The Palaeontological Association

68th Annual Meeting

9th–13th December 2024

Erlangen, Germany

PROGRAMME ABSTRACTS

The Palaeontological Association
68th Annual Meeting
9 – 13 December 2024
Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

Herzlich willkommen in Erlangen!

We are delighted to warmly welcome you to Erlangen for the 68th Annual Meeting of the Palaeontological Association. This year's Meeting is utterly jam-packed full of fantastic science and opportunities to connect with old and new friends. This will be the first time that the Meeting has been held in Germany and we hope that you enjoy all that Erlangen and the surrounding areas have to offer – especially at Christmastime!

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 (<**annualmeeting2024@palass.org**>) or speak with a friendly member of the local organizing team. Viel Spaß!

Visiting Erlangen

Situated at the heart of Franconia, the Baroque city of Erlangen has lots to offer visitors. The city's many open squares host markets, festivals and cultural events throughout the year. The Altstadt (old town) with its winding alleyways, independent crafts shops and traditional restaurants is a must-see, and if you stroll through the Schlossgarten (palace gardens) and botanical gardens, you might spot a red squirrel or two. If you find yourself visiting the city in early summer, try to catch the Bergkirchweih, a folk festival held in the largest open air drinking venue in Germany. It might not be as big as Oktoberfest, but locals will tell you that it is actually the oldest, is much more traditional, and cosy!

Here at the Annual Meeting in December, the Christmas markets are in full swing, with lots of traditional Bavarian winter food, Glühwein and live music. We strongly recommend the 'Drei im Weckla', a Nürnberg classic, for a hearty warm bite by the fireside. A short train ride south takes you to the historic city of Nürnberg, home to one of the oldest and most famous Christmas markets in the world, the Christkindlesmarkt. To the north of Erlangen is the historic town of Bamberg, where you will find yet another wonderful Christmas market in the town square, only a short walk from the old town, which is a UNESCO World Heritage Site.

For those wishing to see more after the conference, Erlangen's train station is located right in the centre of the city and is approximately ten minutes' walk from the main conference venue. Erlangen has excellent rail connections to most German cities and the rest of Europe. Direct rail routes link Erlangen to Munich and Berlin, while connections to other major cities, such as Frankfurt

and Vienna, are possible through the nearby city of Nürnberg. Coaches through companies such as Flixbus also operate regular schedules across Germany and beyond.

Since Erlangen is a relatively small city, most local destinations can be reached easily on foot. The venues for the conference, including the workshops and Annual Dinner, are all located in the city centre. Taxis, electric scooters (Voi, Tier and Superpedestrian), and an extensive local bus service are also available. We recommend downloading the VGN app to access public transport options and to buy tickets for travel in Erlangen, Nürnberg and the surrounding areas.

We have curated a Google Maps List featuring key conference sites, local bakeries for lunchtime snacks, and some of the best restaurants that Erlangen has to offer (if you need somewhere to get that collaboration you've been talking about for years off the ground). Use the link <**https://tinyurl.com/339zhehm**> or scan the QR code that can be found in the maps section of this booklet, on page 10.

Venue

The 68th Annual Meeting of the Palaeontological Association is hosted by a team based at Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU) here in Erlangen. The Heinrich-Lades-Halle on Rathausplatz close to the city centre will be the main venue for scientific sessions, posters, the Symposium and the Annual Address from 10th to 12th December. Workshops on the morning of the 10th will take place in various university buildings across the city campus – details will be communicated with attendees in advance. All venues are within walking distance of the city centre and main train station.

Registration and presentation upload

Upon arrival at the main conference venue, the Heinrich Lades Halle, all delegates must register at the registration desk to receive their name badge and tickets for additional events (*e.g.* the Annual Dinner and icebreaker). For security purposes, delegates will need to have their name badges and lanyards visible to enter the Heinrich Lades Halle.

Oral presentations (talks) must be uploaded the day before a delegate's 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 at the registration desk on Tuesday 10th and Wednesday 11th December only.

Posters can be put up on Tuesday 10th December or in the morning of Wednesday 11th December. Instructions on how to do so will be available at the registration desk and volunteers will be available to assist. Poster presenters who are eligible for the Council Poster Prize will have been contacted by the Association Council with instructions for uploading a PDF copy of their poster prior to the conference.

Catering

Lunch is not included in the registration costs. Small dishes, such as sandwiches and soups, can be purchased from the snack bar at the Heinrich Lades Halle during scheduled lunch times on Wednesday and Thursday.

For delegates who wish to venture out for lunch, there are many bakeries, restaurants and food stalls nearby – we especially recommend checking out the Christmas market stalls around the town for delicious local food! There is also fresh food (including soup and sushi) available at the nearby

Rewe supermarket. See the Google Maps List for local bakeries and restaurants (scan the QR code on page 10).

Oral presentations

All scientific presentations will take place in the Heinrich-Lades-Halle. Oral presentations (talks) will be allocated 15 minutes in total, and speakers should prepare their talks to allow for hree minutes of questions and switching between speakers. We have three parallel sessions occurring throughout the Meeting, so timing will be especially important. Speakers will upload their talks at the designated upload stations one day before the scheduled presentation slot. Uploading talks directly before sessions will not be possible. Talks should be submitted in a PowerPoint file format (.pptx) or as a PDF file (aspect ratio 16:9). The conference venue uses Windows machines. Please ensure videos and custom fonts are embedded to avoid compatibility issues.

Poster presentations

A dedicated poster session will take place on Thursday 12th December, although posters will remain on display throughout the meeting in the main foyer. Poster boards will accommodate an A0 poster presented in portrait format. Pins 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 should see the Executive Officer, Dr Jo Hellawell (e-mail: <**executive@palass.org**>) in the exhibition area to receive their reimbursement.

Childcare

Baby changing facilities are available at the main meeting venue, Heinrich-Lades-Halle. Childcare will not be provided, but a list of local childcare options can be provided on request. For further details, please e-mail the meeting organizers at <**annualmeeting2024@palass.org**>.

Accessibility

Almost all meeting venues are accessible via ramps and/or lifts. The exception is the historic building of the GeoZentrum Nordbayern, which is the venue for some workshops. The organizers requested that accessibility needs be highlighted when signing up for workshops, and any other queries can be directed to the meeting organizers via e-mail to <**annualmeeting2024@palass.org**>. A quiet room is available at the main meeting venue and dinner venue for use if required; please enquire at reception or e-mail the organizers.

German for beginners

First time in Germany and nervous about speaking German? Luckily, Erlangen is a cosmopolitan town being home to the electronic giant Siemens and one of the largest universities in Germany. This means most people in the town speak some English – 90% of the time you can muddle through with 'Denglisch'. We have compiled a small list of key German phrases that can help you blend in with the locals and get you ordering a warm Kaiserspätzle or Kartoffelklöße in no time.

Hello!	*Hallo/Guten Tag/Grüß Gott (Bavarian)/Servus (Bavarian)*
Excuse me	*Entschuldigen Sie*
I have a question	*Ich habe eine Frage*
Yes, please	*Ja, bitte*
No, thank you	*Nein, Danke*
Do you speak English?	*Sprechen Sie Englisch?*
I don't know/no idea	*Ich weiß es nicht/keine Ahnung*
I'm sorry	*Es tut mir Leid.*
That is correct	*Das stimmt!*
Exactly!	*Genau!*
Where is the bathroom?	*Wo ist die Toilette?*
Is it vegan?	*Ist das vegan?*
I don't like sparkling water	*Ich mag kein Sprudelwasser.*
How much is…	*Wieviel kostet…*
The bill, please.	*Die Rechnung, bitte.*
I would like to pay	*Ich möchte bitte zahlen.*
Can I pay by card?	*Kann ich mit Karte bezahlen?*
Where is the nearest ATM?	*Wo ist der nächste Geldautomat?*
It'll do	*Past schon/Pass 'sho*
This is an 'effing' mess	*Jetzt haben wir den Salat*
It's all sausage (irrelevant) to me	*Es ist mir Wurst*
Help! I've forgotten my PowerPoint!	*Hilfe! Ich habe meinen PowerPoint vergessen!*
Goodbye	*Tschüss/Auf Wiedersehen (formal)/Tschüssi (informal)*

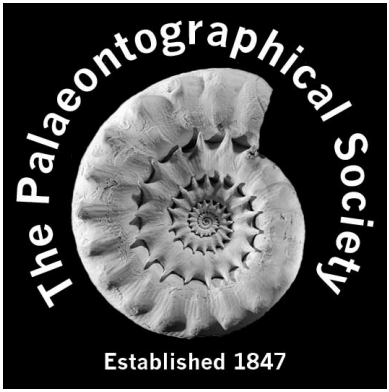
Sponsors

- *Nature Ecology and Evolution*
- The Palaeontographical Society
- *Fossil Studies*
- Royal Society Publishing
- Transmitting Science

fossil studies
an Open Access Journal by MDPI

THE ROYAL SOCIETY PUBLISHING

nature ecology & evolution



Organizing committee

Co-chairs

Dr Emma Dunne

Dr Thomas Clements

Prof. Rachel Warnock

Committee

Dr Danijela Dimitrijević

Dr Elizabeth Dowding

Dr Patrycja Dworczak

Patrick Hänsel

Dr Ádám Kocsis

Anna Merkel

Dr Laura Mulvey

Prof. Axel Munnecke

Dr Barbara Seuss

Isaiah Smith

Lewei Su

Student collaborators

Teela Allmendinger

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Helene Böttger

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Angelo Capaldo

Arion Chao

Katie Cryer

Joelle Dannerbeck

Kohrmann David

Jonas Dill

Gabriella Domokos

Elisabeth Donderer

Katrin Eckardt

Maxime Flaunet

Meghan Gallaspy

Carolin Grether

Maria Gross

Maibritt Härpfer

Sarah Hofmann

Selina Huber

Filip Huić

Aaron Jänsch

Toshiro (Alexis) Jujihara

Tonchaya Khayunkan

Mirabella Krauss

Alfred Maxey

Vicente Tomás Merino Salinas

Maxima Praxl

Ines Pyko

Lilith Rahm

Christian Ringkewitz

Jordan Rodgers

Bastian Seidl

Cristian State

Elena Schlemper

Eren Tasimov

Victoria Thiel

Lars Tischer

Alissa Watson

Matías Zenklusen

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, either in personal or in 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 and respectful, and should 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 (accessed via the PalAss webpage at <**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. Rachel Wood; Vice- President Dr Uwe Balthasar; Vice-President Prof. Susannah Maidment; Diversity Officer Dr Nidia Alvarez Armada; 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 Germany for the police call 110, or for fire or medical emergencies call 112). 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. Rachel Wood
- Vice-President Dr Uwe Balthasar
- Vice-President Prof. Susannah Maidment
- Diversity Officer Dr Nidia Alvarez Armada
- Executive Officer Dr Jo Hellawell.

