas[4], Bridget Warren[1], Daniela N. Schmidt[1]

[1]*University of Bristol, UK;* [2]*Nanjing University, China;* [3]*Yale University, USA;* [4]*The Open University, UK*

The Palaeogene is a dynamic interval of Earth's climatic history, including hyperthermal events such as the PETM and ETM2, perturbations of the global carbon cycle. Extinctions, migrations and evolutionary turnover are associated with all events. Plasticity is considered a means by which organisms deal with physiological stress in response to changing environmental conditions. Here we explore plastic responses to warming, deoxygenation and changes in export production and the biological pump on the morphological plasticity of two common, long-lived deep-sea benthic foraminiferal species – epifaunal *Nuttallidestruempyi* and shallow infaunal *Oridorsalis umbonatus*. We analysed 1,341 specimens from Palaeogene Ocean Drilling Program cores and extracted their morphological traits including volume, surface area and number of chambers using 3D data from micro-CT scanning, to investigate whether rates and amplitudes of warming determine the degree of, or limits to, organismal phenotypic plasticity. Both species show an amplitude-independent plastic spatially heterogeneous response of dwarfing at peak stress during the PETM and ETM2. In contrast, morphological changes did not recover after the long warming period of the EECO.

Saturday 13th December, Session 3C, Portland Building PO 1.74, 15:00 – 15:15.

Microanatomy and functional morphology of the trilobite exoskeleton: a case study of *Morocops? degener*

Matěj Šilinger[1]*, Oldřich Fatka[1], Petr Budil[2]

[1]*Charles University, Czech Republic;* [2]*Czech Geological Survey, Czech Republic*

With more than 20,000 described species, trilobites are one of the most diverse groups of arthropods in the fossil record. Despite the extensive amounts of research devoted to trilobites, the internal and external microanatomy and palaeobiology of their exoskeletons still remains understudied. In the past, several techniques have been employed to study the internal microscopic structure of trilobite exoskeletons. Among them, etching of oriented sections using EDTA acid has proven to be particularly effective. In our study, this method was applied for the first time to samples from the classical Barrandian area. Cephala of *Morocops? degener* (Barrande, 1852) from the Lower Devonian were selected as the most suitable for a detailed study. Microanatomical features were documented and compared with surface structures using both institutional specimens and newly collected material.

The analysis revealed several microanatomically distinct structures. Comparisons with extant arthropods suggest that some of them are functionally analogous to specialized sensory and defensive organs, while others appear unique and without clear modern counterparts. These results provide new perspectives on the functional significance of exoskeletal microanatomy in trilobites.

Study was funded by project GAUK 32124 of Charles University.

Saturday 13th December, Session 2C, Portland Building PO 1.74, 12:00 – 12:15.

Can immunohistochemistry reliably detect fossil proteins?

Tiffany S. Slater, Tara Foley, Maria E. McNamara
University College Cork, Ireland

Evidence of fossil proteins can provide invaluable insight into the biochemistry of ancient organisms. Immunohistochemical data have been used as evidence of corneous beta proteins (CBPs; previously β-keratins) in fossil feathers from *Eoconfuciusornis* and *Anchiornis*. This technique, however, can produce false positive results and may not be suitable for the study of geologically altered soft tissues. This study evaluates the validity of immunohistochemical analysis on fossil soft tissues using untreated and experimentally matured tissues from extant species. Feathers, gymnosperm leaves and ladybird cuticles were experimentally matured at 200°C and 250°C for 1 h; beetle cuticles were matured at 200°C for 24 h in an Ar atmosphere. Samples were stained with customized primary antibodies raised against feather CBPs; primary antibodies were excluded for the negative controls. All feather samples exhibit fluorescence, consistent with the presence of CBPs. Negative controls for feathers and untreated leaves and cuticles lack fluorescence. Unexpectedly, experimentally matured leaves and cuticles and the associated negative controls exhibit fluorescence. Thermally matured tissues lacking feather CBPs can thus produce false positive immunohistochemical results. This study confirms that immunohistochemistry is unsuitable for the analysis of fossil soft tissues. Future efforts to detect proteinaceous residues in fossils require alternative methods.

Saturday 13th December, Session 3A, Richmond Building RB LT1, 15:45 – 16:00.

The Austral Antarctic Forest during the Early Eocene Climatic Optimum – biogeography, diversity and the fate of polar lineages

Miriam Slodownik[1,2]*, Robert S. Hill[2]
[1]*Trinity College Dublin, Ireland;* [2]*University of Adelaide, Australia*

The biogeographic patterns evident in the floras of the Southern Hemisphere have long fascinated naturalists. To explain these patterns, hypotheses have been proposed that invoke either vicariance through Gondwana's break-up or long-distance dispersal. The Lowana fossil plant assemblage in Tasmania, Australia, offers a unique window into this complex puzzle. Situated at the South Polar Circle (~65°S), and dating to the Early Eocene Climatic Optimum (EECO; ~53–50 Ma), it represents one of the oldest post-Cretaceous plant assemblages in Australia and predates the final continental break-up of Australia from Antarctica. We present new data from a near-polar forest, including systematics, diversity and ecophysiological adaptations to the high latitudes, and reveal taxon- and ecosystem-

scale biogeographic patterns across the Southern Hemisphere. Intriguingly, many of the taxa are extant relicts with small populations in tropical Australasia and the Neotropics (South America), often confined to high-altitude and/or humid habitats. The presence of these lineages in early Eocene South American and Australian assemblages, and the Palaeocene of Antarctica, demonstrates a continuous extent of the Austral Antarctic Forest, thus favouring the vicariance hypothesis for many taxa that are today shared between these continents.

Sunday 14th December, Session 6B, Richmond Building RB LT2, 15:45 – 16:00.

The effects of taxa through the Messinian Salinity Crisis on the biogeography of the Mediterranean Sea

Andrej Spiridonov[1], Liudas Daumantas[1], Konstantina Agiadi[2]
[1]Vilnius University, Lithuania; [2]University of Vienna, Austria

The Mediterranean Sea is a uniquely complex region with many islands and peninsulas, making it an intriguing testing ground for new algorithmic approaches to biogeographical inference. Here we studied the biogeography of marine animal genera and species before, during and after the Messinian Salinity Crisis (MSC) by applying and presenting a new state-of-the-art HespDiv class approach that combines the search for spatial structures with taxonomic sensitivity analyses of the revealed spatial structures. The jackknife-like resampling of constituent taxa in the hierarchical biogeographical inference revealed that the MSC profoundly disturbed the previously existing structure of bioregions, shifting from the major west-east axis of variability toward the south-north axis. Moreover, during the transitions from the Tortonian to the pre-evaporitic Messinian and to the Zanclean ages, there was a systemic drift in the endemicity of taxa and their contributions to biotic structuring of the basin: *e.g.* gastropods had the major effect in defining split-lines of bioregions in the first two ages, while losing most of their biogeographic structure after the MSC, thus highlighting the persistence of effects of the event.

This study was supported by the Research Council of Lithuania grant S-MIP-24-62 'BretEvoGeneralized'.

Sunday 14th December, Session 6B, Richmond Building RB LT2, 15:00 – 15:15.

Postmortem biochemical evolution may control kaolinite formation: implications for exceptional preservation

Piyush Sriwastava[1], Nicholas J. Tosca[2], Julie G. Cosmidis[3], Ross P. Anderson[1]
[1]Oxford University Museum of Natural History, UK; [2]University of Cambridge, UK; [3]University of Oxford, UK

Exceptional preservation of soft tissues is critical to understanding the history of life. The aluminosilicate kaolinite has been documented in association with some fossil soft tissues, particularly in instances of Burgess Shale-type preservation. Mechanistically, kaolinite may facilitate preservation by slowing decay due to its inherent antibacterial properties, or by binding to decaying tissues potentially fostering biomolecule polymerization. However, in the latter case, we do not know how decay, and the consequent shifts in pH, may influence kaolinite precipitation in association with organics. For example, lack of oxygen supply to muscles postmortem causes the release of lactic acid, decreasing pH,

whereas later degradation of proteins releases ammonia, buffering the system to basic conditions. Depending on biochemistry, a variety of acids can be released during decay, including acetic acid, succinic acid and pyruvic acid. We undertook geochemical modelling followed by mineral precipitation experiments to mimic postmortem shifts in pH driven by the release of organic acids to understand the effects on kaolinite precipitation. We observe precipitation of Al-silicate only when acids are released that complex strongly with aluminium, and thus they dominate aqueous aluminium speciation; subsequent ammonia release increases pH, destabilizes Al-organic acid complexes, and thus drives supersaturation with respect to kaolinite. We propose that organism biochemical composition and, as such, postmortem organic acid release, can play a significant control on soft tissue preservation.

Saturday 13th December, Session 3A, Richmond Building RB LT1, 15:00 – 15:15.

Micro- and mesofossil analyses of an *Edmontosaurus* bonebed from the Late Cretaceous Lance Formation: palaeoecological insights

Nicolas Adrian Stagg[1]*, Haytham El Atfy[1], Dieter Uhl[2], Philipe Havlik[3], Benjamin Bomfleur[1]
[1]Universität Münster, Germany; [2] Senckenberg Forschungsinstitut und Naturmuseum Frankfurt, Germany; [3]Welterbe Grube Messel, Germany

The Maastrichtian-aged Lance Formation in Wyoming, USA, although broadly coeval with the well-studied Hell Creek Formation, remains comparatively understudied. A newly documented *Edmontosaurus annectens* bonebed provides fresh insights into latest Cretaceous terrestrial ecosystems. This site, rich in vertebrate and palaeobotanical remains, offers a focal point for renewed palaeoenvironmental as well as palaeoecological analysis of the Lance Formation. Palynological and mesofossil evidence reveals a dense marginal flora together with a distinctive aquatic flora dominated by *Azolla*, an ecologically restricted fern, alongside freshwater indicators such as *Pediastrum*, *Botryococcus* and *Gunnera*. These assemblages suggest deposition in floodplain settings with densely vegetated still-water bodies. The co-diversification and -occurrence of abundant *Azolla* and derived hadrosaurids such as *Edmontosaurus* raises questions of ecological interaction. Examination of hadrosaur palaeobiology and -ecology through ecomorphology, feeding height stratification, functional morphology and ontogenetic niche shifting, as well as *Azollas* biology, suggests a scenario where juveniles likely avoided tannin-rich *Azolla*, while subadult and adult *Edmontosaurus* may have consumed it opportunistically, particularly during seasonal blooms, as a plentiful nutrient-rich supplemental resource. This integrated perspective highlights the Lance Formation as a valuable complement to the Hell Creek record, emphasizing its potential to refine understanding of late Maastrichtian ecosystems and plant–herbivore dynamics.

Saturday 13th December, Session 3B, Richmond Building RB LT2, 15:45 – 16:00.

Reconstructing the binocular visual system of a stem-group mantis and its predatory function

Ryo Taniguchi[1]*, Yuki Fukuda[2], Kanta Sugiura[3], Yasuhiro Iba[3]
[1]University of Edinburgh, UK; [2]University of Veterinary Medicine Budapest, Hungary; [3]Hokkaido University, Japan

Most animals possess two eyes and see objects binocularly. Stereopsis provides depth perception via binocular disparity and enables adaptive visual predation. Stereoscopic vision is therefore a potential key innovation that has driven the prey–predator interaction in deep-time animal evolution, although reconstructing ancient visual function, which requires exquisitely-preserved fossil eyes, remains difficult. In this study we evaluated the visual system of a mid-Cretaceous mantis, three-dimensionally preserved in amber from New Jersey, USA. Our measurements indicate that the eyes contain 12,000 facets, with a spatial resolution that matches or exceeds that of living mantises. The geometry of 3D reconstructions shows broad frontal overlap between the eyes (~90°), surpassing that in modern relatives, suggesting that the primitive Cretaceous mantis already had a wide stereoscopic field of view, advantageous for targeting prey. The eyes dominate much of the front of the head (two-thirds of its width). This proportion is larger than that of contemporaneous cockroaches, the closest relatives in phylogeny and ecology, implying the enhanced frontal vision was acquired in the early mantodean lineage following their divergence from cockroaches. Mantises, performing stereoscopic hunting, have likely played a predatory ecological role with an advanced visual system since their early evolution.

Sunday 14th December, Session 6A, Richmond Building RB LT1, 14:30 – 14:45.

High-resolution micro-CT reveals new morphological data in 3D-preserved *Lepidodendron* specimen (Brymbo Fossil Forest, Duckmantian, North Wales)

Ewan Titcombe*
University of Portsmouth, UK; Stori Brymbo, UK

The 314 Ma Pennsylvanian, Carboniferous, equatorial floodplain/swamp deposits of the Brymbo Fossil Forest (North East Wales), harbour many fossil plants preserved in a multitude of ways, such as carbon compressions, pith casts, and within-siderite nodules, the focus of this study. These nodules protect and preserve the three-dimensional placement of the floral fossils. Past three-dimensional reconstructions of the arborescent lycophyte, *Lepidodendron* Šternberg, have largely been based on two-dimensional compressions or by disassembling a permineralized specimen to acquire many thin sections, destroying the fossil in the process. Herein, non-destructive micro computed tomography (μCT) is applied to a *Lepidodendron* branch (L-MCT-1) to reveal the accurate three-dimensional morphology of this long studied genus. It can be seen that the otherwise encased 8 cm bifurcating branch has been extracted digitally in great clarity. Along the specimen, unknown protrusions adorn the adaxial surface of many of the proximal leaf cushions, reducing greatly in number after bifurcation. Results clearly display that this method has great potential and the opportunities for future research into the three-dimensional preservation of flora seen within the siderite nodules of the Brymbo Fossil Forest, and similar sites worldwide, is ripe with new scientific discovery.

Sunday 14th December, Session 4A, Richmond Building RB LT1, 10:00 – 10:15.

talks

Teratological chitinozoans help confirm that hydrothermal brine expulsions caused the Ireviken extinction event

Iris Vancoppenolle[1]*, Poul Emsbo[2], Jay Thompson[2], Pat McLaughlin[3,4], Mikael Calner[5], Thijs R. A. Vandenbroucke[1]

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The Ireviken Event at the Llandovery-Wenlock boundary comprises a biotic extinction event followed by, and partially coinciding with, a global positive $\delta^{13}C$ excursion. While the event is increasingly being recognized as a Silurian oceanic anoxic event (OAE), its underlying trigger has long remained obscure. Using a variety of techniques, including ToF-SIMS and LA-ICP-MS, we measured high abundances of toxic metals in conodonts, chitinozoans, pyrites and bulk rock samples across the Ireviken Event at the classical locality of Lusklint 1 and the nearby Lusklint 1 core (Gotland, Sweden) which coincide with highly elevated concentrations of malformed chitinozoans. Malformations are a known *in vivo* response to metal poisoning and testify that these geochemical signals are primary. The specific suite of metals, the stratigraphic order in which they appear, and their coincidence with a radiogenic Sr-isotope spike, are signatures of metalliferous hydrothermal brine injection into the Silurian ocean providing a trigger for the cascade of environmental catastrophes that characterize the Ireviken Event. Intriguingly, the stratigraphic order in which these metals appear throughout the studied section in Gotland, thousands of kilometres away from the site of brine injection, mirrors the order observed in the near-field sedimentary-exhalative deposits of the Howard's Pass district (Yukon, Alaska).

Saturday 13th December, Session 3C, Portland Building PO 1.74, 15:30 – 15:45.

Evolutionary dynamics and environmental controls on marine biodiversity hotspots during the Cenozoic

Kella Venu Gopal*, Devapriya Chattopadhyay

Indian Institute of Science Education and Research Pune, India

Biodiversity is unevenly distributed across the globe, with certain regions acting as long-term hotspots of exceptional richness and endemism. The processes shaping their origin, persistence and shifts through the Cenozoic remain poorly understood. Using genus-level occurrence data from the Paleobiology Database, we reconstructed diversity patterns of three major marine clades – Mollusca, Cnidaria and Foraminifera – across the Cenozoic. We assembled a large, taxonomically standardized fossil dataset and applied consistent temporal bins, spatially explicit provinces, and employed shareholder quorum subsampling to reduce sampling biases. This framework allowed us to identify 40 clade-specific palaeo-hotspots and trace their temporal dynamics. We then used a hierarchical Bayesian framework with structural equation models to examine how environmental factors (sea-surface temperature, shelf area, sea level) and macro-evolutionary processes (origination, extinction, migration, standing diversity) influenced hotspot development. Environmental variables exerted little direct effect but shaped biodiversity indirectly by modulating macroevolutionary dynamics. Standing diversity was the strongest direct predictor of hotspot probability, while origination and migration played more episodic roles. Overall, our results suggest that marine biodiversity hotspots persisted in evolutionarily stable regions with moderate turnover, while environmental change primarily influenced them indirectly through its effects on diversification and dispersal.

Sunday 14th December, Session 5C, Portland Building PO 1.74, 12:15 – 12:30.

Morphospace testing of published pterosaur depictions: are pterosaur reconstructions fit to fly?

Benton Walters*, Emily J. Rayfield, Philip C. J. Donoghue
University of Bristol, UK

The fragmentary nature of pterosaur remains produces a dichotomy where, while much is known about their diversity, ecology and phylogeny, aspects of pterosaur morphology, particularly wing shape, remain controversial. In the absence of well-preserved stretched fossil wings, shape-based analyses of pterosaur flight are limited to linear measurements or reconstructed wing forms. Using theoretical morphospace analysis, I test whether published pterosaur reconstructions are useful as morphological proxies and whether artist style biases morphospace occupation. I create a theoretical space of all possible shape variation in the pterosaur wing, into which I project 91 modern wing reconstructions (since 2000) from ten taxa to analyse their relative clustering and functional performance. I further examine whether the niche separation proposed for pterosaur groups using linear measurements is preserved, by comparing theoretical morphospace occupation of pterosaurs with that of extant birds. My research indicates that reconstructions of pterosaur wings from the published literature do not function as living animals and exclusively occupy a thin-winged, soaring morphology. While individual artist style has little impact on wing efficacy, reconstructions are not a useful proxy for studying pterosaur flight.

Saturday 13th December, Session 2A, Richmond Building LT1, 12:00 – 12:15.

The earliest Cambrian lobopodians illuminate the origin of legs

Deng Wang[1,2], Martin R. Smith[2], Jean Vannier[3], Georg Mayer[4], Jian Han[1,4]
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Legs underpin the evolutionary and ecological success of arthropods and their relatives. Specialization and adaptation of appendages allows panarthropods to exploit myriad ecological niches in marine, terrestrial and aerial environments, and to engage in complex behaviours. The first leg-bearing Panarthropod is presumed to have arisen close to the base of the Cambrian, and to resemble lobopodians found in younger Burgess Shale-type deposits (< 518 million years ago). However, a dearth of early Cambrian fossils makes it difficult to test this hypothesis. Here we describe three-dimensionally preserved fossils from the 535-million-year-old Kuanchuanpu Formation. Our extensive new collections include six unprecedented specimens of leg-bearing 'worms' that share key features with lobopodians and with modern velvet worms (Onychophora), filling a crucial gap in the evolutionary history of panarthropods. The organism's unjointed legs are considered a key innovation of early bilaterians that facilitated epibenthic locomotion on a variety of soft or harder substrates and resulted in the exploitation of new ecological niches that likely accelerated the establishment of complex, dynamic ecosystems during the early Cambrian animal radiation.

Sunday 14th December, Session 6A, Richmond Building RB LT1, 15:00 – 15:15.

talks

Quantitative ichnology: from trace fossil morphology to evolutionary landmarks

Zekun Wang
Natural History Museum, London, UK

Locomotory trace fossils provide unparalleled insights into the evolutionary history of animals, revealing the behaviours, mobility and body plans of the trace-makers. Their value is especially pronounced during pivotal events, such as the early bilaterian radiation or the onset of terrestrialization, when body fossils are sparse or fragmentary. Yet, most contemporary trace fossil studies remain largely descriptive, limiting objective and quantitative interpretations. Key challenges include the uncertain link between traces and their creators, overlapping ichnotaxonomic diagnoses, and the difficulty of rigorously assessing locomotory and sensory capacities from fossilized traces. Here I introduce quantitative approaches – including metrics such as smoothness, integral scale and bandwidth, alongside computational tools like CFD-DEM coupling – to systematically characterize locomotory traces. My analyses provide compelling evidence for bilaterians with slender anterior-posterior axes and hydrostatic-coordinated bodies exhibiting advanced locomotory, cognitive and sensory abilities by approximately 545 million years ago. These likely included mollusc-, polychaete- or priapulid-like animals, with mollusc-like forms even exploring subaerial environments by the middle Cambrian. This framework transforms ichnological studies from qualitative description to rigorous, testable interpretation, offering more nuanced understanding of early animal evolution.

Sunday 14th December, Session 6A, Richmond Building RB LT1, 14:45 – 15:00.

Optimising CT scanning parameters for high-aspect ratio specimens

Paula Wilson[1], Richard P. Dearden[2,3], Ivan J. Sansom[2], Mark Williams[1]
[1]University of Warwick, UK; [2]University of Birmingham, UK; [3]Naturalis Biodiveristy Centre, the Netherlands

X-ray computed tomography (XCT) has revolutionized the study of life across deep-time, creating a permanent record for irreplaceable fossil samples that yield hidden anatomical insights. However, there remains one sample type that proves particularly problematic. High-aspect ratio (HAR) samples are vexing for palaeontologists looking to employ XCT for three reasons: the propensity for fossils to be extremely compressed on flat slabs; the potential of such material for three-dimensional preservation (*e.g.* Burgess Shale and Solnhofen), and the influence their awkward geometry has on X-ray attenuation profiles, severely impacting data quality. While specialist XCT methods, such as laminography, limited-angle, and iterative reconstruction are under development, access for most palaeontologists is limited. While these continue to mature, it is worth researching and understanding how we can optimize scanning of HAR samples using conventional lab equipment. This talk addresses this subject quantitatively over the course of two experiments: the influence of projection number and the angle of prioritization on image quality; and the influence of using a burial medium, in this case sand, to even out differential attenuation profiles. Results show that the angle of prioritization strongly influences data quality, while using burial mediums significantly reduces it.

Saturday 13th December, Session 2B, Richmond Building RB LT2, 11:00 – 11:15.

Benthic palaeoecological response to environmental changes across the Cenomanian–Turonian interval in the UK Chalk Sea

James D. Witts[1], Harriet Bohun[1,2], Andrew S. Gale[1,3], Zoë E. Hughes[1], Richard J. Twitchett[1]
[1]*Natural History Museum, London, UK;* [2]*Imperial College London, UK;*
[3]*University of Portsmouth, UK*

The Cenomanian–Turonian (Late Cretaceous ~100 — 93 Ma) coincided with dramatic environmental changes, including the global carbon cycle perturbation of Oceanic Anoxic Event 2 (OAE-2), changes in temperature, oxygenation, productivity and sea level. The combined effect of these events on benthic marine ecosystems remains unclear. Using macrofossil collections held at the Natural History Museum, London from the fossiliferous chalk succession at Eastbourne (East Sussex, UK), we quantify turnover, richness and functional palaeoecology of benthic assemblages across the Cenomanian–Turonian interval in the UK Chalk Sea for the first time. 1,503 individuals, representing 186 taxa from 147 horizons, were counted and identified. Palaeoecological data were compared to carbon and oxygen isotope analyses. The onset of the OAE-2 carbon isotope excursion coincides with disruption of a taxonomically and functionally rich Cenomanian community. Taxonomic richness shows a stepwise decline through OAE-2, with establishment of a low richness community which persists through the early Turonian despite carbon cycle recovery. Evenness and diversity metrics show little change, suggesting turnover rather than a significant benthic extinction. Functional richness also declines, but the most striking feature is the temporary disappearance of most epifaunal and semi-infaunal taxa coincident with the warmest temperatures of the early Turonian Cretaceous Thermal Maximum.

Sunday 14th December, Session 4A, Richmond Building RB LT1, 10:15 – 10:30.

Anoxia optional: local redox does not control Proterozoic microfossil preservation

Christina R. Woltz[1], Susannah M. Porter[2], Erik A. Sperling[3]
[1]*Imperial College London, UK;* [2]*University of California Santa Barbara, USA;*
[3]*Stanford University, USA*

Our understanding of early eukaryotic diversity relies heavily on the record of organic-walled microfossils (OWMs). However, variation in the conditions that preserve organic remains can introduce bias into fossil diversity patterns. It is generally accepted that bottom-water anoxia is a necessary condition for soft-bodied fossilization in the Phanerozoic, but whether this applies to the Proterozoic OWM record remains unclear. To test the role of local redox conditions, we employed statistical learning techniques on a dataset that pairs fossil quality – ranked by degradation features – with geochemical redox proxies and geological context. Contrary to long-standing assumptions, local redox state is not a primary predictor of fossil preservation, and more reducing conditions predicted only minor increases in preservation. Instead, the most influential variables were total organic carbon (TOC), confirming prior studies, and palaeoenvironment, which emerged as a significant predictor. These results suggest that nearshore marine settings, characterized by relatively higher sedimentation rates and consequently lower TOC content, enhanced fossil preservation. The differing role of redox in preserving Proterozoic OWMs versus Phanerozoic soft-bodied fossils likely reflects differences in organic compositions and decay resistance. Overall, the OWM record appears to be a reliable archive that is unbiased by the heterogeneous redox landscape of Proterozoic oceans.

Saturday 13th December, Session 3C, Portland Building PO 1.74, 15:45 – 16:00.

talks

A new frondose taxon from the Shibantan Lagerstätte illuminates the palaeoecology of Ediacaran fronds

Chengxi Wu[1,2,3]*, Ke Pang[1], Alexander G. Liu[3], Yarong Liu[1,2,3], Xiaopeng Wang[1,3], Chuanming Zhou[1], Zhe Chen[1], Xunlai Yuan[1,2], Shuhai Xiao[4]

[1]Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, China; [2]University of Chinese Academy of Sciences, China; [3]University of Cambridge, UK; [4]Virginia Tech, USA

Frondose organisms constitute a prominent component of the Ediacaran macrobiota (~574–539 Ma), a collection of largely soft-bodied taxa that document the radiation of complex macroscopic life, including early animals, immediately prior to the Cambrian Explosion. Here we report a new frondose taxon from the late Ediacaran Shibantan Lagerstätte (~550–543 Ma) in the Yangtze Gorges area of South China, hosted in marine limestones of the Shibantan Member, Dengying Formation. This new taxon exhibits a unique frondose morphology characterized by a modular stalk with two rows of unconstrained and flexible first-order branches. The sub-divisions of second order branches possess distinct morphologies resembling the autozooids of some modern cnidarians (*e.g.* sea pens), which together with its separate and flexible first-order branches suggest a suspension-feeding lifestyle. The new fossil shares morphological traits with both arboreomorph and rangeomorph frondose taxa. A cladistic analysis of several Ediacaran frondose taxa resolves this fossil as a sister taxon to the arboreomorph fronds plus *Akrophyllas*, and expands the known morphological diversity of late Ediacaran fronds. These findings provide new insights into the evolution, body plans and ecological strategies of frondose organisms within the Ediacaran macrobiota.

Sunday 14th December, Session 4B, Portland Building PO 1.74, 09:00 – 09:15.

CAM photosynthesis: a key trait in surviving Earth's largest extinction?

Zhen Xu[1], Jason Hilton[2], Jianxin Yu[3], Paul B. Wignall[1], Alexander Farnsworth[4,5], Isabel P. Montañez[6], Benjamin Mills[1], Barry H. Lomax[7]

[1]University of Leeds, UK; [2]University of Birmingham, UK; [3]China University of Geosciences (Wuhan), China; [4]University of Bristol, UK; [5]Institute of Tibetan Plateau Research, Chinese Academy of Sciences, China; [6]University of California, USA; [7]University of Nottingham, UK

The Permian–Triassic Mass Extinction (PTME) marks the Phanerozoic's largest loss of biodiversity. On land, it led to a floral turnover and herbaceous lycophytes dominated the Early Triassic. Through two independent methods of analyses we place these disaster taxa into a phylogenetic framework. Our examination of their fertile leaves (sporophylls) reveals that the Early Triassic lycophytes are closely related to modern Isoeteales lycophytes, a group renowned for ecophysiological flexibility in high stress regimes. Carbon isotope analysis further supports a linkage to Isoeteales as the fossils have an isotopic signature similar to extant Isoetes plants that utilize Crassulacean Acid Metabolism (CAM) photosynthesis. Integration with HadCM3L climate simulations suggests that CAM physiology was a probable critical survival strategy under extreme Early Triassic hot-house conditions. These data suggest a potential unique suite of adaptations that enabled these lycophytes to thrive after Earth's greatest extinction, supporting a global ecological recovery.

Sunday 14th December, Session 5B, Richmond Building RB LT2, 12:00 – 12:15.

Fossilized skin of dinosaurs illuminates stepwise evolution of the avian integument

Zixiao Yang[1], Xing Xu[2,3], Baoyu Jiang[4], Peter Chung[5], Maria E. McNamara[5]

[1]*Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, China;* [2]*Chinese Academy of Sciences, China;* [3]*Yunnan University, China;* [4]*Nanjing University, China;* [5]*University College Cork, Ireland*

Fossilized feathers have provided critical insights into the evolution of feather structures, but how the underlying skin evolved remains enigmatic. Here we present ultrastructural preservation of skin in five dinosaurs, revealing a stepwise acquisition of novel skin characters during the evolutionary transition from scales to feathers. The fossilized nonfeathered skin of *Psittacosaurus* showed evidence for scales, corneocytes with fused cell boundaries and rich in corneous beta proteins, and melanization in the epidermis; these features are consistent with retention of plesiomorphic reptile-type skin. The feathered skin of *Dilong* and *Beipiaosaurus*, however, showed a mixture of reptilian and avian features. The skin lacked scales and had corneocytes with distinct cell boundaries, as in the feathered skin of birds; the epidermis, however, contained abundant melanosomes, a condition known in reptiles but not in *Anchiornis*, *Confuciusornis* or extant birds. With both epidermis and feathers melanized, *Dilong* and *Beipiaosaurus* document a transitional stage in skin evolution prior to fully avian-type integument. Intriguingly, the skin melanosomes of *Dilong* and *Beipiaosaurus* differ to those in the associated feathers, suggesting decoupled melanogenesis in the epidermis and its appendages. This partitioning was likely a key prerequisite for the dramatic expansion of melanosome diversity – and thus diverse colouration – of feathers.

Saturday 13th December, Session 1, Richmond Building RB LT1, 09:15 – 09:30.

Feeding strategies of raptorial radiodont predators in the Cambrian

Mingjing Zhang[1]*, Stephen Pates[1], Xiaoya Ma[2]

[1]*University College London, UK;* [2]*University of Exeter, UK*

Radiodonts are renowned Cambrian predators that occupied the apex of the food chain and exhibited diverse feeding strategies. While the different prey choices of Burgess Shale radiodonts have been inferred, those of Chengjiang raptorial radiodonts remain largely unknown. Here we studied two well-known radiodonts, *Amplectobelua symbrachiata* (Chengjiang) and *Anomalocaris canadensis* (Burgess Shale), to investigate how differences in feeding appendage morphology influenced prey capture. We constructed three-dimensional models to isolate the functional roles of different morphological features. The enlarged proximal-most endite of *Am. symbrachiata* facilitated the capture of smaller prey, while *An. canadensis* utilized its high-angle membranes and greater number of podomeres with specialized morphologies to target larger prey. Two feeding modes were identified: asynchronous and synchronous movements. *An. canadensis* likely employed only synchronous movements toward the oral cone, while *Am. symbrachiata* was capable of transferring food to its gnathobase-like structures using both strategies. Morphological comparisons of Chengjiang taxa reveal three distinct feeding groups: one resembling *An. canadensis*, specialized for synchronous feeding on larger prey (X species); one resembling *Am. symbrachiata*, adapted for asynchronous feeding on smaller prey (Y species); and one intermediate form combining characteristics of both, suited for synchronous feeding on prey of intermediate size (Z species). These differences in feeding strategies suggest limited overlap in prey choice among Chengjiang raptorial radiodonts.

Sunday 14th December, Session 6A, Richmond Building RB LT1, 15:30 – 15:45.

New data on Late Jurassic ichthyosaurs help to resolve a conundrum in the taxonomy of the Ophthalmosauria

Nikolay G. Zverkov[1], Megan L. Jacobs[2], Benjamin G. Thomas[2]
[1]*Geological Institute of the Russian Academy of Sciences, Russia;* [2]*University of Portsmouth, UK*

The potential synonymy of Late Jurassic ophthalmosaurian taxa *Brachypterygius extremus* and *Grendelius mordax* remained a subject of debate for three decades, engendering inconsistent taxonomic opinions and competing phylogenetic hypotheses. In an attempt to unravel this 'Gordian knot', we surveyed all the specimens from the English Upper Jurassic previously referred to *B. extremus* and/or *G. mordax*, and report several yet undescribed specimens. We report several historical specimens from the type locality of *B. extremus* that, based on their provenance, morphology and mode of preservation, may represent parts of the skeleton to which the holotypic forelimb of *B. extremus* belonged. New evidence suggests that *Brachypterygius* had a slender rostrum, which, along with six digits in the forelimb, makes it similar to *Aegirosaurus* from Germany and *Parrassaurus* from Mexico, whereas *Grendelius* has a massive rostrum with robust teeth and only five digits in the forelimb. Moreover, *Brachypterygius* and *Grendelius* are separated temporarily, with the type specimen of *B. extremus* originating from the lowermost Kimmeridgian, whereas specimens referable to *Grendelius* mostly originate from the lower Tithonian. The available material on *Grendelius* implies the presence of several species of this genus in the Kimmeridge Clay.

The work of NGZ was supported by the RSF grant no. 25-17-00210.

Sunday 14th December, Session 5A, Richmond Building RB LT1, 11:00 – 11:15.

Abstracts of Lightning Talks

* Candidates for the President's Prize are marked with an asterisk.
Underlined author denotes designated speaker.

Filling in a knowledge-gap: early Late Ordovician cephalopod assemblages of Estonia

Martina Aubrechtová, Tõnu Meidla
University of Tartu, Estonia

Fossil cephalopods are fairly common and generally well-preserved in the Ordovician rocks of Baltoscandia. However, data on the composition, diversity and distribution of cephalopod assemblages are insufficient in certain intervals, despite the fact that these major Palaeozoic predators were shown to be particularly useful in palaeoclimatic and palaeoecosystem analyses. A research project has recently been initiated to fill in a significant knowledge gap concerning cephalopod assemblages from the early-mid Sandbian (early Late Ordovician) of Estonia. Over 400 specimens have so far been preliminarily studied and results show that approximately 60 % of the collection are represented by orthoceratids, followed by endoceratids (17 %) and tarphyceratids (13 %). The rare elements include lituitids, oncoceratids and actinoceratids (10 % together). The low abundance of the latter groups might reflect relatively cool-water conditions despite the drift of the palaeocontinent Baltica towards low palaeolatitudes. This is in contrast to the late Sandbian–Katian cephalopod fauna which was previously interpreted as inhabiting sub/tropical shallow and reef environments.

Saturday 13th December, Session 2C, Portland Building PO 1.74, 11:40 – 11:45.

Were areas of higher ecological uniqueness consolidated as centres of recovery after the end-Cretaceous extinction?

Emma Ayres[1,2]*, Jorge García-Girón[3], Stephen L. Brusatte[2]
[1]University of Bristol, UK; [2]University of Edinburgh, UK; [3]Universidad de León, Spain

The selectivity of the end-Cretaceous extinction and establishment of new ecosystems may have been influenced by ecological differences between dinosaurs, which became extinct, versus mammals and freshwater taxa. Applying ecological methods for extant ecosystems, like ecological uniqueness measures, can help untangle these by determining spatiotemporal links between species distributions and abiotic environment. We tested whether notably unique late Cretaceous species compositions corresponded to Palaeogene centres of post extinction recovery by comparing Campanian–Danian uniqueness measures of Laramidian terrestrial and fluviolacustrine vertebrate faunas. Calculations were based on a fossil occurrence database compiled from the Paleobiology Database, considering environmental conditions from climate models and fossil record biases. We found that high pre-extinction ecological uniqueness was not maintained across the extinction, indicating that pre-extinction ecologically unique areas were not preferential centres of post-extinction recovery. Freshwater taxa contributed the most to Danian beta diversity, suggesting that freshwater and terrestrial ecosystems were affected differently by the extinction, perhaps recovering more rapidly. Little correlation between biotic and abiotic uniqueness implies

that environmental conditions did not consistently control spatiotemporal variation of faunal uniqueness. In conclusion, faunal recovery patterns were not determined by pre-extinction ecological uniqueness and were driven by freshwater taxa, despite the appearance of new mammal taxa.