Emergency contacts

Emergencies in Germany
Calling the emergency number **112** in Germany will get you through to the fire brigade and ambulance services. If you urgently need the police, the number to call is **110**. Emergency dispatchers normally speak English.

Regular and out-of-hours medical care
When in Germany, you can use your EHIC (EU residents) or GHIC (UK residents) to get medical care through the public healthcare system. This gives you the same access to medical services as residents who are registered with public healthcare.

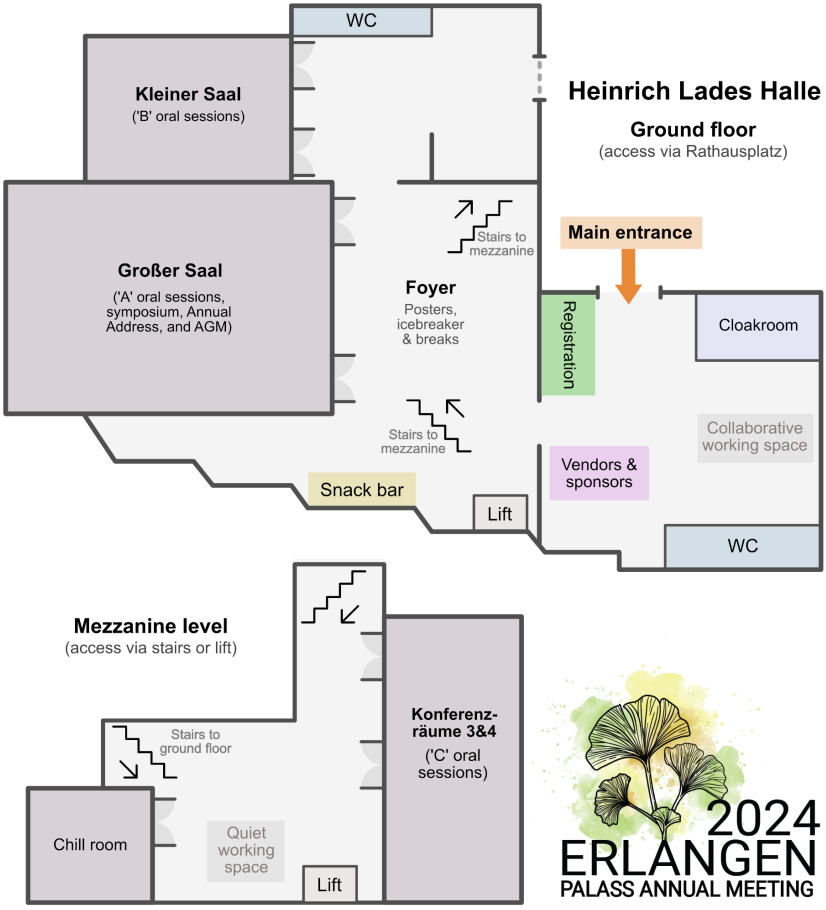
If you're a non-EU visitor, you may benefit from certain deductions with a travel insurance plan in place. We strongly advise all delegates to have travel insurance: in the event you need emergency care, travel insurance can help you avoid high medical costs.

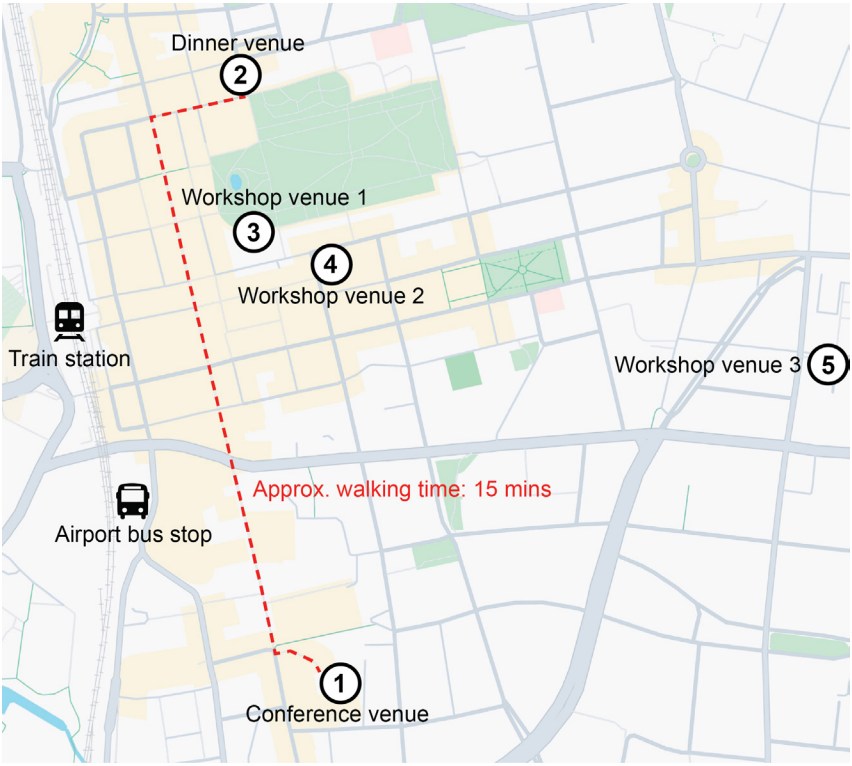
An out-of-hours clinic (Notfall Praxis) is available on Bauhofstrasse in Erlangen. You can reach the reception by calling 09131 816060 and find information about opening times on their website (<**www.notfallpraxis-erlangen.de**>).

There are several pharmacies (Apotheke) in Erlangen and surrounding areas where you can speak with a pharmacist and purchase over-the-counter medication. Most healthcare professionals in Erlangen speak English.

Maps


Eingang
Kleiner Saal
HEINRICH-LADES-HALLE


WC
Kleiner Saal
('B' oral sessions)
Heinrich Lades Halle
Ground floor
(access via Rathausplatz)
Stairs to mezzanine
Main entrance
Großer Saal
('A' oral sessions, symposium, Annual Address, and AGM)
Foyer
Posters, icebreaker & breaks
Registration
Cloakroom
Stairs to mezzanine
Collaborative working space
Vendors & sponsors
Snack bar
Lift
WC
Mezzanine level
(access via stairs or lift)
Stairs to ground floor
Konferenz-räume 3&4
('C' oral sessions)
Chill room
Quiet working space
Lift
2024
ERLANGEN
PALASS ANNUAL MEETING



Key addresses:

1. Heinrich-Lades-Halle, Rathausplatz 2, 91052, Erlangen
2. Redoutensaal, Theaterplatz 1, 91054, Erlangen
3. Geozentrum Nordbayern, Schlossgarten, 91054, Erlangen
4. Universitätsbibliothek, Schuhstrasse 1a, 91052, Erlangen
5. Henkestrasse 91, 91052, Erlangen

Field trip meeting point (FT): Fichtestraße 10, 91054, Erlangen
Train station: Erlangen Hauptbahnhof, 91054, Erlangen
Airport bus stop: Arcaden, 91052, Erlangen

We have curated a Google Maps List featuring key conference sites, local bakeries for lunch-time snacks, and some excellent restaurants. Scan the QR code to see it or use <**https://tinyurl.com/339zhehm**>!

Summary of Schedule

Monday 9th December: pre-conference field-trip and museum visit

Solnhofen Lagerstätte

A one-day pre-conference field-trip will visit the world-famous Jurassic Konservat-Lagerstätte, found in the municipality of Solnhofen, Bavaria. Departing at 07:30, we will travel approximately 100 km south of Erlangen to the quaint and picturesque town of Solnhofen, where delegates will visit the Bürgermeister-Müller-Museum, home to many stunning Jurassic fossils, including examples of the iconic *Archeopteryx*. Delegates will receive a personal tour from the scientific manager of the Museum, Dr Valentina Rosina, with a brief opportunity to explore the town during the lunch break. In the afternoon, delegates will be taken on a tour of a local quarry, with an opportunity to split limestone and search for fossils. As the light begins to fade, delegates will be given a tour of a lithographic limestone factory, before returning to Erlangen at approximately 18:30.

Naturkundemuseum Bamberg (Bamberg Natural History Museum)

The Naturkundemuseum Bamberg is situated in Bamberg's old town in a former Jesuit college and contains both geological and biological exhibits, with the majority of these highlighting local geology, palaeontology and biodiversity from the surrounding areas and across Bavaria, including fossils from the Solnhofen Lagerstätte. One of the main attractions is the stunning Bird Gallery (Vogelsaal), which emerged from a 'Cabinet of Curiosities' (Wunderkammer) dating back to 1810. Delegates will make their own way to Bamberg by train (or car), followed by a short 15-minute walk from the main train station to the Museum. At the Museum, museum director Dr Oliver Wings will take participants on a bespoke guided tour of the historic exhibits and fossil collections. Afterwards, delegates are encouraged to explore the rest of what Bamberg has to offer, including the quaint (and delicious!) Christmas market in the market square and the city's famous smokey beer (Rauchbier).

Tuesday 10th December: workshops, Symposium and icebreaker

The morning of 10th December features four workshops led by specialists from FAU and other institutions across Germany. See below for more details. Registration for workshop participants will be available in the scheduled buildings; this will be communicated in advance by e-mail.

The scientific part of the Meeting will begin with a Symposium entitled 'Extinction'. Registration will be available from 13:00 to 18:00 at the entrance to the Heinrich-Lades-Halle.

Following the Symposium there will be an icebreaker reception from 18:00 to 21:00, also at the Heinrich-Lades-Halle.

Wednesday 11th December: conference, AGM, Annual Address and Annual Dinner

Registration will be open from 08:30 at the Heinrich-Lades-Halle.

The conference will start at 09:00 in the Heinrich-Lades-Halle. Oral presentations will be held in three rooms, all within close proximity. The Annual General Meeting (AGM) will be held at 16:00 followed by the Annual Address at 16:30. Posters will be set up in the foyer of the Heinrich-Lades-Halle where coffee breaks will also be held.

The Annual Dinner will take place on the evening of Wednesday 11th December in the Redoutensaal, a Baroque theatre situated in the centre of Erlangen's Altstadt (old town). Doors open at 18:30. A delicious menu of locally-sourced food will be served, and guests can enjoy a variety of local beers and other non-alcoholic drinks from the cash bar.

Thursday 12th December: conference

Registration will be open from 08:30 at the Heinrich-Lades-Halle.

Talks will begin at 09:00 in the same rooms as those of the previous day. Coffee breaks will be served in the foyer of the Heinrich-Lades-Halle, where posters will be on display. There will be a dedicated poster session in the afternoon (15:15–16:15), during which the usual coffee break refreshments will be available.

Talks will end at 17:30, after which the Conference will close with presentations by the organizing committees of upcoming meetings, the awarding of the President's Prize and the Council Poster Prize, and concluding remarks.