Sunday 14th December, Session 5C, Portland Building PO 1.74, 11:35 – 11:40.

Reassessment of a gigantic pliosaur mandible from the Kimmeridge Clay Formation of Cumnor, Oxfordshire, UK

Edward Bartlett[1]*, Roy Smith[1], David Martill[1], Jake Kean[1], Judyth Sassoon[2]
[1]University of Portsmouth, UK; [2]University of Bristol, UK

The macropredatory marine reptile *Pliosaurus* Owen, 1842 is represented by multiple gigantic specimens with an estimated total body length of 10–12 m. Among the largest is a reconstructed mandible measuring 2.95 m from the Kimmeridge Clay Formation (Kimmeridgian, Upper Jurassic) of Cumnor, Oxfordshire. Discovered between 1880 and 1888, the fragmentary mandible (OUMNH J.10454) was reconstructed in 1933, and the total length of the specimen was exaggerated; the full extent of the reconstruction and preservation of the mandible has yet to be determined. Here we present topographic scans and a photogrammetric model of OUMNH J.10454, assessing the proportion of the material that comprises the reconstruction. A total mandibular length of 2.1–2.5 m is estimated using a wide range of methods including scaling from symphysial length and previously unreported cranial material associated with the mandible. We describe the additional cranial elements and attempt to resolve the taxonomic identity of the specimen. Despite the reconstruction extending the mandibular length, OUMNH J.10454 still represents one of the largest *Pliosaurus* specimens, with an estimated total length of 9–10 m. The redescription of OUMNH J.10454 builds on our understanding of *Pliosaurus* cranial anatomy and intraspecific variation, representing one of the oldest 'short symphysis' *Pliosaurus* specimens.

Sunday 14th December, Session 5A, Richmond Building RB LT1, 11:30 – 11:35.

Review of femoral length as a body mass predictor in Aves

Alex Colesmith*
University of Cambridge, UK

Estimation of body mass from fossil specimens is a difficult task and usually relies on proxy measurements. In fossil birds, the most commonly-used proxy measurements are femoral dimensions, which are good predictors of body mass. Due to the thin-walled bones, fossil bird femora are frequently found crushed, even in well-preserved specimens such as those from the Messel Pit, Germany, which distorts femoral dimensions; femur length is the least distorted by this crushing process, and hence an important proxy metric. The existing equations for femur length to body mass consistently over- or under-predict the body mass of certain ecotypes and clades when applied to modern birds. Using a large dataset of modern birds, I show that when ecology and phylogeny are taken into account, femur length becomes a very good predictor of body mass, and I demonstrate the use of this for fossil taxa.

Sunday 14th December, Session 5B, Richmond Building RB LT2, 11:30 – 11:35.

A new cranial reconstruction of the gliding tanystropheid *Ozimek volans* from the Triassic of Poland

Thomas Ducrey[1]*, Torsten Scheyer[2], Feiko Miedema[3]
[1]*University of Birmingham, UK;* [2]*University of Zurich, Switzerland;* [3]*Naturhistorisk Museum, University of Oslo, Norway*

Ozimek volans is a member of Tanystropheidae, a clade of non-archosauriform archosauromorphs characterized by elongated cervical vertebrae. Uniquely, *O. volans* possessed plate-like coracoids fused with the sternum and elongated limb bones resembling those of *Sharovipteryx* mirabilis from the Triassic of Kyrgyzstan, a potential glider. Based on these features, *O. volans* is interpreted as the only known gliding member of Tanystropheidae. The postcranial anatomy of *O. volans* is well documented from several semi-articulated skeletons in the Carnian lacustrine deposits of Krasiejów, Poland. The skull reconstruction, however, was based only on a few identified mandibular and temporal-lateral elements in the original description of ZPAL AbIII/3191. Through detailed manual CT segmentation and comparison with 3D datasets of other tanystropheids, we reidentify misassigned cranial elements and document new material, producing a revised 3D skull reconstruction. This includes a mostly complete palate with tooth-bearing pterygoids and palatines, a clarified occipital region with supraoccipital, opisthotics and prootics, and a skull roof with prefrontals and frontals. Mandibular anatomy is expanded with the splenial, angular, surangular and prearticular. These findings provide the most complete cranial reconstruction of *O. volans* to date, offering insights into cranial evolution, functional morphology and phylogenetic position within Tanystropheidae.

Sunday 14th December, Session 5B, Richmond Building RB LT2, 11:35 – 11:40.

A new three-dimensional description of *Saurostomus esocinus* and its implications for asthenocormine success

Benedict Emmerson[1]*, Samuel L. A. Cooper[2], Sam Giles[3], Michael J. Benton[1]
[1]*University of Bristol, UK;* [2]*Staatliches Museum für Naturkunde Stuttgart, Germany;* [3]*University of Birmingham, UK*

The pachycormids are a diverse family of stem teleosts ranging from the early Jurassic to the end Cretaceous. A major sub-family of the pachycormids are the asthenocormines, known mainly for their large suspension feeding forms such as *Leedsichthys*. *Saurostomus esocinus* is an early diverging member of the asthenocormines from the Toarcian known mainly from two-dimensional compacted material from the Posidonia Shale. From this material much of *S. esocinus* has been described; however, critical three-dimensional detail is missing meaning that the skull roof and internal features of the skull could not be fully assessed. Here we describe two exceptionally-preserved three-dimensional skulls of *Saurostomus esocinus* from the southwest of England, one from Strawberry Bank and the second from a new locality. We CT scan and segment the internal features of the skull to reveal new details including the brain case and gill skeleton. From the gill skeleton we describe for the first time the gill rakers of *Saurostomus*, confirming its ecology as a macrophage. Furthermore, we find many of the derived characteristics of the asthenocormines already present in *Saurostomus esocinus*, giving new insight into how and when these large suspension feeders became so successful.

Sunday 14th December, Session 5A, Richmond Building RB LT1, 11:40 – 11:45.

Finite element analysis of horse toe bones: the next step in decoding anchitheriin locomotion

Tanya Gunnarsdottir*, Natalia Trepp Centellas, Christine M. Janis
University of Bristol, UK

Members of the extinct clade Anchitheriini (Equidae: Perissodactyla) were thought to retain the basal foot condition for ungulates: subunguligrade posture with a footpad (seen in modern tapirs, rhinoceroses and hippopotamuses). Other ungulates, such as extant horses and ruminants, are specialized for sustained locomotion and have a derived, fully unguligrade, energy-saving spring foot. Among artiodactyls, extant suiforms (pigs and peccaries) have neither footpad nor spring foot, but no extant perissodactyls have this condition. Evidence from osteological correlates and an intriguing trace fossil suggests that anchitheriins may have paralleled suiforms with respect to foot condition. To test this, eight perissodactyl specimens (pad-footed, spring-footed and anchitheriin) were compared using finite element analysis: simplified digital models of forelimb proximal phalanx III were simulated at different gaits to look for correlates of foot condition in their resultant stress patterns and relative performance under load. The anchitheriins performed best, particularly when modelled as unguligrade rather than subunguligrade, potentially indicating that they relied less on a footpad or robust suspensory apparatus for support. Other parameters such as phalanx aspect ratio or cortex thickness may explain the findings; this could be investigated via further biomechanical analysis of both perissodactyls and artiodactyls to explore the possible parallel with suiforms.

Saturday 13th December, Session 2A, Richmond Building LT1, 11:40 – 11:45.

talks

Analytical minimization of squared change solves parsimony and likelihood problems fast

Jennifer F. Hoyal Cuthill[1], Graeme T. Lloyd[2]
[1]*University of Essex, UK;* [2]*Independent*

Hoyal Cuthill and Lloyd have teamed up to expand methodological options for measuring homoplasy with the R package Claddis. We recently provided minimum and maximum step measures for an exhaustive range of discrete character types (Hoyal Cuthill and Lloyd 2025). Here we describe new methods for continuous characters. We present a new algorithm for analytical minimization of squared changes on a tree and show speed-test results against three other R packages. Simulations up to 1,000 tips show an uncompiled R version is an order of magnitude faster than two of the most commonly used R functions ('ace' in the *ape* package and 'fastanc' in the *phytools* package). Further results from a compiled C++ version implemented using Rcpp show a potential additional order of magnitude speed gain. We note that ancestral state and character length reconstructions are the same for algorithms motivated by squared-change parsimony and maximum likelihood under Brownian motion. Therefore, minimization of squared change provides both a rapid parsimony and likelihood estimator, giving consequent insights into the nature of inferred evolutionary change for continuous traits. Collectively our results emphasize the continuing utility of work on maximum parsimony approaches for phylogenetics more broadly.

Sunday 14th December, Session 5C, Portland Building PO 1.74, 11:30 – 11:35.

The Porma Biota: a community of wiwaxiids, priapulimorph worms and palaeoscolecids from Cambrian Epoch 2 northwestern Gondwana

Blanca Martínez-Benítez[1,2]*, Teodoro Palacios[3], J. Javier Álvaro[2]
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The uppermost part of the lower Láncara Member cropping out in the surroundings of the Porma Dam, Cantabrian Mountains, Spain, has yielded a diverse metazoan community rich in small carbonaceous fossils (SCFs). Sampling field-trips over the last twenty years have uncovered the presence of wiwaxiid and palaeoscolecid sclerites, priapulimorph teeth and acritarchs exhibiting different degrees of preservation. The Porma Biota comprises: the first record of *Wiwaxia* sclerites and the oldest record of *Hadimopanella*-like sclerites from palaescolecid worms of the Iberian Peninsula, priapulimorph teeth, the extinction horizon of the acritarch genus *Skiagia*, and the identification of the *Volkovia dentifera-Liepaina plana* zone in the Cantabrian Mountains. The SCF organisms inhabited low-energy clayey substrates that represent the lower part of shallowing-upward cycles, up to 4 m thick, which ended in carbonate shoal complexes fringing the northwestern Gondwana margin. This stratigraphic framework suddenly disappeared as a result of a widespread tectonic and erosive event, marked by the unconformity that separates the lower and upper members of the Láncara Formation. This erosive contact corresponds to the regional Cambrian Series 2-Miaolingian boundary, where the former community was replaced by the establishment of the chancelloriid-echinoderm-sponge meadows that characterize the beginning of Miaolingian times in the Cantabrian Basin.

Saturday 13th December, Session 2C, Portland Building PO 1.74, 11:35 – 11:40.

The emergence of metabolisms through Earth history and implications for biospheric evolution

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We investigate the evolution of microbial metabolisms from the last universal common ancestor to extant biota through comparative phylogenomics, reconciling the evolution of the genes that underpin metabolic pathways with a time-calibrated tree of life. We find that the majority of metabolic pathways were established within the first two billion years of Earth history, with pathways accreting at different rates. Methanogenesis and acetogenesis are recovered to be among the earliest energy metabolisms, whereas photosynthetic pathways achieved completeness by 2 Ga, much later than most previous studies have envisaged. Horizontal exchange of metabolic genes is widespread, but it has occurred largely among closely related lineages and for some pathways there is a strong signal of vertical inheritance. We also find that the rate of horizontal gene transfer has been higher in Bacteria than in Archaea through evolutionary history. Finally, we evaluate how our reconstructed history of metabolism can help to constrain hypotheses of biospheric evolution, considering the entropic and Darwinized Gaia hypotheses as well as a simple neutral model for the assembly of biogeochemical cycles.

Saturday 13th December, Session 2B, Richmond Building RB LT2, 11:40 – 11:45.

#Yourpalaeolife: interrogating the status of fieldwork amongst early-career palaeontologists

Harriet E. Nuttall*
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Over the last year, concerns have been raised in the palaeontological community, and across scientific academia more generally, that the practice of fieldwork is no longer being given sufficient priority in the education of student researchers, nor in the project proposals of those researchers when they reach a position of greater independence. From the perspective of some, we are at a precipice of a widespread professional 'extinction of experience', in which the early-career investigators who represent the future of Palaeontology do not develop the requisite skillset to undertake those field expeditions that, ultimately, generate all palaeontological data. Thus far, the conversation has been based solely on anecdotal evidence, with much informal speculation as to possible causal factors but no ground-level enquiry to provide verification. The #Yourpalaeolife global ECR survey, conducted over three months this past autumn, provides the first empirical assessment of fieldwork in the experiences and views of this key demographic of palaeontologists. Here I present the preliminary statistical analysis and salient findings from the survey and propose the next stages of investigation into this fundamental community predicament.

This work was supported by NERC CENTA2 grant NE/S007350/1.

Saturday 13th December, Session 2B, Richmond Building RB LT2, 11:30 – 11:35.

Extinction and survival at the dawn of plant life on land

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Lycophytes are the most ancient lineage of vascular plants, first appearing during the Silurian. Over the Silurian–Devonian transition, they split into two lineages: zosterophylls and lycopsids. While zosterophylls were major components of early land floras, they vanished by the end of the Devonian. By contrast, lycopsids diversified and persist today. Explaining these divergent evolutionary trajectories remains a central question in plant evolution. This study uses a trait-based approach to investigate factors contributing to zosterophyll decline, focusing on exceptionally-preserved fossils from the Rhynie Chert (407 Ma, Aberdeenshire, Scotland). These hot spring deposits capture some of the earliest terrestrial ecosystems in three-dimensional silica preservation. This has allowed the first 3D reconstructions for *Trichopherophyton teuchansii*, with preliminary results revealing an alternating pattern of sporangial arrangement on leafless stems, lateral growth during circinate unfurling and dense spinose coverage. Putative rhizoids are present, but true roots are thus-far absent. By contrast, lycopsids evolved true roots and leaves – traits likely providing ecological flexibility and resilience to environmental change, underpinning their long-term persistence. The absence of such traits in zosterophylls suggests limited growth capacity and habitat specialization. These findings refine understanding of early plant diversification and extinction, and highlight functional traits enabling lycopsid survival.

Sunday 14th December, Session 5B, Richmond Building RB LT2, 11:40 – 11:45.

Macroscopic carbonaceous compression fossils from the Tonian Changlingzi Formation in the Liaonan region of North China

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The Tonian Period represents a critical interval for the ecological rise of crown-group eukaryotes. However, the evolutionary pattern of early eukaryotes, particularly regarding morphological and functional innovations, remains unclear due to the limitation of fossils. Here we describe a new assemblage of carbonaceous compression macrofossils, comprising *Chuaria*, *Tawuia*, and the 'worm-like' annulated tubular taxon *Protoarenicola* from the Tonian Changlingzi Formation in the Liaonan region of Liaoning Province, North China. Additionally, dark discoidal structures, which are interpreted as epibionts, have been identified on the surface of these macrofossils. Biometric analysis suggests that *Chuaria* with a minimum diameter of no less than 1.2 mm may share a biological relationship with *Tawuia*. The *Protoarenicola* specimens, characterized by their narrow tube width and the continuous distribution of transverse annulation spacing, may represent an ecotype within the genus. This study highlights the increasing biostratigraphic significance of annulated tubular fossils, including *Protoarenicola*, *Pararenicola* and *Sinosabellidites*, for Tonian successions.

Saturday 13th December, Session 2C, Portland Building PO 1.74, 11:30 – 11:35.

The complex relationship between brachiopods, bivalves and the environment

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Perceptions of brachiopod and bivalve diversification dynamics have changed considerably over the last half-century. Initially considered a textbook example of competitive displacement, environmental factors have grown increasingly important in modern interpretations of the evolutionary histories of both groups, with some excluding competition altogether. However, these interpretations continue to be based upon global-scale analyses, which fail to account for spatial biases in fossil distributions. Consequently, whether the inverse correlation between bivalve and brachiopod richness presented by the fossil record reflects a causal relationship remains uncertain. Here we tackle this problem by analysing the diversity dynamics of both groups using spatially explicit methods and a new dataset of over half a million fossil occurrences compiled from museum collections, the Paleobiology Database and the Global Biodiversity Information Facility. Assuming an inverse relationship between brachiopod and bivalve richness in geographically constrained regions reflects competitive displacement, we recover a complex relationship between the two groups that incorporates environmental factors such as bathymetry, lithology and, to a lesser extent, latitude and the presence of reefs. Ultimately, whilst they highlight important caveats to analyses of this type, our results suggest that bivalves and brachiopods may not have been ships that pass in the night after all.

Sunday 14th December, Session 5C, Portland Building PO 1.74, 11:40 – 11:45.

A new phocid seal from Peru highlights ancient diversification of monk seals in the Southern Hemisphere

Rafael M. Varas-Malca[1,2*], Mario Urbina[2], Vanessa Meza-Vargas[1,2]
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Monachinae seals (Phocidae) solely dominated the pinniped southeastern Pacific communities from ~ 8 Ma – 4.5 Ma. Despite having no clear phylogenetic affinities within Monachinae, up to four coeval species have been described from the Pisco Formation (Peru) in Sacaco that depicted different ecomorphologies. One of them is the stout-teeth-bearing, long-snouted *Hadrokirus*, hypothesized as a durophagous seal. MUSM 430, an incomplete skull, was originally referred to *Hadrokirus*. Interestingly, it originates from younger layers (Yauca locality, 4.8 Ma) and exhibits distinct cranial proportions including a larger bizygomatic width, broader breadth at canines, a medium-sized snout and other craniodental features suggesting it could represent another taxon. We included MUSM 430 in a maximum parsimony analysis, using the TBR algorithm on 37 operational taxonomic units and 168 morphological characters, following the premises and matrix available. The consensus tree (CI=0.35, RI=0.63) reflects a topology where most of the Peruvian seals form a clade, close to Lobodontini. Moreover, MUSM 430 is nested within the Monachini clade (monk seals), far from the previous assignation to *Hadrokirus*. This unexpected record is in accordance with Pliocene Australasian monachins; it thus supports their wider distribution and ancient presence in the southern hemisphere and adds to the yet underexplored Neogene Pacific phocid diversity.