Friday 13th December 2024: post-conference field-trip

Grube Messel (Messel pit)

A one-day post-conference field-trip will visit the iconic Eocene Grube Messel Konservat-Lagerstätte. Leaving at 06:00, we will travel approximately 200 km west of Erlangen to the quarry where we will meet with Dr Krister T. Smith and Dr Sonja Wedmann (Senckenberg Research Institute and Natural History Museum, Frankfurt) who will give attendees a tour of the working Messel pit. Delegates will then visit the associated visitor centre for lunch at the canteen, and an opportunity to have a tour of the special exhibition about Eocene Perissodactyla from the three different sites in Germany by the curator, Philipe Havlik. Afterwards, we will head towards the town of Messel, stopping in at the research station, where Dr Wedmann will showcase the preparation techniques for the fossils found at the site. Upon arrival in the small town of Messel, we will visit the local museum before heading back to Erlangen, returning at approximately 19:30. The number of participants will be limited due to safety considerations, with places allocated on a first-come, first-served basis.

Detailed Schedule

Monday 9th December

Pre-conference field-trip – Solnhofen Lagerstätte (Lead: Thomas Clements).

Pre-conference museum visit – Naturkundemuseum Bamberg.

Tuesday 10th December

Pre-meeting workshops

Participants must be pre-registered as spaces are limited.

09:00 – 12:30 **Fossils in thin section**
Instructors: Axel Munnecke (FAU), Anna Merkel (FAU) and Patrycja Dworczak (FAU)
Venue: Paläoübungsraum, Geozentrum Nordbayern

09:00 – 12:30 **Fossil sampling biases and phylogenetics**
Instructors: Bethany Allen (ETHZ), Laura Mulvey (FAU), Rachel Warnock (FAU) and Joëlle Barido-Sottani (PSL)
Venue: FAU Main Library (Ground floor seminar room)

09:00 – 12:00 **Rotten fossils: Experimental design in taphonomy**
Instructors: Thomas Clements (FAU) and Orla Bath Enright (SMNS)
Venue: Seminar room (ground floor), Geozentrum Nordbayern

09:00 – 12:00 **Deep-time palaeogeography in R**
Instructors: Adam Kocsis (FAU) and Elizabeth Dowding (FAU)
Venue: Palaeo seminar room, Henkestraße 91, Haus 8

Registration

12:00 – 18:00 Heinrich-Lades-Halle

Symposium: 'Extinction'

Großer Saal, Heinrich-Lades-Halle

13:30 – 13:45 Opening remarks and welcome

13:45 – 14:15 **The collapse of biodiversity and restructuring of ecosystem across the Permian–Triassic mass extinction**
Baran Karapunar

14:15 – 14:45 **Inferring extinction rates from phylogenies**
Bethany J. Allen

14:45 – 15:15 **Getting to grips with extinction in the late Ediacaran**
Simon A. F. Darroch

15:15 – 16:00 Tea/coffee break

16:00 – 16:30 **From fossils to forecasts: enhancing conservation with palaeontological records**
Eileen Straube

16:30 – 17:00 **Lessons for crises past and present? Extinction and resilience in Cretaceous-Palaeogene marine ecosystems**
James D. Witts

17:00 – 17:30 **Green Resilience: plants through the end-Permian Mass extinction**
Evelyn Kustatscher

Icebreaker reception

17:30 – 19:30 Heinrich-Lades-Halle

Day 1 schedule, Wednesday 11th December

Conference, AGM, Annual Address and Annual Dinner

Underlined author denotes designated speaker.

*Candidates for the President's Prize are marked with an asterisk.

Session 1A
(Großer Saal) Chair: Ricardo Pérez-de la Fuente

09:00 – 09:15 **Ancient biomolecules confirm the high-altitude origin of fossil woolly rhinoceroses and their cold-adaptations**
Ryan Paterson*, Xiaoming Wang, Mikael Fortelius, Alba Refoyo Martínez, Alberto Taurozzi, Gaudry Troché *et al.*

09:15 – 09:30 **Of bites and dogs: bite simulations in the stem-Canini *Eucyon davisi* and insights on its palaeoecology**
Emanuele Peri, Saverio Bartolini-Lucenti, Lorenzo Rook

09:30 – 09:45 **New insights into marine ray-finned fish evolution: fossil discoveries from the Late Cretaceous and Palaeogene of Egypt**
Sanaa El-Sayed*, Matt Friedman, Hesham Sallam

09:45 – 10:00 **Using methods from computational palaeobiology to elucidate the evolutionary origin of teeth**
Madleen Grohganz*, Antonio Ballell Mayoral, Benjamin Griffin, Humberto G. Ferron, Zerina Johanson, Emily J. Rayfield, Philip C. J. Donoghue

10:00 – 10:15 **Theoretical and functional analysis of insect wings reveals attraction to functionally-adequate not functionally-optimal morphologies**
Yuming Liu*, William J. Deakin, Pablo Milla Carmona, Emily J. Rayfield, Philip C. J. Donoghue

10:15 – 10:30 **Comparing the evolutionary trajectory of bird and bat wing shapes**
Benton Walters*, Philip C. J. Donoghue, Emily J. Rayfield, William Deakin, Yuming Liu

Session 1B
(Kleiner Saal) Chair: Laura Mulvey

09:00 – 09:15 **Combining fossil taxa with and without morphological data improves dated phylogenetic analyses**
Mark Nikolic*, Rachel C. M. Warnock, Melanie J. Hopkins

09:15 – 09:30 **Evaluating the impact and detectability of mass extinctions on total-evidence dating**
Minghao Du*, Joëlle Barido-Sottani

09:30 – 09:45 **Estimating lineage-specific diversification rates on phylogenies**
Bjørn Tore Kopperud*, Sebastian Höhna

09:45 – 10:00 **The timescale of eukaryote evolution estimated from Bayesian modelling of the fossil record**
Ruolin Wu*, Leigh A. Riedman, Davide Pisani, Susannah M. Porter, Philip C. J. Donoghue, Daniele Silvestro

10:00 – 10:15 **Introducing the Early High Disparity Phylogenetic Comparative Model, with Applications to Ichthyosaur Macroevolution**
Ricardo Ely*

10:15 – 10:30 **Revealing patterns of homoplasy in discrete phylogenetic datasets with a new cross-comparable index**
Elizabeth M. Steell*, Allison Hsiang, Daniel J. Field

Session 1C
(Konferenzräume 3&4) – Sponsored by the Palaeontological Society
Chair: Michela Johnson

09:00 – 09:15 **A revision of *Praearcturus gigas* and a critical review of Palaeozoic scorpion gigantism**
Richard J. Howard, Gregory D. Edgecombe, David A. Legg

09:15 – 09:30 **Imputation of missing data for palaeobiological analyses**
Harriet B. Drage

09:30 – 09:45 **Bivalves and brachiopods: direct competitors, ships in the night, or something in between?**
Thomas J. Smith, Erin E. Saupe

09:45 – 10:00 **The role of trait variation in predicting directions of phenotypic evolution during anagenesis and cladogenesis**
Meghan Balk, Kjetil L. Voje

10:00 – 10:15 **Functional overlap shapes the adaptive landscape of cetacean feeding**
Travis Park, Robert J. Brocklehurst, Stephanie E. Pierce, William M. G. Parker, Ellen J. Coombs, Tahlia I. Pollock *et al.*

10:15 – 10:30 **A phylogenetic plesiomorphy zone obscures the early evolutionary history of crown birds**
Juan Benito, Elizabeth M. Steell, Matteo Fabbri, Klara E. Widrig, Bhart-Anjan S. Bhullar, Daniel J. Field

10:30 – 10:55 Break

Session 2A
(Großer Saal) Chair: Lin Na

11:00 – 11:15 **Morphometric and spatial analyses of *Charniodiscus* from the Ediacaran of Newfoundland, Canada**
Princess Aira Buma-At*, Nile Stephenson, Neil Mitchell, Jason Head, Charlotte G. Kenchington, Emily G. Mitchell

11:15 – 11:30 **Developmental biology of *Megaclonophycus* from Ediacaran Weng'an biota**
Kirsten Flett*, Kelsie Cracknell, Johnny C. Yamahuchi, Zongjun Yin, Maoyan Zhu, Philip C. J. Donoghue

11:30 – 11:45 **Predators, zooplankton, and the origins of ecosystem stability**
Euan N. Furness*, Nicholas J. Butterfield, Emily G. Mitchell

11:45 – 12:00 **Basement membrane assembly as a constraint on animal evolution**
Philip B. Vixseboxse*, Sean McMahon, Alexander G. Liu

12:00 – 12:15 **Molecular fossils from the Barents Shelf across the Permian/Triassic boundary in Svalbard**
Stella Zora Buchwald*, Daniel Birgel, Yu Pei, Anja Frank, Monica A. Gomez Correa, Tereza Mosociova *et al.*

12:15 – 12:30 **A time-integrative biomineralization signal reveals templated silica precipitation as a driver of cellular preservation in Phanerozoic stromatolitic fossils**
Liam Olden*, Jasmina Wiemann

Session 2B
(Kleiner Saal) Chair: Lisa Schnetz

11:00 – 11:15 **Neuroanatomy of a new galeaspid from the Silurian of Anhui (China) and implications for the evolution of the vertebrate head**
Xinyuan Meng*, Davide Pisani, Zhikun Gai, Philip C. J. Donoghue

11:15 – 11:30 **Exceptional preservation of soft-tissues in late Palaeozoic amphibians documents terrestrialization and life cycle changes**
Antoine Logghe*, Pierre Gueriau, François Clarac, Jean-Sébastien Steyer, Sophie Sanchez

11:30 – 11:45 **CT-based re-evaluation of the anatomy and phylogeny of the trematopid *Rotaryus gothae***
Lena Schmitz*, Mark J. MacDougall, Jörg Fröbisch

11:45 – 12:00 **Potential evidence of salt glands in extinct gharial crocodylians provides support for transoceanic dispersal in Gavialoidea**
Paul Burke*, Carly Pligersdorffer, Sophie Boerman, Gwendal Perrichon, Jeremy Martin, Thierry Smith *et al.*

12:00 – 12:15 **Body size evolution of Caimaninae (Crocodylia, Alligatoroidea) and the influence of climate**
Ana Laura Paiva*, Pedro Godoy, Emma Dunne, Alexander Farnsworth, Paul Valdes, Daniel Lunt *et al.*

12:15 – 12:30 **Analyses of morphological variation in the early sauropodomorph dinosaur *Plateosaurus trossingensis* using 3D geometric morphometrics**
Joep Schaeffer*, Rémi Lefebvre, Rainer R. Schoch

Session 2C
(Konferenzräume 3&4) Chair: Joëlle Barido-Sottani

11:00 – 11:15 **'Phylogeochemistry': can trace elements inform belemnite evolutionary relationships?**
Alexander Pohle, Kevin Stevens, René Hoffmann, Adrian Immenhauser

11:15 – 11:30 **Modelling among-character rate variation with the Mkv model: lessons learned and perspectives for morphological phylogenetics**
Alessio Capobianco, Sebastian Höhna

11:30 – 11:45 **Selecting genes for phylogenetic analysis based on the geometry of gene-treespace**
Xiumei Lu

11:45 – 12:00 **Nothing but the tooth? A total evidence approach to the elasmobranch tree of life**
Richard Dearden, Zerina Johanson, Martin Rücklin

12:00 – 12:15 **Unravelling ancient sharks and rays: phylogenetic insights into the Late Jurassic and Early Cretaceous neoselachians**
Eduardo Villalobos Segura, Sebastian Stumpf, Manuel Amadori, Arnaud Begat, Patrick L. Jambura, Julia Türtscher, Jürgen Kriwet

12:15 – 12:30 **Late Triassic drepanosauromorphs and the paraphyly of bird-headed reptiles (Diapsida: 'Avicephala')**
Valentin Buffa, Eberhard Frey, Jean-Sébastien Steyer, Michel Laurin

12:30 – 13:45 Lunch + Events

Session 3A

(Großer Saal) Chair: Hannah Byrne

14:00 – 14:15 **The experimental effects of wave processes on arthropod taphonomy: implications for Lagerstätten and small carbonaceous fossils (SCFs)**
Laura Devine*, Nicholas Minter

14:15 – 14:30 **Understanding activity patterns in ancient birds and mammals using eye melanosomes**
Beatriz Carazo del Hoyo*, Aaron Quigley, Daniel Cirtina, Catherine McCarney, Jane Brennan, Soudeh Ziapour Razlighi, Maria E. McNamara

14:30 – 14:45 **Selective preservation of coleoid soft tissues in Lebanese Lagerstätten Deposits**
Alison Rowe*

14:45 – 15:00 **Changes in redox potential during decay: insights into the preservation of Cambrian animals**
Nora Corthésy*, Allison C. Daley, Jonathan B. Antcliffe, Farid Saleh

15:00 – 15:15 **Decay experiments and the preservation potential of marine algae in the fossil record**
Rut Mayo de la Iglesia*, Farid Saleh, Jonathan B. Antcliffe, Pierre Gueriau, Allison C. Daley

15:15 -15:30 **Thermal taphonomy experiments challenge ultrastructural preservation in the Chengjiang yunnanozoans**
Kaiyue He*, Jian Han, Jianni Liu, Qiang Ou, Giovanni Mussini, Mike Reich, Degan Shu

Session 3B

(Kleiner Saal) Chair: Kat Jordan

14:00 – 14:15 **Cuticle ultrastructure of the Early Devonian trigonotarbid arachnid *Palaeocharinus***
Emma J. Long*, Gregory D. Edgecombe, Paul Kenrick, Xiaoya Ma

14:15 – 14:30 **Moulting and development in a freshwater prawn from the Late Cretaceous of Morocco**
Sinéad Lynch*, Pierre Gueriau, Harriet B. Drage, Didier B. Dutheil, Sylvain Charbonnier, Allison C. Daley

14:30 – 14:45 **The ichnological optimum: evaluating spatial patterns in the Cambrian trace fossil record as a function of ecology, sedimentation, and outcrop**
Yorick Veenma*, Neil Davies, Anthony Shillito

14:45 – 15:00 **A global comparison of functional trait extinction selectivity across the rapid climatic change of the Pliocene–Pleistocene transition**
Sarah Gale*, Katie Collins, Stewart Edie, David Jablonski, Shan Huang

15:00 – 15:15 **The oldest record of *Seebachia bronni*, type species of Seebachia (Bivalvia: Astartidae), from the late Tithonian (Jurassic) of Kutch, India, and its palaeobiogeographic and evolutionary implications**
Ranita Saha*, Shubhabrata Paul, Shiladri Das, Subhendu Bardhan

15:15 – 15:30 **New fossil evidence from the Shibantan Lagerstätte of South China illuminates the Ediacaran–Cambrian transition**
Xiaopeng Wang, Zhe Chen, Shuhai Xiao, Chuanming Zhou, Chengxi Wu, Yarong Liu *et al.*

Session 3C
(Konferenzräume 3&4) Chair: Stephan Spiekman

14:00 – 14:15 **Crushing 3D-printed ammonites to study the relationship between curvature and failure**
Robert Lemanis, Erynn Johnson, David Peterman, Karsten Tittmann

14:15 – 14:30 **Ecological disparity of extinct flying vertebrates; did birds compete with pterosaurs?**
Jordan Bestwick, Thomas Stubbs, Case Miller, Rodrigo Pêgas, Torsten Scheyer

14:30 – 14:45 **Sensory reconstruction of the early Miocene lorisid *Mioeuoticus* (Strepsirrhini, Primates): behavioural and evolutionary implications**
Holly Anderson, Adam Lis, Ingrid Lundeen, Mary Silcox, Sergi López-Torres

14:45 – 15:00 **Evolution of growth in alligators and caimans informed by osteohistology of the Eocene alligatoroid *Diplocynodon hantoniensis***
Devin Hoffman, Erika Goldsmith, Alexandra Houssaye, Susannah C. R. Maidment, Ryan N. Felice, Philip D. Mannion

15:00 – 15:15 **Osteosclerotic bone in a Spinosaurus vertebra supports an aquatic mode of life**
Susannah C. R. Maidment, Zichuan Qin, Kathleen N. Dollman, Richard J. Butler

15:15 – 15:30 **Bird's stomach stones and other contents from "the dinosaur's great viscera" at Howe Quarry**
Emanuel Tschopp, Carl Mehling, Ulrich Kotthoff, Stefanie Kaboth-Bahr

15:30 – 15:55 Break

Annual General Meeting

(Großer Saal)

16:00 – 16:30 **Annual General Meeting**. The agenda and papers pertaining to the AGM can be found in *Palaeontology Newsletter* **116**, available under the Publications tab on the Association website.

Annual Address

(Großer Saal)

16:30 – 17:30 **Fossils of the future: how palaeontological thinking can help predict humanity's legacy on Earth**
Sarah E. Gabbott, University of Leicester, UK

Annual Dinner

(Redoutensaal, Altstadt)

18:30 onwards Annual Dinner

Day 2 schedule, Thursday 12th December

Session 4A

(Großer Saal) Chair: John Clarke

09:00 – 09:15 **Evolution and development of early chondrichthyan teeth: Histological observations from three Devonian key taxa from Morocco**
Merle Greif*, Héctor Botella, Torsten, M. Scheyer, Christian Klug

09:15 – 09:30 **Born for greatness: on the origin and body size evolution of lamniform sharks (Chondrichthyes; Elasmobranchii)**
Patrick L. Jambura*, Julia Türtscher, Eduardo Villalobos-Segura, Manuel A. Staggl, René Lauer, Bruce Lauer *et al.*

09:30 – 09:45 **From peak to decline: the story of Cenozoic neoselachian diversity**
Manuel Andreas Staggl*, Eduardo Villalobos-Segura, Michael J. Benton, Jürgen Kriwet

09:45 – 10:00 **Deeper than Bolca: the Ypresian fish-bearing Fossil-Lagerstätte of Sòlteri (Trento, northern Italy) and its faunal content**
Pietro Calzoni*, Luca Giusberti, Giuseppe Marramà, Alessandro Garassino, Giovanni Pasini, Eliana Fornaciari *et al.*

10:00 – 10:15 **The oldest three-dimensionally preserved actinopterygian hearts: soft tissue preservation in a stem teleost**
Sophie Fasey*, Jake Atterby, Rodrigo T. Figueroa, Matt Williams, Sam Giles

10:15 – 10:30 **Diversity and biogeography of Old-World killifish from the Oligocene until today**
Andrea Herbert Mainero*, Bettina Reichenbacher

Session 4B
(Kleiner Saal) Chair: Alison Rowe

09:00 – 09:15 **Was palaeolake Messel a death-trap? Insight from machine learning, modern bat drownings and decay experiments**
Krister T. Smith, Renate Rabenstein, Joy O'Keefe

09:15 – 09:30 **Unusual early diagenetic preservation of an Oligocene whale bone as compared to other marine mammals from Hokkaido, Japan revealed by molecular taphonomy**
Raman Umamaheswaran, Takuto Ando, Tatsuya Shinmura, Ken Sawada

09:30 – 09:45 **The enigma of Mother's Day: exploring the taphonomy of porous *Diplodocus* scales**
Tess Gallagher, Michael Pittman, Tom Kayes, Jason Schein

09:45 – 10:00 **The Upper Triassic dinosaur beds of Trossingen, Germany: taphonomy of a mega-scale fossil Lagerstätte**
Eudald Mujal, Joep Schaeffer, Orla G. Bath Enright, Samuel L. A. Cooper, Volker Neipp, Rainer R. Schoch

10:00 – 10:15 **Synchrotron X-ray tomography sheds light on the anatomy and the phylogenetic affinities of the enigmatic Thylacocephala**
Thomas Laville, Marie-Béatrice Forel, Sylvain Charbonnier

10:15 – 10:30 **A facilitated grouped access route for major-to-trace elemental mapping and speciation of flat fossils at the PUMA beamline of the SOLEIL synchrotron, France**
Pierre Gueriau, Sebastian Schöder

Session 4C
(Konferenzräume 3&4) Chair: Lewis Jones

09:00 – 09:15 **Climate change drives neoselachian extinctions over geological timescales**
Gregor Mathes, Daniele Silvestro, Kristína Kocáková, Jaime Villafaña, Catalina Pimiento

09:15 – 09:30 **The out-of-place 'Lilliput effect': a case in Ostracoda (Crustacea) from the Pebas Mega-wetland (Miocene of Western Amazonia)**
Andres Felipe Salazar-Rios, Martin Gross, Maria Belen Zamudio, Werner E. Piller

09:30 – 09:45 **Coupling of climate and biosphere dynamics in the Ediacaran Period**
Thomas W. Wong Hearing, Mark Williams, Thomas H. P. Harvey, Alexandre Pohl, Alexander G. Liu, Lin Na *et al.*

09:45 – 10:00 **Phanerozoic ocean biogeochemistry and marine biodiversity in space and time**
Richard G. Stockey, Benjamin Mills, Erin E. Saupe, Pam Vervoort, Pedro Monarrez, Alison Cribb *et al.*

10:00 – 10:15 **Lateglacial to Holocene climate changes in the Upper Lena Region of Eastern Siberia inferred from a multi-component stable isotope analysis**
Jana Gliwa, Franziska Kobe, Pascal Olschewski, Svetlana Kostrova, Aleksandr A. Shchetnikov, Aleksandra I. Krikunova *et al.*