Sunday 14th December, Session 5A, Richmond Building RB LT1, 11:35 – 11:40.

talks

Row, row, row your bone: using computational fluid dynamics to investigate the formation of fossil bone beds

Fraser Weston[1*], Zekun Wang[2], Susannah C. R. Maidment[1,2], Imran A. Rahman[2,3]
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Fossil bone beds consist of accumulations of disarticulated skeletal material, offering valuable palaeoecological and palaeoenvironmental insights. One of the main processes responsible for forming such beds was fluvial transport. Previous work grouped bones based on flume experiments on mammalian bones, and this has been widely cited in subsequent interpretations of bone bed formation, even when the fossils in the deposits are non-mammalian. In this study, we investigated the transportation potential of bones from three ornithischian dinosaurs, which vary in size and shape. We used computational fluid dynamics to quantify drag and lift produced by the bones in flow and performed a principal component analysis on these and other variables (*i.e.* mass and surface area). We also calculated settling velocities. Our results highlight distinct differences from previous work and between ornithischian species, with settling velocities less stratified in the studied dinosaurs compared to previous experiments on mammals. We identify three distinct groupings of bones: ribs/phalanges; vertebrae/distal limbs; and proximal limbs. This highlights that both bone mass and morphology are key factors controlling transport and, hence, formation of bone beds. This novel quantitative approach for interpreting bone beds has broad applications for taphonomic and palaeoenvironmental interpretations.

This project was funded by Palaeontological Association Undergraduate Research Bursary PA-UB202504.

Saturday 13th December, Session 2A, Richmond Building LT1, 11:35 – 11:40.

The evolution of theropod tooth form and function

Morgan Whitley*, Manabu Sakamoto, Chris Venditti
University of Reading, UK

Teeth are critical for vertebrate feeding, with morphological changes influencing function. Theropods evolved a diversity of sizes and niches; hence, they are ideal to explore the relationship between tooth form and function. Additionally, theropods transition from teeth-to-beaks several times. This project investigates how size, diet, time, phylogeny and beak evolution influenced theropod tooth form and function. A 2D theoretical morphospace was constructed using tooth outlines from 262 theropod species to generate 1,000 hypothetical tooth forms. The empirical theropod teeth were projected onto the morphospace and categorized by family, diet, four different size measurements, and geological period. A separate morphospace was created using only teeth from families that transitioned from teeth to beaks. Heatmaps plotting tooth crown base length-to-width ratios and mesial edge to centre width ratios were projected onto the morphospaces to indicate puncturing and cutting efficiency. Significant overlap occurs when categorizing tooth form by diet and family. Diversity increased through time, whereas increasing size constrained teeth to wider, slightly recurved forms. Developing beaks had no impact on tooth form and function. These results demonstrate little diversity in 2D form in lingual view. Perhaps theropod tooth diversity is observed in other views or with other tooth characteristics (serration density).

Saturday 13th December, Session 2A, Richmond Building LT1, 11:30 – 11:35.

Are humans a transient agent of destruction or a potential persistent driver of biosphere net gain?

Thomas W. Wong Hearing, Mark Williams
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Earth's biosphere has been subject to transient and persistent disruptors throughout its history. Transient disruptors, including large igneous province volcanism and asteroid impacts, are associated with temporary but sometimes massive loss of biomass and biodiversity. In contrast, persistent disruptors, like the Cambrian agronomic revolution and the evolution of land plants, have ultimately enhanced planetary habitability with new ecosystems and symbioses, even when they had harmed the incumbent biosphere. Here we seek to understand anthropogenic impacts on the biosphere within the framework of past transient and persistent disruptors. Our analysis suggests that most contemporary anthropogenic impacts on the biosphere resemble past transient disruptors, massively degrading wild biomass and biodiversity through mechanisms including rapid temperature change, deforestation, ocean deoxygenation and ocean acidification. However, humans are the first disrupting agent with the capacity to make conscious choices about our impact on planetary habitability. We ask whether intentional changes to human–biosphere interactions could stabilize biosphere degradation, increase productivity, and augment planetary habitability, including through a combination of enhanced ecological heterogeneity, ecological protection and the development of novel ecologies.

Saturday 13th December, Session 2B, Richmond Building RB LT2, 11:35 – 11:40.

Abstracts of poster presentations

* Candidates for the Council Poster Prize are marked with an asterisk.
Underlined author denotes designated presenter.

Density dependence of traits within Charniodiscus Populations from the Ediacaran of Newfoundland

Princess A. Buma-at*, Nile P. Stephenson, Jason Head, Charlotte G. Kenchington, Emily G. Mitchell

University of Cambridge, UK

Ediacaran macrofossils (580–539 Ma) represent the earliest-known animals, providing critical insight into the evolution of life. This study focuses on *Charniodiscus*, one of the most iconic Ediacaran frondose organisms, because it was widely distributed throughout the terminal Ediacaran and its body plan may have potentially persisted into the Cambrian. *In situ* populations of the sessile, benthic *Charniodiscus* occur in the UNESCO Mistaken Point Ecological Reserve and the Discovery Geopark Newfoundland, Canada, enabling the use of quantitative population studies to elucidate key aspects of their eco-evolutionary dynamics. Morphological traits were obtained from 257 *Charniodiscus* specimens across ten bedding surfaces using photogrammetric maps and laser scan data. We used multivariate cluster analyses to explore physical variation across specimens and to identify distinct morphogroups with defining morphological traits. Random labelling analyses were then used to investigate whether these morphogroups or traits displayed density-dependent behaviour. Morphogroup distributions were spatially independent, indicating that changes in density didn't impact the trait distributions within *Charniodiscus* populations. These results suggest that density-induced intraspecific competition likely didn't influence trait-variations for *Charniodiscus*, shedding light on how functional traits drive broad-scale Ediacaran population dynamics.

Reassessing the Miaolingian–Furongian (Cambrian) paucity of metazoan reefs paradigm

J. Javier Álvaro[1], Aram Bayet-Goll[2], Mehdi Daraei[2], Blanca Martínez-Benítez[1]

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The apparent extinction of archaeocyaths at the beginning of the Miaolingian and the subsequent Miaolingian–Furongian scarcity in metazoan reefs coincided with: a significant turnover in skeletal biomineralization (replacing dominant high-Mg calcite and aragonite shells by low-Mg calcite skeletons); and a global persistent fall in the relative abundance of preserved carbonates and reefal volume, excluding purely microbial reefs, of three orders of magnitude. However, this kind of global analysis has not yet considered basins where carbonate production and non-reefal and reefal volume increased throughout Miaolingian–Furongian times, as in the case study represented by the Alborz margin of northeastern Gondwana. This Iranian margin arrived to subtropical latitudes during Miaolingian times and recorded the onset of microbial-dominant carbonate factories, replaced during the Furongian by widespread blanketing of pelmatozoan-rhynchonelliformean meadows, locally punctuated by anthaspidellid (demosponge)-microbial patch reefs. Although the first anthaspidellid debris of *Rankenella* occurred there in late Miaolingian substrates, the first frame-building skills of the genus were controlled in the Alborz margin by tectonic activity and substrate (firm- to hard-ground) properties.

Exploring interrelationships between fossil and extant lorisids (Strepsirrhini, Primates) and the question of their biogeographic origins

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Extant lorisids are distributed across equatorial Africa (pottos and angwantibos) and Southeast Asia (slow and slender lorises), and this notable degree of geographic separation suggests a complicated evolutionary history. Molecular phylogenetic analyses have addressed the inter-relationships among extant lorisids and generally agree with the family being divided into two monophyletic clades: the African Perodicticinae and the Asian Lorisinae. However, how modern lorisids relate to their extinct kin is poorly understood. Here we created a data matrix of 191 morphological characters for 17 extant lorisoids (14 lorisids and 3 galagids) and 13 fossil lorisoids to test their inter-relationships, making it the most comprehensive phylogenetic study for this primate group. Molecular sequence data are also included for 14 of the extant taxa, and a Bayesian total evidence analysis was performed. *Karanisia*, a late Eocene stem lorisoid, was used as the outgroup. The resulting tree is more consistent with an African origin of the family Lorisidae, as opposed to an Asian origin. This result would agree with previous inferences that lorisids may have used the '*Gomphotherium* Landbridge' to reach Asia from Africa during the Middle Miocene.

Trilobite diversity changes throughout the Murero Formation (Miaolingian), northeastern Spain

Antonio Arriola*, Abel Barral, Jorge Esteve

Universidad Complutense de Madrid, Spain

Assessment of biodiversity fluctuations during the Cambrian is key to understanding how ecosystems established and evolved across this period. Here we analysed biodiversity change patterns in the Murero Formation (Iberian Chains, northern Spain) during the late Wuliuan and the Drumian. Twenty beds were sampled, and the relative abundance of taxa was analysed, allowing us to study fluctuations in trilobite communities based on ecological characteristics (lifestyle, way of feeding and blindness). Analysis of biodiversity shows that while the trend in species richness remains constant, evenness decreases over time, stabilizing irregularly at the end of the Murero Formation. This decreasing trend is associated with the dominance of *Augaulos longicephalus* and the transformation of trilobite communities. We show that trilobite communities in the Murero Formation underwent a transition from a blind, detritivorous taxa assemblage to one characterized by infaunal taxa with normal vision. We hypothesize that this transition could be due to either: light variation caused by changes in bathymetry in a transgressive environment; change in turbidity due to depositional changes; and/or migratory phenomena affecting some of the taxa in those communities.

This research is a contribution to projects PID2021-125585NB-I00 and CNS2024-154147 of the Spanish Ministry of Science and Innovation.

Jelly-fishing for answers: Affinities and preservation of hydrozoan medusae from the Grès à Voltzia Lagerstätten

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Progonionemus vogesiacus Grauvogel and Gall, 1962, from the lower Middle Triassic Grès à Voltzia Lagerstätten, represents an exceptionally-preserved limnomedusae hydrozoan, including the umbrella, tentacles with stinging cells, and reproductive organs. To clarify their affinities we analysed the original specimens, including the holotype, and studied 34 additional undescribed medusoid remains. Multispectral imaging revealed previously unidentified internal structures such as the gastrovascular cavity and umbrella margin, while the undescribed material showed that the tentacles are more commonly preserved than other parts of the carcass. Previous work attributed preservation to rapid microbial growth resulting in iron oxide enrichment and mineralization via phosphatization; however, this has not been validated using modern analyses. To test this hypothesis, we applied synchrotron-based micro X-ray fluorescence (μXRF) and SEM-EDX. Our results show that the soft tissues are preserved as carbonaceous films enriched with trace elements, particularly copper; there is no evidence for phosphatization or iron oxides associated with the preserved soft tissues. The recognition of these soft tissues as carbonaceous films enriched in copper highlights the need for a detailed analysis of the taphonomic pathway that has led to the exceptionally-preserved biota of Grès à Voltzia.

A new model for prediction of fossil feather colour using melanosome geometry, metal chemistry and reflectance spectrophotometry

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Melanin pigments, contained within melanosomes, underpin visual communication in feathers either by producing colours directly or by serving as a backing pigment for structural colours. Melanosome geometry has been used to predict the colour of fossil feathers, albeit with low accuracy (<60 %). Our study tests the hypothesis that predictive models for feather colour are more accurate if they incorporate data on additional melanosome and feather characters. We used a fully quantitative approach based on spectral data for feather colour coupled with melanosome geometry and synchrotron X-ray fluorescence data on melanosome metal chemistry. We analysed 293 feathers from representatives of all 44 extant avian orders. Spectral data support the following discrete colour categories: black, brown, grey, dark rufous, light rufous and iridescent and non-iridescent structural colour. Analysis of melanosome geometry reveals significant differences among colour categories. Predictive models for feather colour using geometry alone yield low accuracy (~ 46 %). Preliminary analysis of synchrotron X-ray fluorescence data indicates that feathers belonging to different colour categories also differ in elemental chemistry. Initial results suggest that combining data on melanosome geometry and chemistry can improve the accuracy of feather colour prediction and provide a new framework for predicting the colour of fossil feathers.

The global context of a new theropod trackway from Dewars Farm, Oxfordshire

Thomas M. Beard[1]*, Richard J. Butler[1], Kirsty M. Edgar[1], Luke E. Meade[1], Emma L. Nicholls[2], Duncan J. E. Murdock[2] and Peter L. Falkingham[3]
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Excavations in 2024 of a major new exposure of the dinosaur track site at Dewars Farm, Oxfordshire, UK revealed over 200 dinosaur tracks in five trackways: four sauropod and one theropod. Data collected during fieldwork included track measurements, anatomical observations, identification, sediment observations and photographs for photogrammetric models. The palaeoenvironment at Dewars Farm was likely lagoonal, evidenced by sedimentology and the presence of marine benthic organisms. Observations and 3D models of trackway intersections suggest that the theropod moved through the landscape prior to the sauropods. Track measurements allow an estimation of the theropod trackmaker speed as a walking pace of ~4–5 km/h. The trackmaker identity is hypothesized as *Megalosaurus* using anatomical observations, estimated hip height, and the geographic and stratigraphic range of confirmed *Megalosaurus* body fossils. Global theropod track site data (lithology, palaeoenvironment, time period and geographical location) were compiled and quantitatively analysed. The Early Jurassic contains the highest number of documented theropod track sites. Geological, anthropogenic and taphonomic factors cause disproportionate concentrations of known theropod track sites in the northern hemisphere.

High functional optimality in mammalian jaws reflects an evolutionary trade-off between strength and speed

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The vertebrate mandible provides an ideal system to test the evolutionary relationships between form and function, offering rich extant and fossil sampling, and playing a key role in feeding biomechanics. Furthermore, the jaw can be modelled as a simple lever system, presenting a well-established functional trade-off between strength and speed. Here we quantify jaw shape diversity across Mammalia and evaluate the impact of the strength–speed trade-off in this key vertebrate clade. Using Elliptical Fourier analysis, we quantified lateral jaw shape in 2,063 extant and extinct mammal species, representing all 27 extant and 25 extinct orders. To investigate functional jaw properties throughout morphospace we evaluated the mechanical performance of theoretical jaw morphologies across the morphospace. Rotational efficiency and median von Mises stress during a bite-muscle load simulation act as proxies for speed and strength respectively. Combining the subsequent functional landscapes in a Pareto optimality ranking revealed high optimality in the strength–speed trade-off. Extreme morphologies linked to specialized ecologies, *e.g.* filter-feeding, show reduced optimality, suggesting relaxation or over-riding of the trade-off in these groups. Our findings showcase the importance of biomechanical trade-offs in morphological evolution, revealing how mammalian jaws have evolved to balance competing mechanical demands across a great range of ecologies.

Causes of increased faunal cosmopolitanism in the Tournaisian in light of its Devonian–Carboniferous context

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University of Leeds, UK

The global Hangenberg Crisis (~359 Ma) represents one of the major Phanerozoic extinction events, with greater than 50 % marine invertebrate genera loss. The recovery and radiation of life following the Hangenberg Crisis was exceptionally slow; marine biodiversity remained at low levels for more than 20 million years, potentially making this the longest aftermath of any biotic crisis of the Phanerozoic. Here we examine the biogeographic dynamics of marine invertebrates across the Devonian and Carboniferous in relation to post-extinction recovery patterns. Using a series of biogeographic metrics on a dataset of 4,530 marine invertebrate genera, we identified two episodes of faunal cosmopolitanism: one in the Frasnian and a second in the Tournaisian. A third potential cosmopolitanism episode was identified in the Moscovian–Kasimovian, but biogeographic patterns during this interval were likely biased by spatial sampling heterogeneity. Comparison of the biogeographic connectedness values of newcomers, survivors, and all genera in the Famennian and Tournaisian indicate that post-Hangenberg faunal cosmopolitanism was driven by the selective extinction of endemics and the geographic expansion of survivors. Such homogenization may have left behind a residue of already widespread generalists that were relatively resistant to rapid diversification, thereby potentially contributing to delayed biotic recovery.

Review of the tetrapod assemblage of the Purbeck Limestone Group (Tithonian–Berriasian) of Dorset, southern England

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The Purbeck Limestone Group is a lithostratigraphic unit that outcrops along the Jurassic Coast in Dorset, southern England, providing one of the richest known mid-Mesozoic tetrapod assemblages in the world. Following the first documented excavations by Samuel Beckles in the mid-1850s, the Purbeck has yielded over 60 species of small- and large-bodied tetrapods, including lissamphibians, turtles, lepidosauromorphs, ichthyosaurs, sauropterygians, crocodylomorphs, pterosaurs, dinosaurs, and both mammalian and non-mammalian mammaliaforms. Most specimens have been collected using screenwashing to extract small teeth, jaws and other skeletal fragments from fossiliferous horizons. Whilst this has been successful in increasing our understanding of Purbeck tetrapod diversity, it has not yet been applied systematically throughout the Group to examine large-scale patterns of faunal change and community structure. This study provides an updated overview of the geology of the Purbeck, and a detailed review of the tetrapod fauna known from the assemblage. For the first time, taxa are placed within their stratigraphic context through a biostratigraphic range chart displaying the distribution of species from the base of the Lulworth Formation (Tithonian) to the top of the Durlston Formation (Berriasian). Our analysis reveals new potential tetrapod-rich horizons that will be the primary focus for sampling efforts in the future.

A new reconstruction of the skull of the Late Jurassic sauropod dinosaur *Dicraeosaurus hansemanni* from 3D surface digitisation

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Dicraeosaurids are unusual sauropod dinosaurs that are characterized by their small overall size, short necks and elongated neural spines. The genus *Dicraeosaurus* includes two species from the Late Jurassic Tendaguru Formation, Tanzania, of which one – *D. hansemanni* – preserves skull material. Since the original description of this *Dicraeosaurus* skull material by Janensch in 1936, several additional taxa have been assigned to Dicraeosauridae. Understanding of general sauropod cranial morphology, and of dicraeosaurids in particular, has considerably improved, underscoring the need for a revisited examination of the *Dicraeosaurus* skull. Here we present a new reconstruction of the skull of *D. hansemanni* generated through 3D surface digitization. Our reconstruction suggests the orbits were less rostrocaudally elongate and the rostral portion of the skull was more ventrally inclined relative to the braincase than previously assumed. The robustness of skull markedly deviates from other dicraeosaurids and diplodocids as well as from that of *Giraffatitan*, the only other sauropod from Tendaguru from which a skull is satisfactorily known. The overall skull morphology of *D. hansemanni*, combined with its short neck, suggests a specialization for tougher plant matter at low-middle browsing level, furthering our understanding of the ecological dynamics and niche partitioning among the sauropods of Tendaguru.