10:15 – 10:30 **Do ecological communities age?**
Björn Kröger, Alexis Rojas

10:30 – 10:55 Break

Session 5A
(Großer Saal) Chair: Alex Dunhill

11:00 – 11:15 **Effects of cryptic diversity on diversification dynamics analyses in Crocodylia**
Gustavo Darlim*, Sebastian Höhna

11:15 – 11:30 **Time-integrated biosignatures applied to new fossils combined with genomic evidence suggest an archosaurian origin of avian endothermy**
Megan Miller*, Jasmina Wiemann

11:30 – 11:45 **Triassic Temnospondyls of the Central European Basin: biogeography, diversity and ecological insights**
Raphael Moreno*

11:45 – 12:00 **Exceptional preservation of the brain and radiation of the jawed vertebrates**
Alicia Sánchez Gimeno*, Karim Benzerara, Mathieu Thoury, Pierre Gueriau, Gaël Clément, Alan Pradel

12:00 – 12:15 **An ecological network for the Dinosaur Provincial Park biota and its vicinity in Late Cretaceous (Campanian) Canada**
Alexandre Demers-Potvin*, Hans C. E. Larsso

12:15 – 12:30 **From Darwin finches to giant pterosaurians – using geometric morphometrics to attempt reconstructing flying ornithodiran feeding ecology in deep time**
Joshua Gauweiler*, Florian Braig, Carolin Haug, Joachim T. Haug, Marie K. Hörnig

Session 5B
(Kleiner Saal) Chair: Andrej Spiridonov

11:00 – 11:15 **Biogeographic shifts driven by faunal turnover during the Ordovician–Silurian transition**
Shasha Liu, Qijian Li, Lin Na, Wolfgang Kiessling

11:15 – 11:30 **Exploring phenotypic evolution as a consequence of changes in the adaptive landscape across lineages and timescales**
Marion Thaureau*, Kjetil L. Voje

11:30 – 11:45 **Testing the fossil record of early animal evolution: regional versus global signals**
Lara J. Uttinger*, Ben Slater

11:45 – 12:00 **Palaeozoic marine latitudinal diversity gradients were regulated by plate tectonics, climate change, and genus-specific traits**
Die Wen*, Junxuan Fan, Lewis A. Jones, Philip D. Mannion

12:00 – 12:15 **Linking form, function and environment across the last 30,000 years of evolution in island lizard *Podarcis pityusensis***
Stephanie Woodgate*, Josep A. Alcover, Ana Pérez-Cembranos, Valentín Pérez-Mellado, Alistair R. Evans, Johannes Müller

12:15 – 12:30 **The fate of South America's endemic mammalian fauna in response to the most dramatic Cenozoic climate disruption**
Lucas Buffan*, Fabien L. Condamine, Narla S. Stutz, François Pujos, Pierre-Olivier Antoine, Laurent Marivaux

Session 5C
(Konferenzräume 3&4) Chair: Gemma Benevento

11:00 – 11:15 **Fin(e) tuning echoes from the past – should *Albertocetus meffordorum* (Odontoceti: Xenorophidae) have practised his scales?**
Mickaël J. Mourlam, Rachel A. Racicot

11:15 – 11:30 **New insights into *Wamradolops*, an enigmatic metatherian from the Palaeogene of Peruvian Amazonia**
Narla Stutz, Laurent Marivaux, François Pujos, Ana M. Ribeiro, Aldo Benites-Palomino, Rafael Varas-Malca *et al.*

11:30 – 11:45 **A new perspective on reduced squamation in Pachycormidae (Actinopterygii)**
Erin E. Maxwell, Samuel L. A. Cooper, Giovanni Serafini, Günter Schweigert

11:45 – 12:00 **Coding confidence in taxonomic identification as metadata for large databases and shareable resources**
Omar Rafael Regalado Fernandez

12:00 – 12:15 **Cohabitation patterns in Cretaceous chondrichthyan ecogroups**
Emma Nicholls

12:15 – 12:30 **Occupancy modelling as a novel approach for conservation palaeobiology**
Christopher D. Dean, Philip D. Mannion

12:30 – 13:45 Lunch + Events

Session 6A
(Großer Saal) Chair: Phil Jardine

14:00 – 14:15 **A surge of malformed chitinozoans accompanies the onset of the Ireviken Event**
Iris Vancoppenolle*, Poul Emsbo, Patrick I. McLaughlin, Mikael Calner, Thijs R. A. Vandenbroucke

14:15 – 14:30 **Fossil biomolecules illuminate biological affinities of enigmatic acritarchs**
Pjotr Meyvisch*, Viktoria Baranyi, Ferenc Borondics, Manuel Bringué, Vânia Correia, Robert A. Fensome *et al.*

14:30 – 14:45 **Stratigraphic trends in chitinozoan teratology across the Silurian Mulde Event in the distal Baltic Basin (Gotland, Sweden)**
Carolina Klock*, Mikael Calner, Patrick I. McLaughlin, Poul Emsbo, Thijs R. A. Vandenbroucke

14:45 – 15:00 **The oldest phloem: uncovering the history of sugar transport in the early Devonian Rhynie chert**
Laura Cooper*, Alexander J. Hetherington

15:00 – 15:15 **Diet change and potential larval development in Late Devonian conodont**
Przemysław Świś, Paweł Bącal, Tomasz Szczygielski, Sergi López-Torres

Session 6B
(Kleiner Saal) Chair: Danijela Dimitrijevic

14:00 – 14:15 **Extinction vulnerability of foraminiferans of differing body sizes**
Yan Feng*, Lee Hsiang Liow, Haijun Song

14:15 – 14:30 **Long-term patterns of the prey–predator interaction in the Late Cretaceous brachiopods of Ariyalur, India**
Arghya Poddar*, Adrish Mahata, Shubhabrata Paul, Debahuti Mukherjee, Arkaprava Mukhopadhyay, Debarati Chattopadhyay

14:30 – 14:45 **Metacommunity structural changes of Antarctic invertebrates over the latest Maastrichtian (72.1 to 66 Ma)**
Tasnuva Ming Khan*, Rowan J. Whittle, James D. Witts, Huw J. Griffiths, Andrea Manica, Emily G. Mitchell

14:45 – 15:00 **Contrasting ecological selectivity patterns of the end-Permian and end-Triassic mass extinctions suggested from Bayesian analysis of marine invertebrates**
Lewei Su*, Zhen Guo, Zhong-Qiang Chen, Wolfgang Kiessling

15:00 – 15:15 **Adaptive response of shallow-marine ostracods during the Permian–Triassic climate crisis**
Monica Alejandra Gomez Correa*, Christoph Bonow, Jana Gliwa, Dieter Korn, Evelyn Kustatscher, Herwig Prinoth *et al.*

Session 6C
(Konferenzräume 3&4) Chair: Jane Reeves

14:00 – 14:15 **Optimality analyses of hydrodynamic performance refute hypotheses of ecospace saturation during the early evolution of vertebrates**
Antonio Ballell Mayoral, Elsa Leflaëc, Oscar Sanisidro, Humberto G. Ferrón

14:15 – 14:30 **3D imaging the head and tail of a complete Devonian jawless fish**
Lisa Schnetz, Agnese Lanzetti, Andy S. Jones, Richard P. Dearden, Stephan Lautenschlager, Sam Giles *et al.*

14:30 – 14:45 **Functional and ecological determinants of the internal architecture of avian wing bones**
Fabio Alfieri, Oliver E. Demuth, Elizabeth M. Steell, Anne-Claire Fabre, Daniel J. Field

14:45 – 15:00 **The extended 'common cause': links between punctuated evolution and sedimentary processes**
P. David Polly

15:00 – 15:15 **Transitions and multistability in macroevolutionary dynamics of large mammals**
Simona Bekeraitė, Robertas Stankevič, Kristian Agasoster Haaga, Ivona Juchnevičiūtė, Andrej Spiridonov

15:15 – 16:10 Poster Session

Session 7A
(Großer Saal) Chair: Juan Benito Moreno

16:15 – 16:30 **A humerus perspective on the evolution of early moles (Mammalia, Talpidae)**
Eli Amson, Daisuke Koyabu, Stanislav Čermák, Quentin Martinez

16:30 – 16:45 **A diverse vertebrate fauna from the Middle to Late Pleistocene of eastern Sudan**
Faysal Bibi, Brian Kraatz, Robert Bussert, Anne Delagnes, Sumiko Tsukamoto, Marianne Brasil *et al.*

16:45 – 17:00 **Determining the relative scientific and cultural 'values' of *in situ* dinosaur track sites in the UK**
Richard J. Butler, Kirsty M. Edgar, Jonathan Larwood, Joshua Smith

17:00 – 17:15 **Amniote traits and terrestriality in an early amphibian**
Michael I. Coates, Benjamin Otoo, Abigail Caron, Kristen Tietjen, Marcello Ruta

17:15 – 17:30 **Innovation in chondrocranial morphogenesis underpins the origin of the avian beak**
Matteo Fabbri

Session 7B
(Kleiner Saal) Chair: Mark Patzkowsky

16:15 – 16:30 **Top 10 disparity metrics you can use; number 10 will surprise you!**
Thomas Guillerme

16:30 – 16:45 **Extinction magnitude within the graptoloid clade**
James Crampton, Michael Foote, Peter Sadler

16:45 – 17:00 **Convergent evolution and ecological substitution: a quantitative morphological approach**
Carolin Haug

17:00 – 17:15 **Comparison of model-based predictions of body size and body proportions with empirical data reveals differential sets of growth rate parameters across trilobites**
Melanie J. Hopkins

17:15 – 17:30 **The structure of the marine carbonate record: implications for reconstructing evolutionary processes**
Emilia Jarochowska, Niklas Hohmann, Johan Hidding, Xianyi Liu, Charlotte Summers, Hanno Spreeuw *et al.*

Session 7C
(Konferenzräume 3&4) Chair: Thomas Clements

16:15 – 16:30 **Origin of fabric-retentive irregular calcite (FRIC) in stromatoporoids**
Patrycja Dworczak, Steve Kershaw, Axel Munnecke

16:30 – 16:45 **Investigating global plate models and diversity metrics to decipher the spatio-temporal evolution of Cambrian echinoderms**
Pauline Guenser, Léa Tremeau, Melly Lauze, Claude Monnet, Elise Nardin, Martina Nohejlová, Bertrand Lefebvre

16:45 – 17:00 **New taxa and palaeoecological insights from the latest Ediacaran Aar Member of southern Namibia**
Alexander G. Liu, Elkan Utoni, Buck Blake, Brennan O'Connell, William J. McMahon, Catherine E. Boddy *et al.*

17:00 – 17:15 **Clingin' to Nusplingen: morphological and microstructural analysis of microbes and biofilm associated with soft tissue in the Nusplingen Lagerstätte of SW Germany**
Orla G. Bath Enright, Thomas Clements, Brianne Palmer, Julien Kimmig, Sabina Karačić, Pierre Gueriau, Günter Schweigert

17:15 – 17:30 **Colonial green algae in the Cambrian plankton: 'acritarchs' shaped by animal grazing**
Thomas H. P. Harvey

Closing business

(Großer Saal)

17:30 – 18:00 Presentations from organising committees for PalAss 2025 and ProgPal 2025

18:00 – Presentation of awards and closing remarks

Friday 13th December

Post-conference field-trip – Messel Lagerstätte (Lead: Thomas Clements)

Annual Address

The Annual Address will be given on Wednesday 11th December in Großer Saal, starting at 16:30.

Fossils of the future: how palaeontological thinking can help predict humanity's legacy on Earth

Prof. Sarah E. Gabbott
University of Leicester, UK

As palaeontologists we aim to understand past life through investigation of the fossil record. To do so we must read it correctly: taking into account a myriad of processes that have affected the make-up of the fossil archive. For example, we consider how depositional environment, sediment composition and taphonomy interact to determine what taxa are preserved, and how they are expressed as fossilized remains. In this talk I will argue that palaeontological thinking has a critical role to play in predicting the nature of the future fossil legacy that humanity will leave on Earth, and how that might help us to mitigate this legacy now. To demonstrate this new conceptual approach I will show that taphonomy can be applied to modern materials, and in particular to plastics, to predict their preservation potential. Controlled laboratory experiments, using similar research design principles to those in 'decay experiments', have provided us with data to predict the near-future fate of plastics. And to extend our understanding over millions of years, we have drawn on the fossil record of algae and macroplankton that are composed of polymer-like biomolecules. That such fossils survive in rocks 400 million years old should be a call to action for us – and for policy-makers. Humanity is producing and discarding plastics, and other materials destined to be technofossils, in ever increasing amounts. The occurrence and abundance of plastics in the environment is now recorded across many thousands of research papers: we know where plastics end up (everywhere) and in what quantities (a lot). But it is the application of the science of palaeontology that can provide us with the long view, offering robust evidence that helps reveal the ultimate fate of plastics, and of the other materials that our global industrial society makes and discards so freely.

Abstracts of Symposium presentations

Extinction

Tuesday 10th December in Großer Saal, Heinrich-Lades-Halle, from 13; 30 to 17:30.

talks

Inferring extinction rates from phylogenies

Bethany J. Allen
ETH Zürich, Switzerland
(Großer Saal, 14:15–14:45)

Determining the timing of extinction events is difficult. First, the incompleteness of the fossil record means that the youngest fossil of a species must predate, by an uncertain amount, the extinction of that species. Second, abundant genetic data have led to the widespread inference of phylogenies containing only extant taxa, but these phylogenies do not contain extinction events, and whether these phylogenies can be used to infer extinction rates has been fiercely debated. However, phylogenies containing both living and extinct tips can combine evidence from genetic data and the fossil record. When inferred using a model that incorporates speciation, extinction and sampling in a mechanistic fashion, such phylogenies may allow us to accurately infer extinction rates through time. To demonstrate this, I simulated the evolution of clades using a fossilized birth–death skyline model, under which speciation, extinction and fossilization rates change through time in a piecewise-constant manner. I then used the same model to infer extinction rates through time for these simulated clades based on a variety of subsets of the simulated data. These results demonstrate the power of phylogenies containing fossils in allowing us to infer extinction rates through time.

Getting to grips with extinction in the late Ediacaran

Simon A. F. Darroch[1], Matthew Craffey[2] and Peter J. Wagner[2]
[1]Senckenberg Institute and Museum of Natural History, Germany; [2]University of Nebraska-Lincoln, USA
(Großer Saal, 14:45–15:15)

The late Neoproterozoic history of complex life is marked by one or more intervals of biotic turnover. While some workers see these as a natural consequence of evolutionary dynamics near the base of a diversifying metazoan tree, others have interpreted them as extinction events, hypothesizing a variety of different abiotic and biotic drivers. Despite recent and focused work on this interval, including new fossil discoveries and improving geochronology, the fundamental question remains: is the late Ediacaran marked by one or more short-lived pulses of elevated extinction? Answering this question is crucial to understanding the character of the Ediacaran–Cambrian transition and – potentially – drivers of the Cambrian explosion. Here we use a Bayesian method for accommodating uncertainty in first and last appearance dates to compile revised stratigraphic ranges for fossil groups emerging over the late Ediacaran. We use these to produce new estimates of origination and extinction, present quantitative evidence for turnover pulses

at the end of all three Ediacaran 'assemblages', and assess the temporal overlap with several hypothesized sources of ecological stress. Lastly, we contrast our global-scale signals with a regional and field-based case study, highlighting outstanding questions and opportunities for targeted work in community palaeoecology.

The collapse of biodiversity and restructuring of ecosystems across the Permian–Triassic mass extinction

Baran Karapunar
University of Leeds, UK
(Großer Saal, 13:45–14:15)

The Permian–Triassic mass extinction (PTME) was the largest biotic crisis recorded in Earth's history and significantly altered the composition and structure of marine communities. However, there are few continuous fossiliferous sections across the PTME, and changes in trophic structure have not been investigated extensively. New data from Türkiye show an abrupt shift in community composition from the domination of the Palaeozoic evolutionary fauna (brachiopods, echinoderms, bellerophontids) in the Changhsingian to the domination of modern evolutionary fauna (bivalves, modern gastropods) in the Induan–Olenekian. Additionally, analysis of trophic structure of communities from the equatorial palaeolatitudes (Dolomites, Italy; Meishan, China) reveal common phenomena in post-extinction communities: increase in mean trophic level and lower levels of competition. The increase in mean trophic level is even more pronounced in faunas from northern (Greenland, Siberia) and southern mid palaeo-latitudes (Kashmir, Tibet), suggesting that the PTME affected higher trophic levels less. Despite the loss of many species and ecological guilds, communities did not collapse and sustained multiple trophic levels. The selective extinction of lower trophic levels during the PTME turned communities into "inverse trophic pyramids" in extreme cases, contrary to previous presumptions stating truncation of higher trophic levels across the extinction event and stepwise bottom-up recovery.

Green Resilience: plants through the end-Permian Mass extinction

Evelyn Kustatscher[1,2,3]
[1]Museum of Nature South Tyrol, Italy; [2]Ludwig-Maximilians-Universität München, Germany; [3]Bayerische Staatssammlung für Paläontologie und Geologie, Munich, Germany
(Großer Saal, 17:00–17:30)

The Permian–Triassic transition has long been recognized as the most severe extinction event for marine invertebrates, but its impact on terrestrial ecosystems, especially plants, remains debated. Studies have provided conflicting conclusions. Integrated global occurrence data from plant macrofossils and microfossils challenge the prevailing view of a mass extinction among plants. Discrepancies between gymnosperm macrofossil and microfossil records highlight taphonomic biases, particularly in the Early Triassic, giving a false impression of higher extinction rates. While marine invertebrates faced up to 96% species loss, plant records – especially for gymnosperms – show a more gradual transition. Regional variations in fossil abundance suggest a locally significant terrestrial crisis, but not one that was synchronous or as severe as previously thought. The apparent

drop in plant diversity during the Early Triassic likely reflects taphonomic bias and regional responses rather than true extinction. Our findings suggest diachronous regional extirpations, driven by environmental changes like rising CO_2 levels, shaped the gradual recovery of terrestrial ecosystems after the Permian–Triassic event.

From fossils to forecasts: enhancing conservation with palaeontological records

Eileen Straube
University of Bayreuth, Germany
(Großer Saal, 16:00–16:30)

The palaeontological record offers an extensive archive of insights into patterns and processes of past extinction events. Understanding these patterns is crucial, especially in the face of the current biodiversity crisis. This unique long-term perspective can help us understand the resilience and vulnerability of organisms and ecosystems to environmental stressors. Here, I illustrate how palaeontological analyses can deepen our understanding of extinction processes. Specifically, I show how we can use the marine fossil record, with information on geographic range and organismal traits, to inform effective conservation approaches. Through integrating palaeontological data in modern conservation studies, we can enhance predictive models and create strategies to address contemporary environmental challenges. I further show how amber can provide insights into terrestrial ecosystems in times of ecological crisis. By using such lessons from Earth's history, palaeontology can contribute crucial information to navigate the ongoing biodiversity crisis and preserve the health and stability of our planet's ecosystems.

Lessons for crises past and present: extinction and resilience in high latitude Cretaceous–Palaeogene (K–Pg) marine ecosystems

James D. Witts
Natural History Museum, London, UK
(Großer Saal, 16:30–17:00)

The Cretaceous-Palaeogene (K–Pg) boundary 66 million years ago coincides with the most recent of the 'Big Five' Phanerozoic mass extinction events. Up to 76% of marine species disappeared alongside evidence linking the extinction to rapid environmental change following the Chicxulub bolide impact in the Gulf of Mexico, although there remains debate as to the role Deccan Traps Large Igneous Province (LIP) volcanism may have played. The excellent global fossil record of the K–Pg extinction and recovery allows examination into how severe environmental perturbations affect organisms and ecosystems across different oceanographic settings. In this talk, I will present data from new quantitative field study of the highest southern latitude onshore K–Pg boundary succession on Seymour Island, Antarctica (65°S), along with records from ODP Site 690 in the Weddell Sea (also 65°S). These sites, which represent deposition on a shallow marine shelf and in an open-ocean deep-sea environment, reveal the extent of ecological change and importance of morphological plasticity for promoting survival across this mass extinction. They also suggest that trait changes across the K–Pg occur at different times in different environmental settings and taxonomic groups, supporting the hypothesis that environmental heterogeneity plays an important role in modulating resilience to perturbation.

Abstracts of oral presentations

Functional and ecological determinants of the internal architecture of avian wing bones

Fabio Alfieri[1,2], Oliver E. Demuth[2,3], Elizabeth M. Steell[4], Anne-Claire Fabre[1,5,6], Daniel J. Field[2,6,7]
[1]Universität Bern, Switzerland; [2]University of Cambridge, UK; [3]Liverpool John Moores University, UK; [4]University College London, UK; [5]Naturhistorisches Museum der Burgergemeinde, Bern, Switzerland; [6]Natural History Museum, London, UK; [7]Museum of Zoology, University of Cambridge, UK

Bird bones represent an ideal study system in evolutionary morphology, the clade being one of the most diverse in vertebrates in terms of taxonomy, ecology, development, phenotype and body size. This is especially true concerning bones involved in flight, such as wing bones, since flight acquisition represented a key event in bird diversification. Accordingly, several analyses elucidated the role of ecology, allometry, ontogeny and phylogeny in the evolution of bird wing bones, mostly focusing on external morphology. Similar analyses of the bone internal structure were rarely undertaken despite the potential of the inner structure to reveal how disparate factors, especially ecological ones, influence phenotypic evolution. We performed the first macroevolutionary study of the internal structure of bird wing bones, *i.e.*, humerus and ulna, to understand how ecology, phylogeny and allometry relate to this anatomical level. To characterize ecological diversity, we accounted for biomechanical aspects related to flight styles and ecological factors, related to lifestyle and habitat. Preliminary results suggest the primary role of body mass in explaining bird wing-bone inner structure diversity, while minor factors related to extreme ecological adaptations are present. These results can be used to infer palaeobiology in extinct bird species by studying their wing elements' fossil remains.