Marine Isotope Stage 11 in the Southern Pacific Ocean: coccolithophore assemblages and calcification at IODP Site U1540

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Marine Isotope Stage 11 (MIS 11; ~424–374 ka) was one of the warmest and longest interglacials of the past 800,000 years, with higher-than-present sea levels and significant carbon cycle feedbacks. Its Holocene-like orbital configuration makes MIS 11 an important natural analogue for studying long-term climate dynamics. Coccolithophores were particularly abundant during this time period, with *Gephyrocapsa caribbeanica* dominating the assemblage. This study uses data from IODP Expedition 383, Site U1540, in the Southern Pacific Ocean to look at how coccolithophore assemblages and calcification patterns responded to warm conditions, as well as their potential role in carbon export. The findings will provide new insights into high-latitude ecosystem dynamics during MIS 11 and their implications for future climate change.

Boneless wings: the evolution and distribution of manual claws in avialans

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Tree-climbing and wing claws are plesiomorphic traits for avialans. Nonetheless, hoatzins (*Opisthocomus hoazin*) are the only modern birds that climb using wing claws, though not the only clawed arboreal birds. This is a long-standing mystery in avian evolution. We used CT scans of intact bird hands to study the distribution of manual unguals, informing

ancestral nodes with a literature review of fossil birds. Ancestral state reconstructions from this show that crown-birds (Neornithes) ancestrally had two wing claws, but were terrestrial so probably did not use them to climb. Claws are lost or reduced over thirty times in Neornithes, but rarely regained. Claw loss is associated with altriciality, which occurs primarily in high-nesting birds; claw loss events are associated with transitions to inaccessible nesting. Altriciality post-displaces wing development relative to hatching, forcing the wings to 'catch up' without fully ossifying or even forming the unguals. Where precocial taxa lack claws, this is associated with secondary precociality or short wings relative to body size. We show that precocial clawless taxa have shorter wings and much weaker wing:mass allometry than precocial clawed taxa. Hoatzin claws are neither atavistic nor regained, but a specialization for the hoatzin's folivorous lifestyle and unique life history.

Fidelity of Earth historic archives unrelated to rock quantity

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The sedimentary-stratigraphic record is the principal repository of empirical historic evidence for evolution and deep time environments. However, the spatial heterogeneity of deposition and erosion means unequal quantities of rock are preserved from different intervals of Earth history. This is argued to bias fossil records, with correlations apparent between fossil diversity and mapped rock area from different intervals. However, mapped rock area is a poor measure of rock available for fossil studies because most is concealed and, due to tectonic tilting, spatially diminutive older rocks commonly sample a greater stratigraphic transect per unit exposure area than widespread younger rocks. We propose observable stratigraphic thickness as an improved measure of rock quantity available for palaeoenvironmental studies, and calculate this throughout geologic history for southern Britain. Rock availability increases with age through the Phanerozoic, contrary to general models of rock survivorship, and shows no correlation to palaeobiodiversity, except in flat-lying strata. Applying the well-studied British stratigraphic record as a calibration sample for strata globally, we suggest that rock quantity biases have been overstated. Local tectonic history renders different regions as stratigraphic hotspots for specific intervals. The British non-marine Palaeozoic record is such an example, hosting high-fidelity records of plant evolution and animal terrestrialization.

Cretaceous sharks from Lithuania and beyond: the collection of Romualda Mertinienė

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A historically important collection of Cretaceous shark teeth, stored at the Nature Research Centre in Vilnius, was assembled around 60 years ago by Lithuanian palaeontologist Romualda Mertinienė. The specimens come from present-day Lithuania, Ukraine, Russia, Kazakhstan and Uzbekistan, with the majority of remains recovered from Lithuania. Stratigraphically, the material ranges from the Albian, when the major Late Cretaceous marine transgression began, to the Turonian, when it reached its maximum. During

this time, the basin deepened from about 50 m to 200–500 m and was connected to the Polish–German–North Sea Basin and the North Atlantic Ocean. The warm subtropical climate supported a diverse marine ecosystem. From Lithuania alone, Mertinienė recovered more than 6,000 shark teeth. Our review of this extensive collection documents nine orders, ten families and 20 species, with Lamniformes comprising over half of the material. This collection represents the largest and most diverse record of Cretaceous sharks from Lithuania, significantly expanding our knowledge of the palaeobiogeography and diversity of Cretaceous chondrichthyans in the Eastern European region.

Functional diversity in the first actinopterygian adaptive radiation

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Ray-finned fishes (Actinopterygii) are the most diverse group of vertebrates, displaying huge diversity in morphology, ecology and life history strategies. By contrast, the earliest Palaeozoic actinopterygians displayed low levels of abundance, richness and morphological diversity until diversity levels exploded during the Carboniferous. This drastic change has been interpreted as an adaptive radiation following the Devonian–Carboniferous (D–C) extinction, potentially driven by the opening of novel ecological niches. Here we integrate continuous and discrete trait data, functional measurements and 3D data from CT scans of exceptionally well-preserved mandibles to formally test the hypothesis that a radiation in lower jaw morphology of ray-finned fishes was associated with the D–C boundary. Compared to Devonian actinopterygians, Carboniferous species possessed far more varied jaw morphologies, including tooth plates, sigmoidal dentition, beak-like oral jaws, and even edentulate jaws. Disparity through time increases considerably after the D–C boundary, with peaks in the Viséan (346.7–330.9 Ma) and Moscovian (315.2–307 Ma) pinpointing the timing of bursts of diversity and setting the stage for their future success. Three-dimensional and discrete trait datasets show similar overall patterns; however, the largest increases in disparity appear when analysing discrete trait data.

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Geochemical signatures of latest Ediacaran complex trace fossils from southwest Mongolia: insights into the substrate revolution

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The Ediacaran–Cambrian transition heralded a significant radiation of complex bilaterian animals, accompanied by an increase in the depth, intensity and complexity of burrowing in marine sediments. The advent of widespread, complex bioturbation in the earliest Cambrian and subsequent intensification of sediment mixing by benthic animals are thought to have dramatically altered benthic ecosystems (agronomic revolution) and marine sediments (substrate revolution). For example, biogeochemical cycling across the water–sediment and burrow–sediment interfaces would have been increased by bioturbation.

However, the magnitude and timescale of the substrate revolution is uncertain. Vertically penetrative *Arenicolites* trace fossils from latest Ediacaran carbonate sediments of the Zavkhan Terrane, southwestern Mongolia, are among the oldest complex bed-penetrative traces, providing a window into the impact of burrowing on the benthic environment during the Ediacaran–Cambrian transition. Stable isotopic analyses of *Arenicolites* burrows reveal a sharp shift in $\delta^{13}C$ and $\delta^{18}O$ values at the burrow-sediment interface. Given that the burrows appear to be filled with contemporaneous sediment and marine cement, this sharp geochemical boundary indicates that these burrows had limited impact on the biogeochemical cycling between the overlying water column and the sediment. Consequently, isotopic analyses of latest Ediacaran penetrative traces support a delayed onset of the substrate revolution.

Hot oceans, more fish: mesopelagic fish productivity across the Palaeocene–Eocene Thermal Maximum

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Marine ecosystem models predict variable changes in the direction and magnitude of pelagic fish production under anthropogenic warming. Long-term, low-resolution data records suggest elevated pelagic fish productivity in the Pacific Ocean during the Early Eocene Climatic Optimum (EECO; ~49–53 Ma), the peak of the Cenozoic greenhouse. However, pelagic fish responses to shorter-term warming remain unclear. We present new ichthyolith accumulation rates (IARs), a proxy for productivity, along with diversity records to reconstruct pelagic fish community dynamics across the Palaeocene–Eocene Thermal Maximum (PETM; ~56 Ma) – a major global warming event, often regarded, though imperfect, as an analogue for anthropogenic warming. Records are derived from three deep-sea sites: IODP Site U1514 (mid to high-latitude Indian Ocean), ODP Site 1260 (equatorial Atlantic Ocean) and ODP Site 1209 (equatorial Pacific Ocean). Preliminary results show transient elevated IARs during the peak of the PETM that cannot be accounted for by changing sedimentation rates or dissolution alone, indicating increased fish productivity associated with the warmest temperatures with little or no change in community composition. This suggests that, regardless of warming rate or duration, mesopelagic fish production is higher globally in warmer oceans.

Morphological assessment of stacked sandwich columnar units in two Cambrian acrotetid brachiopods from north Spain

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The Cambrian explosion was marked by the sudden appearance of biomineralized skeletons. Brachiopods are the only metazoans able to mineralize shells with both apatite and calcite. However, while calcitic brachiopod shells are well documented, phosphatic taxa with complex architectures remain less studied. A distinctive trait of phosphatic-shelled brachiopods is the presence of columnar microstructures. These columnar sandwich-like arrangements are increasingly understood as an adaptive innovation during

the Cambrian radiation of small brachiopods. This study aims to investigate the variation in columnar architecture in *Genetreta* and *Iberotreta*, two acrotetid brachiopods from the Wuliuan of the Láncara Formation (northern Spain). Their shells show exquisitely preserved hierarchical structures, consisting of a thin laminated primary layer and a stratiform columnar secondary layer. In both genera, the columnar units form stacked 'sandwich' arrangements, with orthogonally-oriented cylindrical columns separated by stratiform lamellae. The columns, only a few micrometres in diameter and height, contain central canals, while the interlaminar spaces may originally have been filled with organic material. Our preliminary results reveal little variation in the sandwich structure between the ventral and dorsal valves in both taxa, suggesting a morphofunctional adaptation of this columnar architecture that is convergent across different taxa.

Exploring fluctuations in diversity through morphological and ecological disparity in trilobites

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The evolutionary history of trilobites, from the Cambrian to the Ordovician, reflects a dynamic interplay of extinction, diversification and functional constraints. Analyses of cephalic and pygidial disparity reveal a functionally constrained pattern that is taxonomically controlled and that shaped their evolutionary trajectories. During the Cambrian Series 2, cephalic disparity indicated niche partitioning, whereas pygidial disparity suggested broad niche occupation, consistent with low ecological disparity and limited competition. The Redlichiid–Olenellid Extinction Carbon isotope Excursion (ROECE) imposed environmental stress that restricted morphospace but promoted ecological diversification. From the Drumian to the Ordovician, cephalons adapted to broader ecological roles, and pygidia underwent mechanical specialization through canalization, a trend that culminated in the Great Ordovician Biodiversification Event (GOBE), marked by maximum taxonomic richness and highest ecological disparity. Our results demonstrate lineage constraint, particularly in redlichiids and asaphids, highlighting the combined influence of functional specialization, taxonomic history and environmental perturbations on trilobite disparity over the Cambrian Explosion and the Ordovician Radiation.

SGP Phase 2: a community resource for sedimentary geochemistry across Earth history

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The Sedimentary Geochemistry and Paleoenvironments Project (SGP) is a research consortium that seeks to address questions of environmental evolution across Earth history through statistical analyses of the sedimentary geochemical record. The project is centred around open data and community-driven development of tools and resources. The Phase 1 dataset primarily included Neoproterozoic–Palaeozoic shale data. Phase 2, released in February 2025, expanded coverage to include more Palaeoproterozoic and Mesoproterozoic data and, in addition, focused on better accommodation of carbonate data. The dataset was built through the direct involvement of >200 researchers worldwide in academia, government and industry. It also incorporates data from the United States

Geological Survey (USGS), Geoscience Australia OZCHEM, the Alberta Geological Survey, and the Deep-Time Marine Sedimentary Element Database (DM-SED) compilation. Here we describe the complete Phase 2 dataset in terms of age, geography, lithology and other geological characteristics, and highlight examples of its use. The dataset is available through our search website and API and includes 126,006 samples and 4,132,371 geochemical analyses, representing the largest publicly available sedimentary geochemical data resource. It supports research in a broad range of fields, including geochemistry, palaeontology, sedimentology, tectonics, Earth history and palaeoclimate, and we welcome participation from new collaborators.

3D modelling and biomechanical assessment in Cambrian rhynchonelliform brachiopods

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Brachiopods are a group of sessile organisms that exhibit significant variability in the position and size of their muscles. This variation relates to the type of substrate or environment they inhabit, which may require greater force to open their shells. During the Cambrian Explosion, rigid and stable substrates covered by microbial mats were gradually replaced by less consolidated materials. Interestingly, even with this increase in substrate diversity, no direct link has been detected between the shape of brachiopods and the substrate they attach to. So, to adapt to a broader range of environments, early brachiopods may have developed the ability for considerable muscular plasticity. This study focuses on a Cambrian rhynchonelliform brachiopod, which displays morphological variations throughout its development, resulting in three distinct morphotypes. Using 3D modelling, the primary muscle groups responsible for shell movements, adductors (closing) and diductors (opening), were identified through scars on the shell and subsequently modelled and sculpted. Our biomechanical analysis shows that muscle force exhibits positive allometric scaling with body size, while morphological traits also contribute, suggesting that environmental context influences in the intraspecific morphological variation and its functional performance.

Red Queen and Court Jester interactions drive unisexual reproduction in digital populations

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What drove the maintenance of sexual reproduction in early eukaryotes – and what drives it today – is a key question in evolutionary biology. Studies that investigate this seemingly disadvantageous reproductive method are widespread but, to date, there are no definitive answers regarding the ecological conditions or evolutionary benefits that may have led to the rise and retention of sexual breeding. Unisexuality (mating without sexes or types) is a likely ancestral state of eukaryotic sex. This, and associated traits, are yet to be investigated in conjunction with abiotic forcing such as environmental change. Here we use the eco-evolutionary model REvoSim to assess how biotic Red Queen, abiotic Court

Jester, and pluralistic drivers impact the prevalence of sex in a unisexual digital ecosystem over macroevolutionary timescales. Our results indicate that frequent antagonistic biotic interactions (pathogens/predators) and high rates of abiotic change both elicit a high proclivity towards sex in unisexual evolutionary agents. Pluralistic investigations demonstrate that a synergistic relationship exists between Red Queen and Court Jester drivers: a combination drives increased investment in sex. Sexual life cycles break down maladapted epistatic relationships in stressful conditions, regardless of the ecological origin of that stress. We suggest that both biogenic and non-biogenic stressors could have maintained unisexuality in Proterozoic environments and early eukaryotes.

A detailed coccolith assemblage analysis over the mid-Pliocene Warm Period

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Coccolithophores, a marine haptophyte algae, intracellularly create calcite plates called coccoliths, which are often abundant in marine sediments and are excellent recorders of surface ocean environmental change through time. Detailed assemblage analysis using the automated image recognition system SYRACO allows an in-depth look at how communities are affected by intense climatic changes, such as during the mid-Pliocene Warm Period (mPWP; 3.3–3.0 Ma). vThe mPWP is a key period of study as its atmospheric CO_2 was close to modern levels and temperatures were warmer than at present. It is the closest 'future analogue' for the climate of the future according to the International Panel for Climate Change (IPCC). Here we present high resolution coccolith assemblage data for three high-latitude ocean drilling sites: DSDP Site 594 to the east of New Zealand; ODP Site 982 in the North Atlantic Ocean; and ODP Site 1090 in the southeastern Atlantic Ocean. Changes in community are present at all three sites over the mPWP, as well as variations in size and thickness, but the nature of response is site-specific, indicating a stronger role for climate-controlled local-to-regional changes in oceanography rather than a uniform response to global atmospheric CO_2.

Stratigraphic palaeobiology of carbonate systems

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Stratigraphic palaeobiology posits that the fossil record is a joint expression of geological and biological processes, and that interpretations of eco-evolutionary change derived from it must consider the stratigraphic context. This has been demonstrated empirically and *in silico*, providing stratigraphic null hypotheses for the interpretation of fossil data linked to sequence-stratigraphic interpretations. While previous work on stratigraphic palaeobiology focuses on terrestrial and siliciclastic environments, carbonate systems respond differently to external drivers, such as changes in sea level, and will thus record biotic change differently. In addition, groups of calcifying organisms change throughout the Phanerozoic and with environmental conditions, resulting in distinct stratigraphic architectures. We examine how different carbonate systems (rimmed platforms and ramps) record extinction patterns and biostratigraphic precision as a function of external forcing by sea level, fossil abundance, and niche preferences. These simulations are possible thanks to a new open-source model, CarboKitten.jl. We find that range offset and patterns

of last occurrences differ substantially between carbonate platforms, carbonate ramps and siliciclastic systems, which we attribute to high *in situ* production rates and rapid cementation. Our results demonstrate that preservation of biotic signals differs between depositional systems, and understanding their evolution is key to disentangling stratigraphic from palaeobiological patterns.

Biogenic phosphate pollution inducing eutrophication and extinction in the Baltic Tremadoc

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During the late Furongian to early Tremadocian, the Baltoscandian epicratonic basin was environmentally diverse, with a central black shale depocentre (Alum Shale) bordered in northern Estonia by coastal plains and shoal complexes. These marginal settings supported low-diversity benthic assemblages dominated by linguliform brachiopods (*Obolus*, *Oepikites*, *Schmidtites*, *Ungula*), organisms with organophosphatic shells. *Skolithos* trace fossils are common, reflecting opportunistic colonization of shifting substrates influenced by tides and storms. From the mid-Cambrian onward, such nearshore environments were marginal for most benthic taxa, though obolid brachiopods expanded steadily, peaking in the latest Furongian (*Cordylodus andresi*–*C. proavus* zones). Their dense shell accumulations generated bioclastic-rich siliciclastics, supplying abundant phosphate and leading to the formation of major phosphorite ore bodies, notably the Toolse deposit, with reserves exceeding 27 million tons of P_2O_5. Early Tremadocian transgressions (*C. lindstromi*–*C. angulatus* zones) coincided with Alum Shale expansion and a decline of these shallow-water communities. Low sedimentation rates left Furongian shell beds exposed at the sediment–water interface, fostering phosphate recycling, coastal eutrophication and fluctuating oxygen conditions. Chemogenic phosphorite crusts along basin margins confirm persistent phosphate availability. The ecological simplicity of suspension-feeding obolids, combined with nutrient enrichment, likely underpinned both their unchecked proliferation and ultimate collapse.

Ecospace occupation of a Cenomanian echinoid fauna from England

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The evolutionary success of echinoids has often been attributed to adaptive radiations into diverse modes of life. However, how lower taxa differ ecologically and how community structures respond to environmental settings remain under-explored due to methodological limitations and fragmentary fossil records. We conducted modified Novack-Gottshall ecospace analyses on a highly fossiliferous shallow-marine Cenomanian echinoid fauna from Wilmington, Devon, England, based on a historically published dataset housed in the Natural History Museum, London, comprising 35 species (>1,500 individuals) from 55 beds. Using 16 discrete traits, we identified 21 modes of life. Our results indicate that irregular echinoids occupied significantly larger ecospace areas that were entirely distinct from those of regular echinoids. Stratigraphically, the sum of ranges shows no significant change, whereas the sum of variances and centroid shifts correlate with sea-level fluctuations, highlighting that rising sea levels maintained the number of modes of life

but made infaunal grazers become more dominant. This case study demonstrates clear ecological differentiation between taxa and across environmental settings.

A new phylogeny for ctenocystoid echinoderms

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Echinoderms (*e.g.* starfish and sea urchins) are a successful group of marine invertebrates, with a rich fossil record stretching back over 500 million years to the Cambrian Explosion. Many extinct echinoderm groups do not closely resemble modern forms, which has made reconstructing their phylogenetic relationships, and the early evolution of the phylum, extremely challenging. However, recent developments in palaeobiological methods, including Bayesian phylogenetic approaches and fossil observation using X-ray tomography, provide a powerful set of tools for investigating the evolutionary history of problematic extinct groups such as fossil echinoderms. Here we investigate the ctenocystoids, an enigmatic group of Cambrian echinoderms lacking a robust systematic framework. We present a new phylogeny for this group based on a morphological character matrix consisting of 64 characters and 15 species, including three new taxa. Specimens were studied with the aid of high-resolution micro-CT which provided new insights into their morphology. Bayesian phylogenetic analyses were conducted using a fossilized birth-death model of evolution in BEAST2. The results have transformed our understanding of the inter-relationships of ctenocystoids and the trajectory of their evolution, and have allowed us to propose a new scenario for the origin and evolution of this extinct class.

A new species of the Late Jurassic pachycormiform fish *Orthocormus* sheds light on the evolution of protosphyraenids

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Pachycormiformes are a group of stem-teleost actinopterygians known from Early Jurassic to Late Cretaceous marine deposits. However, progress in our understanding of them is mostly due to specimens from Jurassic Lagerstätten of Western Europe. In 2015, an exceptionally well-preserved specimen of *Orthocormus*, comprising the anterior part of the body, was found in Russia. This is the most complete pachycormiform specimen discovered in the Jurassic of Eastern Europe, representing a new species, and the eastern-most occurrence of *Orthocormus*. The pectoral fin of the new species shows features hitherto considered unique for Cretaceous *Protosphyraena nitida*, and thus unambiguously links Jurassic and Cretaceous macrocarnivorous pachycormiform taxa. The great similarity of the pectoral fin of *P. nitida* to the new species of *Orthocormus* rather than other species of Protosphyraena suggests its intermediate phylogenetic position between *Orthocormus* and *Protosphyraena*, and requires its placement in a separate genus, *Erisichthe*, as initially described by Cope. My phylogenetic analysis confirms the prevailing hypotheses of two major pachycormiform

lineages. However, the interpretation of these lineages in terms of Linnaean taxonomy appears more complex than previously assumed, and one of the subclade names should stem from the family-group name Protosphyraenidae Woodward, 1888.

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The birds and the beetles? Beetle iridescence evolved as a defence against visual predators

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Iridescence is a structural colour that has evolved independently multiple times in beetles and is thought to primarily serve a predator defence function. We investigated the temporal and phylogenetic distributions of iridescence acquisitions in beetles, and compared them with the emergence of visual predators in the fossil record to identify the most likely predatory driver. We performed molecular clock analyses using pre-published beetle data to produce dated 805-taxa supertrees, upon which we performed stochastic mapping estimations and ancestral state reconstructions. We found that speciation rate in iridescence lineages is significantly higher than that in non-iridescent lineages, and that each type of iridescence broadly corresponds to a different ecology, with diffraction gratings being more common in substrate- and water-associated beetles, whilst photonic crystals and multilayer reflectors are more common in herbivorous beetles. Through comparisons between the fossil record of visual predators and the first-gain events of iridescence through time, we propose that birds, frogs and praying mantises drove the evolution of iridescence during the Cretaceous–Palaeogene Angiosperm Terrestrial Revolution. In this time of ecological upheaval, diversifying herbivorous beetles entering foliage-associated environments were increasingly exposed to diversifying birds, mantises and frogs, triggering a selective pressure for these beetles to evolve visual predator defences.

First mammal (Gondwanatheria) from the Upper Cretaceous Kallamedu Formation of the Cauvery Basin, South India

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Gondwanatherians, considered as part of Allotheria and sister taxa to Multituberculata, are an extinct group of mammaliforms, known to have been uniquely distributed throughout all Gondwanan landmasses, except for Australia. The group's temporal range is known to have extended from the Late Cretaceous up until the Middle Eocene. India's gondwanatherians, as of now, have been best represented by a single genus and species, *Bharattherium bonapartei* (Prasad *et al*. 2007). In this study, we describe additional collected material (DUGF/167) from the south of India, potentially belonging to the same species, but with a distinct set of morphological characters, such as a likely transitional occlusal surface pattern consisting of an un-isolated and connected enamel islet to two transverse lophs. Previous studies have considered such differences as uncertain variations within the morphology of Indian sudamericid molariforms and placed them at a phylogenetically basal position. This study discusses the scope of such variations linked to different growth and wear stages, appearing distinct according to different depths of occlusal surface patterns due to the height of the crown at different wear or growth stages, and respective molariform positioning along the jaw. It also deliberates on the scope

of narrowing down the phylogenetic position of *Bharattherium bonapartei* within the superfamily Gondwanatheroidea based on molariforms.

Palaeoecology of the Permian–Triassic extinction–recovery interval in the Confusion Range, Utah

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The impacts of the Late Permian mass extinction event on marine ecosystems and their post-extinction recovery appear to be variable. In some locations and habitats, there is evidence for extremely slow recovery through the Early Triassic, whereas in others, complex ecosystems re-appeared relatively rapidly. This study tested which of these two end-member responses took place in the shallow marine, marginal habitats of the western USA, by undertaking quantitative palaeoecological analyses across the Permian–Triassic boundary. Twelve bulk samples were dissolved in buffered acetic acid and resulting microfossils were picked, identified and counted. In total, 4,665 individuals representing 12 taxa/morphotypes were identified, including gastropods, bivalves, fish, conodonts, bryozoa and echinoderms. Notwithstanding the methodology employed, while limited or no evidence was recorded of some taxa in the immediate post-extinction interval (bivalves, bryozoa and echinoderms), evidence was found of marine ecosystem recovery in the Early Triassic, particularly amongst gastropods and fish. Both pointed and crushing fish teeth were recorded in the Early Triassic, suggesting there was a well-developed ecosystem in this environment. This, along with the taxonomic diversity recorded in the Early Triassic, suggests that the marine ecosystem recovered quickly in this environment compared to that reported in some global shallow marine localities.

Non-trilobite arthropods from the Kalana Lagerstätte

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Kalana Lagerstätte, a unique Silurian-age (Llandovery, Raikküla Regional Stage) locality in Estonia, is renowned for its abundant exceptionally-preserved algal fossil flora, but it has also yielded a remarkably diverse faunal assemblage, including crinoids, vertebrates, sponges, trilobites, graptolites and several other groups. Among the latter are numerous non-trilobite arthropods, an informal but widely used category that encompasses eurypterids, xiphosurans, phyllocarids *etc*. Kalana is particularly notable for its chelicerate arthropod fauna, which provides valuable insights into early Silurian marginal-marine ecosystems. Chelicerates, an ancient lineage of arthropods, are typically rare in the fossil record due to their low preservation potential. Estonian geological collections, however, contain more than 600 specimens identified as chelicerates. Most of these specimens, whether nearly complete or fragmentary, belong to the iconic species *Eurypterus tetragonophthalmus*, which originates from Wenlock-age localities on Saaremaa Island. The oldest known chelicerate fossils in Estonia, however, come from the considerably older Kalana Lagerstätte. Detailed analysis of these specimens allows us to reconstruct the palaeobiology and palaeoecology of these ancient arthropods, shedding new light on their role within the broader Silurian marine community.

Macroevolutionary diversification of feeding structures in echinoids

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Sea urchins (Echinoidea) have one of the most complete fossil records of any animal, presenting an ideal model system to answer a fundamental question in evolutionary biology: how does functional performance influence macroevolution across deep time? Crown group echinoids are characterized by a distinct structure – the perignathic girdle (PG) – which serves as the attachment site for the muscles that move their feeding apparatus. A wide diversity of PG morphologies exists, ranging from small, gracile pegs to robust wing-like ridges. Whilst the PG has been recognized as a crucial feature underlying echinoid systematics, the functional roles of the different morphologies are unknown, making its role in echinoid diversification unclear. Combining deep learning approaches to micro-CT segmentation with 3D geometric morphometrics, we have quantified PG shape for 100 taxa, forming the largest growing databases of 3D echinoid morphology to date. Preliminary results reveal convergent evolution of PG shapes across evolutionarily distinct lineages, suggesting that there may be strong responses to selective pressures related to performance, with adaptive optima driving the evolution of different PG morphologies. This work provides insight into how changes in the functional performance of feeding morphology have influenced morphological and ecological diversification over the last 300 million years.

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Early tetrapod skull hydrodynamics across the water-to-land transition

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Vertebrates are now ubiquitous in terrestrial and aerial environments, yet for a third of their existence they were constrained to aquatic habitats and a fish-like body plan. The transition from water to land was therefore one of the most profound evolutionary events in the history of life. Head shape is strongly influenced by feeding function and diet, yet in aquatic species, it also plays a crucial role in navigating dense fluids. However, the functional consequences on skull hydrodynamics during this shift remain unclear. This project integrates computational morphofunctional methods to test how skull hydrodynamics evolved across the water–land transition. Digital skulls of 15 early tetrapods were analysed through 3D geometric morphometrics to quantify skull shape variation. Computational fluid dynamics (CFD) simulations were used to estimate hydrodynamic performance under standardized flow conditions. Evolutionary model-fitting was subsequently employed to resolve the evolutionary dynamics shaping hydrodynamic performance in a phylogenetic context. Our results demonstrate that early tetrapod heads became progressively less hydrodynamic as species became more terrestrial, with secondarily aquatic forms re-evolving more streamlined morphologies. By combining morphometric and biomechanical approaches, this study provides novel insight into the evolutionary, ecological and functional dynamics of the earliest tetrapods across this enigmatic interval.

A newly benthic fossil assemblage from the Tonian Liulaobei Formation, North China

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The Tonian Period (~1000–720 Ma) bridges the so-called 'Boring Billion' and the 'Snowball Earth', representing a pivotal transitional interval in Earth's history. Here we describe an excellently-preserved carbonaceous compression fossil assemblage from the Tonian Liulaobei Formation, North China. This assemblage is dominated by cyanobacterial fossils, along with some eukaryotic fossils preserved on the same shale surfaces. Eukaryotes are represented by the discoidal *Chuaria*, the sausage-shaped *Tawuia*, and the worm-like annulated *Sinosabellidites*. Cyanobacterial fossils are classified into two groups: filamentous and spherical forms. Filamentous cyanobacterial fossils include *Anhuithrix magna*, *Mucoplagum primitivum*, *Glomulus filamentum*, ?*Oscillatoriopsis*, *Siphonophycus* spp., and two newly identified morphotypes. Spherical cyanobacterial fossils comprise *Myxococcoides*, ?*Gyalosphaera*, ?*Glenobotrydion*, and two new aggregated morphotypes. These two groups occur as individual specimens, in colonies, or collectively forming mat-like communities. Most of these fossils, especially those of cyanobacteria, have been interpreted as benthic organisms. Previous studies have clearly demonstrated that the Liulaobei Formation shale was deposited in a mid-depth continental margin, indicating that benthic organisms were widespread in mid-depth water settings during the Tonian period. Consequently, assessments of the Tonian biosphere must account for these deep-water benthic communities, especially in terms of biodiversity and functionality.

The trilobite nervous system and the early evolution of the mandibulate central complex

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Fossil central nervous systems (CNS) offer key insights into early euarthropod evolution. Trilobites are the most diverse and earliest appearing Palaeozoic euarthropods but their CNS remain unknown, yet can potentially clarify long-standing questions, including their affinities relative to modern representatives. We report the CNS of the cheirurid *Anacheirurus adserai* from the Fezouata Shale, Morocco. Digestive system preservation is also known in *A. adserai*, but with a distinct morphology and preservation style from the CNS. Backscattered electron microscopy combined with energy dispersive spectroscopy and Raman spectroscopy demonstrate that the fossilized CNS in MCZ:IP:202503b is replicated by the iron oxide goethite, with several regions enriched in kerogen. The CNS and digestive system both preserve kerogen, but a cluster analysis shows distinct signatures that likely reflect original compositions and decay pathways. Anacheirurus' CNS consists of a tri-partite brain with an anteriomedian protocerebral protrusion, a central complex, and a ganglionated nerve cord. *Anacheirurus*' CNS closely resembles that of Cambrian stem-group mandibulates and shares the presence of a central complex with a protocerebral bridge and lateral accessory lobes with extant pancrustaceans. We consolidate Trilobita as stem-group mandibulates and offer direct anatomical evidence of the sensorimotor system innovations that originated during the Cambrian Information Revolution.

Comparative study of micropalaeontological and ecological aspects of Holocene benthic foraminifera in coastal sediments of Asaluyeh and Hormuz Island in the Persian Gulf

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This study investigated the micropalaeontology and ecology of benthic foraminifera in Holocene sediments from two ecologically diverse areas of the Persian Gulf: Hormuz Island and Asaluyeh. Surface sediment samples were collected and analysed for foraminiferal species, along with water parameters including temperature, salinity, pH and dissolved oxygen. At Hormuz Island, 14 genera and 22 species were identified, with *Ammonia beccarii* being the most abundant, featuring a perforate calcareous shell. Genera such as *Amphistgina*, *Elphidium*, *Textularia* and *Quinqueloculina* represented hyaline, porcelaneous, and agglutinated shell types. Higher temperature and salinity increased the abundance and size of hyaline and porcelaneous foraminifera, while agglutinated forms declined. Dissolved oxygen was a key factor for diversity and abundance. In Asaluyeh, 12 genera and 14 species were found, with *Ammonia beccarii* dominant, and porcelaneous foraminifera more common than agglutinated ones. An inverse correlation existed between sediment particle size and foraminiferal density. Porcelaneous shells showed high sensitivity to environmental changes, making them effective bioindicators of pollution. The benthic assemblages reveal environmental variations, helping reconstruct past ecological and pollution conditions. This study provides an integrated approach for future palaeoenvironmental and ecological research in the Persian Gulf.

The E. M. Coombs Surface: a new Ediacaran Lagerstätte from Conception Bay, Newfoundland

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Ediacaran deposits preserve the earliest complex macroscopic life, but most fossil surfaces are limited either by preservational fidelity or taxonomic diversity. The newly discovered E. M. Coombs Surface at Inner Meadow, Upper Island Cove, Newfoundland, Canada, addresses both limitations. Here we report its preservation, diversity and ongoing discoveries to evaluate its significance as an Ediacaran Lagerstätte. The surface occurs at a ferruginous siltstone–tuffite interface, preserving microbial mat textures and filamentous fabrics. Fossils are preserved in exceptional density and fidelity, with ~17 body and trace fossil taxa already identified – the highest diversity of any Avalonian surface – with additional forms under description. For comparison, the Mistaken Point 'E' Surface preserves 11 taxa. The assemblage includes familiar Ediacaran groups such as rangeomorphs, arboreomorphs, erniettomorphs and discoidal forms, as well as new taxa including the rangeomorphs *Aninoides coombsorum* and *Charnia brasieri*, and undescribed pinnulate organisms. The E. M. Coombs Surface thus represents the most taxonomically diverse Avalonian site yet documented. Continued excavation is revealing further forms, underscoring both the dynamic nature of the site and the incompleteness of the Avalonian record. These discoveries provide new insights into Ediacaran community structure, preservational processes and early animal evolution, highlighting the broad significance of this fossiliferous surface.

Filtering the past: modelling the impact of stratigraphic and taphonomic biases on inferring trait evolution

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Fossil data provide critical insights into the evolution of life on Earth, yet are unavoidably shaped by stratigraphic, taphonomic and sampling biases. These processes not only influence which fossils are preserved but also which morphological characters remain. Advancements in stratigraphic forward modelling enable us to simulate the fossil record and explore these biases *in silico*. In this study, we use simulations to systematically assess the impact of these biases on our ability to infer trait evolution. Starting with simulated phylogenies and associated character data, we introduce different biasing processes that remove taxa and/or characters, according to stratigraphic position, preservation potential and sampling intensity. We then apply phylogenetic comparative methods to evaluate how these altered datasets affect our ability to recover evolutionary trends. By quantifying the magnitude and direction of bias across scenarios, this approach allows us to assess the robustness of phylogenetic comparative methods to incomplete and distorted fossil records. Understanding how these biases alter our inferences not only clarifies the reliability of our results but also guides the development of more realistic models that integrate both biological and geological signals.