Day 2, Session 6C, Konferenzräume 3&4, 14:30 – 14:45
Recording allowed: Yes

A humerus perspective on the evolution of early moles (Mammalia, Talpidae)

Eli Amson[1], Daisuke Koyabu[2], Stanislav Čermák[3], Quentin Martinez[1]
[1]Staatliches Museum für Naturkunde Stuttgart, Germany; [2]University of Tsukuba, Japan; [3]Institute of Geology of the Czech Academy of Sciences, Prague, Czechia

Moles (Mammalia, Talpidae) are commonly considered the quintessential subterranean mammals. However, this family includes subgroups with diverse lifestyles, such as ambulatory (shrew-like moles), semi-fossorial (*e.g.* shrew-moles), and amphibious species (desmans and star-nosed moles). These varying lifestyles are associated with different degrees of specialization in the forelimb bones, especially the humerus. The evolutionary transitions in talpid lifestyles are nevertheless poorly understood, with both subterranean and amphibious adaptations currently hypothesized as diphyletic. Here we re-evaluate the systematics of key extinct talpids for which the humerus is available. We also conducted high-resolution CT scans of the humeri from most extant talpids, along with these fossil specimens and other terrestrial mammals, to quantify their bone microanatomy. We found that the humeral diaphysis of extant, amphibious talpids is more compact (osteosclerotic) compared to other members of the family and terrestrial eulipotyphlans.

This likely reflects an adaptation known as bone mass increase (BMI), commonly seen in shallow-diving tetrapods. Interestingly, the humeral microanatomy of several fossil talpids also exhibits high bone compactness, suggesting that these species were amphibious as well. Given their revised phylogenetic placement, this finding challenges the hypothesis of an early aquatic phase in talpid evolution.

Day 2, Session 7A, Großer Saal, 16:15 – 16:30
Recording allowed: Yes

Sensory reconstruction of the early Miocene lorisid *Mioeuoticus* (Strepsirrhini, Primates): behavioural and evolutionary implications

Holly Anderson[1], Adam Lis[1], Ingrid Lundeen[2], Mary Silcox[3], Sergi López-Torres[1]
[1]University of Warsaw, Poland; [2]City University of New York, USA; [3]University of Toronto Scarborough, Canada

The evolutionary history of lorises and pottos (family Lorisidae) potentially dates back to the late Oligocene of Namibia, but a later moderate diversification of this family occurred during the Miocene of Africa and Asia. In the African Miocene, the family Lorisidae is represented solely by one genus: *Mioeuoticus*. The phyletic position of *Mioeuoticus* has been a source of debate, as it has been suggested to belong to either the stem of the family Lorisidae or be further nested within lorisids, as a sister to the African potto clade (subfamily Perodicticinae). Reconstructing the internal sensory anatomy of this specimen could shed light on this debate and possibly clarify how modern lorisoid olfactory, visual sensitivity, and locomotor abilities evolved. Here we collected data from the nasal turbinals, bony labyrinths, and orbits of *Mioeuoticus shipmani* (KNM-RU 2052), from the early Miocene of Rusinga Island, Kenya. The results are consistent with *Mioeuoticus* having developed typical modern lorisid behaviour (*i.e.* slow locomotion, nocturnal activity pattern) and olfactory abilities consistent with modern representatives. However, the arrangement of the nasal turbinals showing an intermediate state between lemuroids and lorisoids is more consistent with a basal position of *Mioeuoticus* within the family Lorisidae or even the superfamily Lorisoidea.

This research was financially supported by National Science Centre Grant 2022/45/NZ8/03585.

Day 1, Session 3C, Konferenzräume 3&4, 14:30 – 14:45
Recording allowed: No

The role of trait variation in predicting directions of phenotypic evolution during anagenesis and cladogenesis

Meghan Balk, Kjetil L. Voje
Natural History Museum, University of Oslo, Norway

An increasing body of literature verifies that phenotypic evolution often proceeds in directions of high genetic variation, or evolvability, suggesting that genetic constraints are important. This, however, is difficult to test in the fossil record as relationships between individuals are unknown. Therefore, it is unknown if this relationship persists over macroevolutionary time. Additionally, it is unknown whether directions of high variance predict directions of phenotypic evolution during and after cladogenetic events. Clonal organisms with a fossil record, such as bryozoans, provide a unique opportunity to branch micro- to macro-evolutionary studies as we can estimate genetic

variation by measuring phenotypic traits. We take advantage of the 2.3-million-year fossil record of four *Microporella* species that are endemic to New Zealand. We use DeepBryo machine learning to rapidly extract morphological traits from hundreds of colonies. This group is polymorphic; morphs may evolve independently or be constrained by one another. We explore how each morph changes individually or together in relation to directions of high variation during periods of anagenesis and cladogenesis.

Day 1, Session 1C, Konferenzräume 3&4, 09:45 – 10:00
Recording allowed: No

Optimality analyses of hydrodynamic performance refute hypotheses of ecospace saturation during the early evolution of vertebrates

Antonio Ballell Mayoral[1], Elsa Leflaëc[2], Oscar Sanisidro[3], Humberto G. Ferrón[1,2]
[1]University of Bristol, UK; [2]University of Valencia, Spain; [3]Universidad de Alcalá, Spain

Jawed vertebrates dominate today's vertebrate diversity, in contrast to their modest success through the early Palaeozoic. During the Devonian, jawed vertebrates emerged as the prevailing group while most jawless vertebrates declined. This transition remains poorly understood, with convergence among jawless groups suggesting they reached ecological limits imposed by their body plan, while key innovations in jawed vertebrates released these constraints, enabling their subsequent ecological success. Here we test this hypothesis by quantifying headshield shape and hydrodynamics in heterostracans, the most diverse clade of jawless fishes, through 3D geometric morphometrics and computational fluid dynamics, and reconstructing hydrodynamic trade-offs and optimality landscapes. Our results show that early-diverging species tend to occupy more sub-optimal areas and there is an apparent trend towards increased optimality in later lineages. Despite possible developmental and phylogenetic constraints, the areas of highest optimality remained unexplored during the evolution of the group. These findings argue against the ecospace saturation hypotheses and indicate that heterostracans became extinct before exploring the range of potentially optimal headshield morphologies. Thus, our study opens a debate about the possible extinction causes that truncated the evolution of this ecologically innovative group.

Day 2, Session 6C, Konferenzräume 3&4, 14:00 – 14:15
Recording allowed: No

Clingin' to Nusplingen: morphological and microstructural analysis of microbes and biofilm associated with soft tissue in the Nusplingen Lagerstätte of SW Germany.

Orla G. Bath Enright[1,2], Thomas Clements[3], Brianne Palmer[4], Julien Kimmig[5], Sabina Karačić[4,6], Pierre Gueriau[7,8], Günter Schweigert[1]
[1]Staatliches Museum für Naturkunde Stuttgart, Germany; [2]University of Portsmouth, UK; [3], Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany; [4]Universität Bonn, Germany; [5]Staatliches Museum für Naturkunde Karlsruhe, Germany; [6]University Hospital Bonn, Germany; [7]University of Lausanne, Switzerland; [8]Université Paris-Saclay, Paris

The fossil record of unequivocal microbes is poor. However, 3D spiral and coccoid microbes have been identified preserved within a fossil biofilm on the muscle tissue of a specimen of the

horseshoe crab *Mesolimulus* from the Upper Jurassic Nusplingen Lagerstätte of SW Germany. Based on this initial discovery, we undertake a unique opportunity to investigate the first detailed analysis of microbial morphological and microstructural characteristics in decapods, horseshoe crabs, and fish from Nusplingen using scanning electron microscopy and energy dispersive spectroscopy (SEM-EDS). We identify distinct variations in microbody morphology and spatial distributions, allowing differentiation of major microbial groups (*e.g.* fungi, bacteria, etc.). Notably, microbial microbodies, interpreted as fossil bacteria, are restricted to fossil soft tissue and are not observed in the surrounding sediment matrix or on cuticle/scales. Our data also calls into question some previous bacterial identifications. Additionally, this investigation adds evidence that bacterial biofilms play a vital role in soft tissue phosphatization. In conjunction with detailed investigations of the depositional environment of Nusplingen and the discovery of larger microbial mats, these findings enhance our understanding of microbially-mediated mineralization and its role in rapidly stabilizing labile tissues.

Day 2, Session 7C, Konferenzräume 3&4, 17:00 – 17:15
Recording allowed: No

talks

Transitions and multistability in macroevolutionary dynamics of large mammals

Simona Bekeraitė[1], Robertas Stankevič[1], Kristian Agasoster Haaga[2,3], Ivona Juchnevičiūtė[1], Andrej Spiridonov[1]
[1]Vilnius University, Lithuania; [2]University of Bergen, Norway; [3]Bjerknes Center for Climate Research, Norway

We investigate the evolutionary impacts of long-term climate change by analysing the dynamics of Cenozoic mammal evolution, looking for the presence of state transitions, stable equilibrium states and their association with long-term climate evolution. We perform Bayesian modelling of Artiodactyla, Carnivora and Perissodactyla evolutionary histories. Then, we use causal inference methods in order to test the information-theoretic extent of associations between the climate and mammal diversity levels. We then use recurrence plot analysis of the species richness time series, identifying the main transitions and regimes in large mammal evolution. Joint recurrence plots of diversity-Cenozoic oxygen isotope record as well as recurrence quantification analysis are used to further investigate the coupled dynamics of climate and mammal evolution. We find that several transitions between different states of the long-term climate evolution correspond to subsequent transitions and multistable states of diversity. The diversity fluctuations increase in amplitude during the Coolhouse regime in Oligocene and Miocene, with the diversity evolution starting an unprecedented decline during the Icehouse. Our results suggest that mammal diversity evolution has been coupled with the dynamical state of palaeoclimate on multi-million-year timescales.