A preliminary evaluation of a new Albian (Cretaceous) mollusc fauna from El Soplao (Cantabria, Spain)

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Initial evaluation of molluscs from the Las Peñosas Formation (Albian) at El Soplao (Cantabria, Spain) superficially reveals a marine fauna preserved as iron pyrites replacements. The bivalves include *Ostrea* sp. (Ostreoida), *Modiolus* sp. (Mytilidae) and '*Astarte*' sp. (Astartidae), with *Modiolus* sp. also found not pyritized in the host shale deposit. The pyritized gastropods include *Confusiscala* sp. (Epitonioidea), *Gyrodes* sp. (Campanilioidea), *Cerithiella* sp. (Triphoroidea), *Periaulax* sp. (Trochidae) and *Conotomaria* sp. (Pleurotomariidae). However, there is also an exceptional record of the boring bivalve *Martesia* sp. (Myida) bored into amber with their shells preserved in calcite. Moreover, the freshwater gastropod *Viviparus* sp. (Viviparidae) is found as fully infilled amber inclusions. Analysis of the fauna supports the hypothesis that deposition at El Soplao was in a shallow marine setting. However, proximity to a coastal swamp analogous to the contemporaneous site at Ariño (Cantabria) is suggested by the presence of drifted wood and bioeroded amber, the latter with inclusions of the freshwater *Viviparus* sp. Therefore, input into a shallow sea from an adjacent coastal swamp woodland is inferred for the site.

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The Great Devonian Interchange (GDI): a viewpoint from Gondwana

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The Great Devonian Interchange (GDI) was a biotic migration event characterized by the invasion of low-latitude cosmopolitan taxa into high-latitude, endemic biogeographic regions. Although well documented in the fossil record of Euramerica, it has only recently been investigated from several localities in Gondwana. Contemporary research points toward the GDI occurring earlier than its proposed coincidence with the Late Devonian mass extinctions, as it may rather align with the biocrises of the Early–Middle Devonian. A database of over 680 brachiopod taxa from 19 localities across West and East Gondwana (in addition to peri-Gondwana) was compiled to investigate the migration of these taxa throughout the Devonian and evaluate the stability of bioregions in relation to the Devonian biocrises. Preliminary findings indicate a distinct division between West and East Gondwanan faunas during the Early–Middle Devonian, with both areas comprising several discrete bioregions; however, a mixing zone appears to persist between the two in northern Africa. These once robust bioregions seem to gradually collapse towards the Late Devonian, becoming more cosmopolitan through time, as indicated by non-metric multidimensional scaling, as well as cluster and network analyses that were used to create time-sliced palaeobiogeographic maps.

A new jawless vertebrate faunal assemblage from the Early Devonian of Shropshire, England

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The Welsh Borders in the UK are home to more than a hundred sites that have yielded early vertebrate remains. Despite such extensive study in this area, new discoveries are still being made. This study presents a taxonomy of a new, Early Devonian-aged jawless vertebrate assemblage from the previously undescribed site of Ruthall Waterfall and identifies one locally abundant pteraspid, *R. crouchi*, another pteraspid, *L. dairydinglensis*, a weigeltaspid (*Weigeltaspis*? sp.) (heterostracans), and three cornuate osteostracans: *B. lankesteri*, *P. whitei* and *J. newtonensis*. The remains of a single jawed vertebrate (*Ischnacanthus*? sp.) were also identified. The studied material is highly disarticulated, particularly the material belonging to *R. crouchi*, which is entirely composed of individualized dermal plates. The most diagnostic of these, the rostral plates, are small compared to those found at other sites in the Welsh Borders and elsewhere, suggesting they belong to young individuals and that Ruthall Waterfall may represent a site of juvenile development. This study contributes to the understanding of early vertebrate diversity in the Welsh Borders and serves as an example of how a taxonomy that incorporates standardized dimensional metrics and ratio data can improve the framework for investigating further questions regarding phylogeny, ecology, ontogeny and palaeobiogeography.

Analysing Cretaceous faunas to predict cohabitation patterns within non-holocephalan chondrichthyan eco-groups

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Life habit and environmental preference were combined with the eight dentition types identified by Cappetta (1987) to identify eco-groups within Recent non-holocephalan chondrichthyans. A dataset was built for Cretaceous sites in the literature, for which sample size, species diversity and palaeoenvironment are known. Eco-groups were assigned to the taxa present. Studies with clear sampling biases were eliminated. Ratios of eco-groups were compared for each palaeoenvironment, across the Cretaceous. Brackish, nearshore and deep-water environments all showed meaningful trends. All three demonstrated a spike in a pelagic eco-group, with a tearing or cutting dentition in the 'mid' Cretaceous that had not been present in the Lower Cretaceous. In every case, this gave rise to a diversification of both taxa and eco-groups in the Upper Cretaceous. The majority of individual faunas were dominated by a benthic, bentho-pelagic or pelagic fauna, regardless of environment type. Preliminary results show that patterns in cohabitation exist, and can be used to predict faunal diversity using minimal bulk sampling, thus reducing resources required. By identifying the ratios of eco-groups represented in a moderate sample size, we can predict what else might be present and whether it would be productive to bulk-sample larger amounts.

Bone morphology of the early pan-anseriform Presbyornis: insights from high-resolution computed tomography

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Presbyornithidae, a lineage of total-group Anseriformes (waterfowl and kin), is possibly the only bird clade with fossil representatives spanning the end-Cretaceous mass extinction, and constitutes one of the most widespread Palaeogene bird groups. *Presbyornis*, from the Upper Paleocene and Lower Eocene deposits of North America, is one of the most abundant fossil birds, found as part of mass mortality assemblages preserving thousands of mostly disarticulated specimens. Despite this extraordinary wealth of material and its crucial stratigraphic and phylogenetic position, only limited descriptions of *Presbyornis* have been published, and most of its morphology has not been investigated in detail. Here we image some of the best-preserved material of *Presbyornis* known, originating from the Angelo Member of the Green River Formation, Fossil Lake, Wyoming, from a mass mortality layer presumably affected by avian botulism. The specimens were µCT-scanned to conduct the most comprehensive characterization of the osteology of *Presbyornis* to date. This material preserves pathological and cartilaginous tissues, such as tracheal rings, as well as immature specimens and evidence of intraspecific variation. This sample will clarify the phylogenetic position of Presbyornithidae within Anseriformes and future investigations will help inform the early diversification of crown-group birds following the Cretaceous–Palaeogene (K–Pg) mass extinction.

New exceptionally-preserved Drumian deuterostomes from western Utah

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Deuterostomes include the major living phyla encompassing echinoderms, pterobranchs and chordates, with their origins dating back to the Cambrian Explosion. Fossil deuterostomes are minor components of Drumian-aged exceptionally-preserved biotas in western Utah, USA. Although their main diversity and abundance consists mainly of early pterobranchs and echinoderms, deuterostomes in these deposits are also represented by enigmatic forms such as vetulocystids and eldoniids, as wells as recently described chordates. *Nuucichthys* represents the first soft-bodied stem-group vertebrate in the Cambrian of the American Great Basin Region, whereas *Megasiphon* is the oldest confirmed tunicate in Laurentia. Here we report the discovery of new deuterostome fossils from the Drumian Wheeler Formation in the Drum Mountains and the Marjum Formation in the House Range of western Utah. We confirm the presence of additional tunicates that can be assigned to Megasiphon, extending its occurrence to the lower Drumian of the Drum Mountains. A second enigmatic taxon features similarities with the genus *Phlogites* from the lower Cambrian Chengjiang biota and to a lesser extent the vetulocystid *Thylacocercus* from the Drumian Wheeler strata in the Drum Mountains. Finally, we report a composite tunicate-like specimen reminiscent of the enigmatic early Cambrian *Shankouclava* from Chengjiang in its gross anatomy.

The geographic structure of trilobite disparity within the Middle Ordovician of Laurentia

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The Middle Ordovician saw a drastic diversification event known as the GOBE, and evidence suggests that trilobite morphological disparity peaked during this interval. However, we still do not know how the disparity was distributed geographically. As a first step in analysing this issue, we focused on the geographical structure of disparity within Laurentia, using trilobites collected from throughout modern-day North America. Fossil collection data from the Paleobiology Database was classified based on the linear distance between collections in four clusters, two in the north and two in the south, facilitating the geographical analysis of disparity between latitudes. This was followed by the Trilomorph protocol to obtain geomorphometric data of the genera present within the Paleobiology Database collections to construct a morphospace. The analysis of regional morphospaces revealed that each geographical region varied very little in comparison to each other, as well as the continent as a whole. Disparity measured as SoV showed no difference between regions, while SoR clearly followed genus richness within each cluster, indicating that each region resembles a random sample of the continental morphospace. These results contrast with expectations, when spanning forty degrees latitude from the tropics of a continent during the single highest peak of trilobite diversity.

Identifying microscopic arthropods as zooplankton: a neontological approach

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Arthropod zooplankton play a critical role in modern marine ecosystems, linking primary producers to higher-level consumers in pelagic food webs. Therefore, identifying fossil arthropod zooplankton in deep time is important for reconstructing the changing complexity of open marine ecosystems. Current approaches for identifying fossil zooplankton combine information from multiple proxies: the geographic ranges and geological context of fossil finds, and morphological comparisons with extant analogues. However, these approaches are limited as they can only be applied to well-known taxa. In addition, the overall and relative strengths of each of these proxies have not been quantified, so they are complex to interpret if proxies disagree. Here we use ostracods, a generally microscopic group of arthropods with an extensive fossil record from the Ordovician to today, with planktonic and benthic representatives, to quantify the performance of proxies used to identify fossil zooplankton. We interrogate geographic range, soft-part morphology and carapace shape and structure, independently and together, to determine the robustness of these proxies in their application to fossil groups. We found that all proxies have power, both independently and when used in concert, providing a mechanism for inferring the life mode of less well-known fossil taxa with some confidence.

Investigating the impact of predation and environmental heterogeneity on species richness in an eco-evolutionary simulation

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Predation is a key driver of biodiversity, yet its interaction with environmental heterogeneity is poorly resolved. For example, the intensity of biotic interactions such as predation may increase towards the equator, reflecting more variable environments, but the prevalence of this pattern and its underlying mechanisms remain unclear. Using the individual-based eco-evolutionary simulation REvoSim, we modelled digital ecosystems across a range of environmental heterogeneities under conditions with and without predators, totalling 1,100 replicates. Species richness increased with heterogeneity but plateaued at higher heterogeneities, a pattern consistent with the area-heterogeneity trade-off hypothesis. This hypothesis proposes that increasing environmental complexity eventually fragments resources across too many niches, limiting further increases in richness. Predation consistently reduced richness, but promoted greater evenness in species population size and thus lower dominance, suggesting a stabilizing influence on community structure. The strongest predator effects were observed at intermediate to high heterogeneities, echoing empirical findings that predation shapes diversity more strongly in equatorial ecosystems. These results highlight that biotic interactions and environmental structure both contribute to biodiversity patterns, with implications for interpreting both modern biodiversity gradients and palaeontological diversity trends.

Population size, environmental heterogeneity and habitat change rate shape speciation dynamics in individual-based simulations

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Speciation is often described in terms of three spatial modes: allopatric (populations diverge in complete geographic isolation), parapatric (divergence occurs across adjacent ranges with limited overlap), and sympatric (divergence takes place within overlapping ranges). Determining the relative frequency of these modes is challenging in empirical systems, as speciation is rarely observed directly. We used an individual-based simulation, REvoSim, to investigate how environmental dynamics influence the spatial relationship between diverging populations at the point of speciation. To quantify these relationships, we developed two complementary metrics: the mean minimum distance between daughter and parent ranges; and centroid distance between species ranges. We showed that faster rates of environmental change and lower levels of environmental heterogeneity produced speciation events skewed towards allopatry. We suggest that both the pace and the structure of environmental change shape opportunities for divergence and the mode of speciation, offering a mechanistic explanation for how different speciation mode distributions emerge in nature.

Rise of the cerapodan dental batteries: measuring ornithischian toothrow complexity through time

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Ornithischians were a diverse clade of Mesozoic dinosaurs, notable for craniodental adaptations reflecting specialized forms of herbivory. A remarkable adaptation is the parallel evolution of tooth batteries in ornithopods and ceratopsians. Tooth batteries have been said to permit increases in complexity of tooth occlusal surfaces, but this has not been tested. Here we use orientation patch count rotated (OPCR) methods to compare tooth complexity across a range of ornithischian taxa, quantifying the average complexity of individual teeth within a toothrow, and the total complexity across the entire toothrow. Ceratopsia, Heterodontosauridae, Ornithopoda and Thyreophora independently evolved higher toothrow OPCR. These trends could represent a shift from omnivory to strict herbivory. In Cerapoda, neoceratopsians and ornithopods convergently evolved higher toothrow OPCR. However, each has a distinct pattern of average tooth OPCR evolution: neoceratopsians had a stable, low average OPCR whereas ornithopods show different average OPCR trends. The sudden drop in average OPCR in Euhadrosauria likely coincides with the appearance of uniform multiple-row dental batteries, whereas neoceratopsians relied on a one-row functional teeth dental battery. Dental batteries have a lower average tooth OPCR in exchange for higher toothrow OPCR. However, there is no specific dental evolutionary pattern that gives rise to toothrows.

Variability of community compositions of Ediacaran palaeocommunities of the Avalon assemblage

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Animal communities are first found abundantly in the fossil record during the Ediacaran period from ~574 Ma. The oldest palaeocommunities form the Avalon assemblage (574–560 Ma) and are found predominantly in Charnwood Forest, UK and Newfoundland, Canada. These Avalon communities consisted of sessile organisms and were preserved *in situ* where they lived by underwater ash falls, such that the bedding planes preserve a near-census of these Ediacaran communities. In this study we mapped out 44 palaeocommunities from Charnwood Forest, UK and Mistaken Point, Discovery Geopark and Spainard's Bay, Newfoundland, Canada using a combination of laser-line probe, LiDAR and photogrammetry. We used NMDS to compare the community composition between these key Avalon localities. While there was a substantial overlap in NMDS space occupied by the localities, each also had areas that were independent to them. These results provide further evidence of the importance of metacommunities dynamics amongst these early animal communities, and lack of biogeographical specialization.

Cambrian phosphatocopid (micro-arthropods) distribution patterns show ocean oxygen, temperature, and biogeographical controls

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Phosphatocopids are small (millimetric) Cambrian crustacean arthropods. Here we assess the spatial and temporal distributions of 75 taxa from nine palaeocontinental areas spanning Cambrian stages 3 to 10 (~521 to 486.85 Ma) in the first global synthesis of this group. We compare phosphatocopid distribution patterns to outputs from general circulation models of Cambrian climate and oceanography, and to different hypotheses of Cambrian palaeogeography. Our dataset supports the preference of phosphatocopids for low oxygen marine settings. This finding is emphasized by a peak in occurrences in the Guzhangian and Paibian stages (interval from 500.5 to 494.2 Ma), around the Steptoean positive carbon isotope excursion (SPICE) in which low oxygen water masses encroached onto shallow marine shelves globally. Further evaluation of our dataset and comparison with model simulations suggests that phosphatocopid distribution is also partly explained by biogeography and ocean temperature patterns, similar to many contemporary marine arthropods. Notably, we find that phosphatocopid distributions can be understood in terms of palaeolatitudinal and water depth temperature gradients, with a shift to higher palaeolatitudes and deeper water depths from the Drumian Stage (beginning 504.5 Ma) onwards.

A systematic review of reported richness trends across the Great Ordovician Biodiversification Event

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The Great Ordovician Biodiversification Event (GOBE) embodies the most dramatic increase of marine biodiversity and escalation of macroecological complexity during the early Phanerozoic. Numerous palaeobiological studies have attempted to quantify the GOBE based on estimates of richness through time for various groups of marine organisms. However, these studies use data restricted to specific regions, clades, or employ disparate methodologies that preclude direct comparisons. To explore the general trends in reported richness, we collated 166 datasets from 65 publications to analyse temporally standardized rates of marine species biodiversity accumulation between the latest Cambrian and the entire Ordovician using an effect-size approach. When combined, the current literature indicates a statistically significant high rate of sustained species accumulation that can be traced from the late Cambrian until the Middle Ordovician, stabilization during the Late Ordovician, and then a precipitous decline during the Hirnantian. Studies of benthic and suspension-feeding organisms show high rates of biodiversity accumulation throughout most of the Ordovician. In contrast, studies of the diversification of nektonic, pelagic and predatory/scavenger organisms suggest their radiations were restricted to the Early Ordovician. By synthesizing information for reported richness from the literature, we provide a complementary perspective on the general literature of the GOBE.

The microbiology of decay and fossilization

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Microorganisms are commonly invoked in models of exceptional fossilization, from Burgess Shale-type preservation to Ediacaran 'death masks', yet the composition and succession of microbial decomposer communities in marine settings remain poorly understood. The microbial 'necrobiome', the community of microorganisms associated with decomposing organic matter, has been characterized primarily in forensic studies of terrestrial vertebrates, leaving a major gap in palaeontological contexts. Here we present a 121-day experimental decomposition of the squat lobster *Munida rugosa*, under two contrasting conditions: natural estuarine mud and artificial seawater. Microbial communities were profiled at multiple timepoints using 16S rRNA gene sequencing to resolve necrobiome succession. Initial assemblages were dominated by host-associated bacteria but rapidly transitioned to opportunistic anaerobes and environmental taxa. In mud, early enrichment of fermentative and facultatively anaerobic populations preceded the rise of sulphur-cycling lineages and archaeal taxa. In contrast, the sediment-free system developed more slowly and was dominated by fermentative guilds with reduced taxonomic complexity. Temporal trajectories revealed stage-specific shifts and convergence during early to mid-decomposition, highlighting deterministic structuring in sediment compared to more stochastic assembly in seawater. These findings provide a time-resolved characterization of a marine invertebrate necrobiome and contribute to understanding how microbial dynamics may influence decay and preservation.

Quantifying disparity in annelid locomotion using discrete non-morphological characters

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Locomotion is an integral part of survival for most animals, and consequently, locomotory strategy captures various aspects of phenotype. Despite its importance, disparity in locomotion is rarely studied quantitatively. Annelid worms comprise a taxonomically and morphologically diverse phylum and show great variation in their locomotion. This is evident when comparing the two major annelid subclasses, Errantia and Sedentaria, which are generally characterized by differing locomotory strategies. Using a novel technique to characterize phenotypic disparity by describing locomotory strategy with a suite of discrete non-morphological characters, we show that the evolution of annelid locomotion is driven by a complex of anatomical, ecological and environmental factors. Annelid locomotion can be broadly divided into two types, appendage-using and non-appendage-using, which align with the Errantia and Sedentaria respectively. Locomotion strategy is weakly associated with feeding guild and lifestyle, but we find no link to sediment type or marine zone. Sedentaria display more locomotory disparity than Errantia, and microphagous taxa are the most disparate feeding guild. In contrast to motile pelagic annelids, infaunal and epifaunal annelids are highly disparate. Our results demonstrate that locomotory strategy constitutes an important aspect of disparity, shaped by anatomy, ecology and environment, and highlight the adaptability of the annelid bauplan.

Why did ammonoids go extinct but nautiloids survive the end-Cretaceous mass extinction?

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Sixty-six million years ago, an asteroid killed the non-avian dinosaurs. It also triggered the extinction of the ammonoids, an iconic and diverse group of shelled cephalopods. Curiously, a far less diverse group of shelled cephalopods survived, the nautiloids. Why did the nautiloids survive, but the ammonoids go extinct? This question is subject to a lively and ongoing debate. Many (not mutually exclusive) hypotheses have been raised, often with some degree of empirical support. For example, nautiloids had larger hatching sizes, which might have allowed them to survive periods of low food availability. Nautiloids also had larger geographic distributions, possibly indicating greater flexibility in response to varying environmental conditions, or a higher chance to end up in refugia post-impact. Drawing on the Paleobiology Database and other published datasets, we collected the largest dataset so far on Maastrichtian shelled cephalopods, combining fossil occurrences, hatching sizes and body sizes. We present some preliminary findings based on these data.

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Preliminary endocranial anatomic description of *Stenaulorhynchus stockleyi* (Archosauromorpha, Rhynchosauria)

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Endocasts have been established as a valuable data source for studies dealing with ecological and evolutionary trends in fossil taxa. These were broadly employed in studies on archosaurs, but not as much among rhynchosaurs, an archosauromorph group with great ecological success in the Triassic. Here we present a preliminary description of the endocast of *Stenaulorhynchus stockleyi* (GPIT/RE/7192), via micro-CT scanning with manual segmentation using 3DSlicer software, which is the first investigation of this kind for Rhynchosauridae. The specimen is deposited in the Paläontologische Sammlung der Universität Tübingen, Germany. The endocast is nearly symmetrical and has a constriction in its medial portion. The internal carotid arteries are anterodorsally located on the floor of the sella turcica, that covers the hypophysis. The fenestra ovalis, which contains endosseous labyrinths, is incompletely preserved in both sides. The metotic foramen is large and houses the exits of the glossopharyngeal (IX), vagus (X) and accessory (XI) nerves. On the basal tubera, a structure potentially corresponding to the pneumatic sinus was identified, as common to stem-archosaurs. Further comparisons and more detailed analyses will be conducted to identify other anatomical traits of the endocast.

The complex relationship between brachiopods, bivalves, and the environment

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Perceptions of brachiopod and bivalve diversification dynamics have changed considerably over the last half-century. Initially considered a textbook example of competitive displacement, environmental factors have grown increasingly important in modern interpretations of the evolutionary histories of both groups, with some excluding competition altogether. However, these interpretations continue to be based upon global-scale analyses, which fail to account for spatial biases in fossil distributions. Consequently, whether the inverse correlation between bivalve and brachiopod richness presented by the fossil record reflects a causal relationship remains uncertain. Here we tackle this problem by analysing the diversity dynamics of both groups using spatially explicit methods and a new dataset of over half a million fossil occurrences compiled from museum collections, the Paleobiology Database and the Global Biodiversity Information Facility. Assuming an inverse relationship between brachiopod and bivalve richness in geographically constrained regions reflects competitive displacement, we recover a complex relationship between the two groups that incorporates environmental factors such as bathymetry, lithology and, to a lesser extent, latitude and the presence of reefs. Ultimately, whilst they highlight important caveats to analyses of this type, our results suggest that bivalves and brachiopods may not have been ships that pass in the night after all.

New Choristodera (Reptilia: Diapsida) material from the Kilmaluag Formation (Middle Jurassic) vertebrate assemblage of the Isle of Skye, Scotland

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Middle Jurassic vertebrate fossils are rare globally, despite representing a crucial period for the origin of many groups. The vertebrate assemblage from the Kilmaluag Formation on the Isle of Skye has therefore produced vital material for understanding vertebrate evolution including mammals, salamanders and squamates. The Kilmaluag Formation has also yielded important material of Choristodera, semiaquatic diapsid reptiles that first appear in the Middle Jurassic fossil record. *Cteniogenys* is the only genus named from this epoch and is known from multiple sites globally. In the UK, *Cteniogenys* specimens have been recovered from the Isle of Skye and Kirtlington, Oxfordshire. However, overlap of material between these sites is limited to phalanges and vertebrae, making it difficult to differentiate them beyond the genus level. Here a new choristoderan specimen is described from the coastline north of Elgol, found *in situ* within the 'vertebrate beds'. This new specimen includes elements not present in previous Kilmaluag discoveries, including a complete ilium and ungual phalanges that are morphologically similar to those from Kirtlington. Given these similarities, as well as similarities in overlapping elements with other Skye fossils, this new specimen is likely another member of *Cteniogenys*, thus providing more information on early choristodere anatomy and evolution.

An adventure in the Arrábida Chain: new palynological discoveries from the Miocene of Portugal

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The Arrábida Chain, located in central-western Portugal, is a morphotectonic structure formed as a result of the main Cenozoic tectonic inversion between 17.5 and 17 Ma. Its complex geological context created favourable conditions for the preservation of the diverse biota, now documented for the first time. Preliminary micropalaeontological studies reveal a wide spectrum of palynomorphs (pollen, spores, dinoflagellate cysts, foraminifera, scolecodonts, and both freshwater and marine microplankton). Other fossil organisms, classified as zooclasts (tintinnids and insect fragments), were also observed. These assemblages suggest alternate phases of marine (distal) and terrestrial (proximal) depositional environments throughout the geological evolution of Arrábida during the Miocene. Such environmental changes reflect the interaction between tectonic activity, sedimentary dynamics and palaeoecological processes, contributing to a refined reconstruction of local palaeoenvironmental and palaeoclimatic conditions. The Arrábida Chain is of notable palaeontological significance, not only for the diversity of its fossil content, but also for the rarity of certain taxa, particularly tintinnids and scolecodonts. These findings highlight the scientific relevance of Arrábida, both nationally, as a unique palaeontological archive in Portugal reflecting post-inversion geomorphological effects, and internationally, as a case study contributing to broader discussions on Miocene ecosystems, palaeoclimate, and the role of tectonics in shaping biotic evolution.

New discovery of Charnia in Arctic Norway: sedimentary controls on fossil occurrence within late Ediacaran deepwater strata

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The late Ediacaran Period marks a pivotal stage in early animal evolution and the frondose organism *Charnia* is among its most iconic and widespread taxa. We present the first discovery of three-dimensional *Charnia* from Arctic Norway, alongside new specimens of *Palaeopascichnus*, *Aspidella*, and scratch circles from the distal shelf to slope deposits of the Indreelva Member (Stáhpogieddi Formation). These fossils reinforce the widespread palaeogeographic distribution of *Charnia* and position the Vestertana Group as an increasingly multifaceted archive of late Ediacaran life. The three-dimensional preservation of one of the *Charnia* specimens is explained in context of transport and incorporation within a sediment gravity flow deposit. Yet despite the abundance of comparable facies in the unit, only two specimens of *Charnia* were found. We attribute this apparent scarcity to inconsistent preservation owing to erosion and winnowing of muddy substrates. However, given that such processes are inherently variable in time and space, rare combinations of more favourable conditions are inevitably preserved at outcrop. Continued interrogation of new exposures therefore remains essential for fossil discovery, even within seemingly monotonous deepwater successions.

Miniaturized experimental taphonomy: tracking decay at micron-to-millimetre scales

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Taphonomic experiments seek to interrogate patterns of information retention, transformation and loss, during the decay, mineralization and maturation of organic remains. Ideally, we would like to monitor these processes without interrupting them. However, many of the most significant organisms in Earth history were micro- or mesoscopic: to understand their taphonomic trajectories requires specially adapted, high-spatial-resolution techniques for imaging and analysis. Here we outline two novel experimental approaches for conducting taphonomic experiments on micrometre- to millimetre-scale organisms. Decay experiments conducted within modified cavity well slides permit the optical examination of decaying microorganisms under high magnification, while maintaining a geochemically realistic aqueous environment. By tracking individual trichomes and cells decaying over time – sometimes disappearing within minutes while being consumed by motile saprotrophic bacteria – we observe that heterotrophs accelerate the decay of cyanobacteria above the baseline of autolytic decomposition. Using optical coherence tomography (OCT), we have also non-invasively monitored both internal and external decay processes within millimetre-scale soft-bodied animal carcasses with remarkable fidelity and temporal resolution. The efficacy of these new approaches provides viable, cost-effective approaches to miniaturize decay experiments without sacrificing resolution, and OCT offers a novel non-ionizing, non-invasive tomographic approach to investigate decay processes in small organisms.

Where are all the fossil viruses?

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In the modern world, viruses are a ubiquitous and highly diverse accompaniment to life, occurring in profusion wherever life is present. Analysis of viral-derived DNA and RNA demonstrates that these enigmatic parcels of genetic material have played a key role in the evolution of life as we know it and may be key to understanding its origins. Experimental taphonomy indicates, in modern substrates, that viruses also play a role in mineralization, acting as centres of accretion. Despite this, the modern understanding of the fossil record records an almost complete lack of viruses. Where are all the fossil viruses? To begin to address this discrepancy, we examine samples of the Rhynie chert biota from northeast Scotland, a hydrothermal system with exceptional preservation. Using SEM and FIB-TEM, we analyse the spatial resolution limits of the chert and identify potential virus-like particles. This analysis forms the basis for a robust evaluation of the preservation potential of viruses in the rock record and a scheme for their identification in ancient silicates. Identifying fossil viruses has further applications for astrobiological investigations as, due to their simplicity, viruses are a potential target in the search for life elsewhere in the Solar System.

Using multimodal analyses to investigate the life history of undescribed *Tyrannosaurus* individuals in the 'Trinity' mount

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As one of the most well-researched dinosaurs, *Tyrannosaurus rex* serves as a model organism in the study of fossil vertebrates. Here we report on previously undescribed individuals from the Hell Creek Formation of Montana and the Lance Formation of Wyoming, USA, providing new insights into the life histories of several specimens. A preliminary palaeopathological analysis revealed the ankylosis of two mid-caudal vertebrae consistent with spondyloarthropathy, a progressive and inflammatory rheumatic disorder that can be caused by a mixture of environmental and genetic factors. A cryptic periosteal reaction of a left metatarsal was histologically sampled, showing complete remodelling, indicating the injury had fully healed. Feeding traces referrable to *Tyrannosaurus* are present in a costal and caudal element. Three dorsal ribs from the composite mount differ in age, suggesting they belong to three distinct individuals. Conversely, both third metatarsals show similar growth patterns, likely indicating the same individual, despite notable differences in size and morphology. The femora, from two individuals, show similar fibrolamellar bone and a subadult stage. Overall, growth patterns and ontogenetic stages confirm the presence of at least four different individuals in the mount. This study presents a model framework with tools and approaches for investigating composite mounts with complicated backstories.

A palaeontological perspective on the sister group of metazoans from Cambrian sites of exceptional preservation

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The phylogenetic relationships among early branching metazoans are an ongoing and hotly contested debate. The traditional Porifera-sister hypothesis is supported by morphological studies but has fallen out of favour in the wake of genetic evidence. The Ctenophore-sister hypothesis leaves open questions regarding the convergent evolution of complex traits such as the nervous system, as well as the ancestral ecology of the first animals. Molecular clocks estimate that early metazoans diverged between 700 and 900 million years ago but the first recognizable body fossils appear in the late Ediacaran and Cambrian periods. In this context, Cambrian sites of exceptional preservation, such as the Burgess Shale (Canada), Chengjiang (China) and Marjum (USA), hold insights into the early evolution of animals through the preservation of soft tissues and a high fidelity of morphological detail. Cambrian sponges and ctenophores share aspects of their gross morphology, including visual similarities in tetraradial symmetry, marginal frills and rigidity structures. However, proper comparisons across these phyla are largely lacking, and affinities of problematic taxa remain unresolved. New work in fossil ctenophores prompts a re-evaluation of enigmatic sponges, such as *Takakkawia lineata* and *Petaloptyon danei*, in the context of the early diversification of the first metazoans of the Cambrian Explosion.

New micro- and macrofossils from the Tonian Little Dal Group, northwest Canada, provide insight into early eukaryote communities

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The early Tonian was a key interval for eukaryote diversification. Molecular clocks predict the emergence of major eukaryotic clades by 1,000 million years ago, and cholestane biomarkers document the rise of red algae as primary producers. The eukaryote fossil record, however, is limited between the ~1,000 Ma emergence of eukaryotic algae and diverse biotas of the late Tonian, obscuring our view of early eukaryotic evolution. The ~890-million-year-old Little Dal Group, a ~2.5-kilometre-thick succession in the Mackenzie Mountains, Canada, provides an excellent target for new fossils, with Little Dal shales remaining understudied despite previous reconnaissance work yielding some well-preserved microfossils. We report preliminary results from high-resolution sampling, documenting a diversity of exceptionally preserved organic microfossils including acritarchs and filamentous forms. Additionally, we report macroscopic carbonaceous fossils, including *Chuaria* and *Tawuia*. Of particular interest is a three-dimensional possible macrofossil which appears to have a coiled morphology atypical of Tonian fossils. These discoveries demonstrate the potential of Little Dal shales to provide new fossil evidence for the diversification of eukaryotes. Detailed characterization of Little Dal palaeoenvironments will provide vital context to these discoveries, helping to discern how the evolution of eukaryotic communities was influenced by environmental gradients (*e.g.* redox or nutrient availability).

A new soft-bodied Halwaxiid-grade metazoan from the Middle Cambrian Marjum Formation, Western Utah

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The Cambrian Marjum Formation of the House Range, western Utah, USA, preserves a diverse assemblage of exceptionally-preserved marine organisms in a deep-water, low-energy depositional environment. Within this succession, we identify an enigmatic new soft-bodied organism with possible affinities to halwaxiid-like lophotrochozoans. The new taxon possesses a dorsal covering of delicate scales arranged into discrete zones, but differs from conventional halwaxiids in lacking mineralized or even sclerotized elements, instead bearing cuticular dorsal elements. The combination of a halwaxiid-like organization and scale metamerism, along with the soft-bodied nature of the dorsal scales, suggests a previously unrecognized early evolutionary stage for this clade before the development of hardened armour. The phylogenetic position of halwaxiids makes them crucial to discussions of molluscan origins, bridging the morphological and fossilization gap between typical Cambrian 'small shelly' forms and more derived crown-group representatives. The discovery of new Marjum species adds complexity to our understanding of Cambrian lophotrochozoan diversity and body-plan evolution, reinforcing the significance of this exceptional deposit as a critical window into early animal evolution and palaeoecology.

Reconstruction of *Jeholornis* and the role of iridescence in early paravian plumage

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Plumage of birds is held at a trade-off in modern ecosystems, used for flight efficiency, vibrant display or crypsis. These plumage trade-offs present in modern bird taxa must also have been present in the fossil record of avian theropods and early birds. *Jeholornis*, an early paravian from the early Cretaceous of China, is known for its unique 'two-tailed' plumage, composed of a fan of feathers protruding dorsally from the base of the tail, and a frond of feathers at the end of the tail. This ornamental plumage is thought to serve in display, making *Jeholornis* an intriguing candidate for palaeo-colour studies. Here, thanks to the co-operation of the Chengjiang Fossil Site Museum, the plumage of *Jeholornis* is described in detail from a new, undescribed specimen, and we were able to reconstruct its colouration using melanosome analysis. The morphologies of melanosomes suggest iridescence in the feathers of the body, wings and tail integument with a set of ginger covert feathers. This plumage patterning is consistent with the complex social or sexual displays observed in modern birds, providing further insights into the role of iridescence in the fossil record of early paravians. This type of colour patterning is new to the fossil record of dinosaurs and early birds.

Did climate events drive the demise of bradoriid arthropods in the Cambrian tropics?

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Bradoriids are a group of Cambrian to Early Ordovician small (millimetric) arthropods characterized by a dorsal shield covering their entire body. A global analysis of their temporal and spatial distribution, comprising nearly 600 occurrences, shows that bradoriids ranged from equatorial to high southern polar latitudes throughout their existence. Bradoriid diversity was greatest in Cambrian ages 3 and 4, when they predominantly occurred in tropical waters. Bradoriid diversity declined after Cambrian Age 4, and shifted away from the tropics after the Wuliuan Age. Most bradoriids were benthic and occupied shallow marine environments above storm wave base in oxygenated facies, making sea temperature and dispersal the most likely controls on their distribution patterns. A smaller subset occupied deeper shelf settings, particularly during Cambrian Age 3, and either tolerated reduced oxygen conditions or adopted a pelagic lifestyle to escape benthic dysoxia. Changing bradoriid latitude and water depth distributions, notably their rarity in the post-Wuliuan tropics and post-Age 3 deep water settings, suggests the impact of climate change. We propose that bradoriid diversity and distribution patterns reflect responses to hyperthermal and ocean deoxygenation events that punctuated an already warm greenhouse world, with the tropical shallow marine benthos particularly severely affected.

Perspectives on eukaryogenesis from biochemical, molecular and fossil evidence

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Eukaryotes play a crucial role in the biosphere today, comprising the majority of biodiversity, biomass and primary productivity. However, our understanding of their origin and early evolution remains relatively limited. We summarize the existing theories for the origin of eukaryotes and test them against all available data including biochemical, morphological, molecular and ecological evidence. Using these data, we produce a series of hypotheses that are testable with the fossil record. We apply this emerging framework to Tonian microfossils from the Brasier Fossil Collection at the University of Oxford, UK. After sorting and collating more than 2,000 thin-section samples, we report new microfossils with distinct morphological structures from Boorthanna (~800 Ma) in South Australia. Comparative morphological analyses reveal eukaryotic characteristics, with clear similarities to multicellular algal microfossils from the Ediacaran Doushantuo Formation of China, providing evidence for the morphological diversity of green algae in the early Neoproterozoic. Our results establish a foundation for future studies to refine the chronology of key evolutionary events, ultimately aiming to reconstruct a more accurate timeline of early eukaryotic evolution and the processes which drove it.

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