Day 2, Session 6C, Konferenzräume 3&4, 15:00 – 15:15
Recording allowed: No

A phylogenetic plesiomorphy zone obscures the early evolutionary history of crown birds

Juan Benito[1], Elizabeth M. Steell[1], Matteo Fabbri[2], Klara E. Widrig[3], Bhart-Anjan S. Bhullar[4], Daniel J. Field[1]

[1]University of Cambridge, UK; [2]Johns Hopkins University, USA; [3]National Museum of Natural History, USA; [4]Yale University, USA

Neornithes (the bird crown group) originated during the Late Cretaceous, yet their pre-K-Pg fossil record is extremely scarce. The only two well-supported Cretaceous neornithines have been attributed to Galloanserae (waterfowl and landfowl), and total-group Anseriformes (waterfowl) are amongst the most common early Cenozoic neornithines. Recently, a galloanseran-like palate has been suggested to be ancestral for Neornithes, yet the plesiomorphic condition of numerous additional aspects of the neornithine postcranial skeleton remain uncertain. Here we re-evaluate a crownward stem bird specimen from North America and reveal that its skeleton combines features of early Cenozoic Anseriformes, stem Palaeognathae (ostriches and kin), and Neoaves (all other birds), clades that span the deepest divergences within Neornithes. Phylogenetic analyses and Principal Coordinate analyses from discrete characters show a large overlap of morphologies across taxa spanning the stem-to-crown bird transition, suggestive of a 'Plesiomorphy Zone' where crownward stem birds and stem representatives of major neornithine lineages are more similar to each other than to their extant relatives, obscuring major evolutionary transitions leading to the origin of the bird crown group. These results may have potential implications for assessing the age of the deepest divergences among Neornithes in the Cretaceous and the ecology of the earliest crown birds.

Day 1, Session 1C, Konferenzräume 3&4, 10:15 – 10:30
Recording allowed: No

Ecological disparity of extinct flying vertebrates; did birds compete with pterosaurs?

Jordan Bestwick[1], Thomas L. Stubbs[2], Case V. Miller[3], Rodrigo V. Pêgas[4], Torsten M. Scheyer[1]

[1]University of Zurich, Switzerland; [2]The Open University, UK; [3]Independent; [4]São Paulo University, Brazil

During the Mesozoic two vertebrate groups exhibited powered flight; birds and pterosaurs. Much debate surrounds whether they competed for resources in ecological and evolutionary contexts. While insight has been gained from previous morphological investigations of bird and pterosaur skeletons, these studies often assume the morphology of a structure is directly linked to its hypothesized function and rarely account for the role of phylogeny. Here we investigate morphological features relating to an organism's lifestyle, mainly within the skull, through multivariate analyses and a phylogenetic framework. With these, we quantify the ecological disparity of birds and pterosaurs and test hypotheses of competition. Overall, pterosaurs exhibit greater disparity and both clades exhibit their highest intraclade disparity in the Early Cretaceous. We find some degree of convergence between early pterosaurs from the Triassic–Early Jurassic and early birds from the Middle–Late Jurassic, which tentatively suggests that the emergence of birds as small-bodied insectivores led to the exclusion of pterosaurs that occupied similar niches. We

also found that body size was an important factor in inter-specific morpho-functional differences. Body size differences may have enabled co-existence of contemporaneous pterosaurs and birds and suggests competition may have been stronger between adult birds and juvenile pterosaurs.

Day 1, Session 3C, Konferenzräume 3&4, 14:15 – 14:30
Recording allowed: No

A diverse vertebrate fauna from the Middle to Late Pleistocene of eastern Sudan

Faysal Bibi[1], Brian Kraatz[2], Robert Bussert[3], Anne Delagnes[4], Sumiko Tsukamoto[5], Marianne Brasil[9], Sakir Önder Özkurt[7], Jean-Renaud Boisserie[8], Antoine Souron[4], Johannes Müller[1], Khalafallah Salih[1,6], Ali Eisawi[6]
[1]Museum für Naturkunde, Berlin, Germany; [2]Western University of Health Sciences, USA; [3]Technische Universität Berlin, Germany; [4]Université de Bordeaux, France; [5]Leibniz Institute for Applied Geophysics, Germany; [6]Al Neelain University, Sudan; [7]Ahi Evran University, Turkey; [8]Université de Poitiers, France; [9]Western Washington University, USA

Despite the antiquity of the Nile River, very little is known about its role in faunal and cultural evolution and dispersal in the geological past. Since 2018 our team has conducted yearly fieldwork in along the middle Atbara River valley in eastern Sudan, with the aim of revealing faunal, archaeological, and environmental conditions during the Pleistocene of the Nile Basin. Our investigations have resulted in the discovery of many new sites, the recovery of a diverse fauna including hominins, excavation of a well-preserved Acheulean assemblage, and a new high-density OSL and ^{14}C geochronology spanning ~400 ka to ~15 ka. With over 30 species represented, the new fossil assemblage provides the opportunity to examine late Quaternary extinctions, morphoclinal variations, and the emergence of modern phylogeography. Extinct forms include *Elephas jolensis*, *Kolpochoerus majus*, *Syncerus antiquus*, and a hipparionine equid. Other finds include sub-Saharan records of a macaque (*Macaca sylvanus*) and aurochs (*Bos primigenius*), and a large mandible attributable to Middle Pleistocene Homo. Most of the fossils are dated to ~160-20 ka and indicate both aspects of connection to the Mediterranean and eastern Africa as well as aspects of regionalization during this time.

Day 2, Session 7A, Großer Saal, 16:30 – 16:45
Recording allowed: No

Molecular fossils from the Barents Shelf across the Permian/Triassic boundary in Svalbard

***Stella Zora Buchwald[1], Daniel Birgel[1], Yu Pei[2], Anja Frank[1], Monica A. Gomez Correa[1], Tereza Mosociova[3], Kim Senger[4], Jörn Peckmann[1], William J. Foster[1]**
[1]Universität Hamburg, Germany; [2]China University of Geosciences (Wuhan), China; [3]University of Oslo, Norway; [4]The University Centre in Svalbard, Norway

The Svalbard archipelago with its nearly continuous Palaeozoic and Mesozoic succession provides a unique opportunity to explore the response of shallow marine, higher-latitude ecosystems to the end-Permian mass extinction. In central Spitsbergen, an unusually diverse fossil fauna has been previously documented, but we also identify a special molecular fossil (lipid biomarker) inventory.

Notably, chlorophyll-derived molecular fossils, primarily pristane and phytane, accumulated in the extinction aftermath, indicating an extended phytoplankton bloom. Furthermore, we observe a strong increase in the abundance of the enigmatic biomarker C_{33}-n-alkylcyclohexane (C_{33}-n-ACH) from < 50 µg/gTOC prior to the extinction event to 513.5 µg/gTOC in the extinction aftermath. Similarly, phytanyl toluene is detected exclusively above the extinction horizon. Therefore, while the source organisms of C_{33}-n-ACH and phytanyl toluene remain unidentified, these compounds were likely synthesized by photosynthetic organisms thriving in the post-extinction environment. We can also utilize the biomarker inventory to test the hypothesis that ultrashallow marine anoxia caused the extinction event. However, based on the pristane/phytane redox proxy and the absence of biomarkers derived from anaerobic microorganisms adapted to sulfidic conditions in the chemocline – as expected in the case of euxinia – we only find short-time occurrences of anoxic conditions in the deepest facies in Svalbard.

Day 1, Session 2A, Großer Saal, 12:00 – 12:15
Recording allowed: No

Late Triassic drepanosauromorphs and the paraphyly of bird-headed reptiles (Diapsida: 'Avicephala')

Valentin Buffa[1,2], Eberhard Frey[3], Jean-Sébastien Steyer[2], Michel Laurin[2]
[1]University of the Witwatersrand, South Africa; [2]Muséum national d'Histoire naturelle, Paris, France; [3]Independent

The chameleon-like drepanosauromorph reptiles show some of the most extreme anatomical specializations for an arboreal lifestyle in tetrapods. Despite their occurrence in the Late Triassic of Europe and North America, they are currently considered as the sister-group to weigeltisaurid gliding reptiles from the Late Permian, forming the clade Avicephala. Drepanosauromorphs are thus thought to be an extremely late-surviving lineage of non-crown group reptiles, with a ghost lineage extending from the Late Permian to the Late Triassic. However, this relationship is debated. Here we re-examine the anatomy of drepanosauromorphs from the Late Triassic of Italy and North America and compile these new observations into a new morphological phylogenetic dataset designed to address the monophyly of Avicephala and early diapsid phylogenetic relationships. Our analyses support the paraphyly of 'Avicephala', with Weigeltisauridae as stem-saurian diapsids and Drepanosauromorpha as sister-group to Trilophosauridae among archosauromorphs, supported by several cranial and postcranial synapomorphies. The deeply-nested position recovered here for Drepanosauromorpha reduces the currently accepted ghost lineage at the base of this group, that no longer necessarily crosses the Permian–Triassic boundary. These results provide new insight into the early evolution of archosauromorph reptiles, including the evolution of arboreality.

Day 1, Session 2C, Konferenzräume 3&4, 12:15 – 12:30
Recording allowed: No

The fate of South America's endemic mammalian fauna in response to the most dramatic Cenozoic climate disruption

***Lucas Buffan[1], Fabien L. Condamine[1], Narla S. Stutz[1], François Pujos[2], Pierre-Olivier Antoine[1], Laurent Marivaux[1]**

[1]Université de Montpellier, France; [2]CONICET-Universidad Nacional de Cuyo, Argentina

The Eocene–Oligocene transition (EOT, *c.* 34 Ma) marked the most dramatic global climatic cooling of the Cenozoic. On a planetary scale, palaeontological evidence suggests that this transition was associated with major faunal turnovers, now regarded as a mass extinction crisis. In South America, there is no consensus on the response of the endemic mammals to this transition. Here, using a vetted fossil dataset and cutting-edge Bayesian methods, we analysed the dynamics of South American mammal (SAM) diversification and their possible drivers across latitude (tropical vs. extratropical), taxonomic groups, and trophic guilds throughout the Eocene–Oligocene (*c.* 56–23 Ma). Our results did not evidence any mass extinction among SAMs at the EOT. Instead, they experienced a gradual and long-term diversity decline from the middle Eocene to the early Oligocene, followed by a sudden waxing-and-waning diversity associated with a large taxonomic – but not ecological – turnover. Tropical and extratropical lineages have had very distinct macroevolutionary histories, and no effective change in tropical diversification rates was found. Diversity-dependent effects, temperature, and Andean uplift were recovered as probable drivers of SAM diversification across the period but not the abundance of open landscapes, thereby rejecting the common hypothesis linking Oligocene faunal changes to grassland expansion.

Day 2, Session 5B, Kleiner Saal, 12:15 – 12:30
Recording allowed: Yes

Morphometric and spatial analyses of *Charniodiscus* from the Ediacaran of Newfoundland, Canada

***Princess Aira Buma-At[1,2], Nile Stephenson[1,2], Neil Mitchell[3], Jason J. Head[1,2], Charlotte G. Kenchington[1], Emily G. Mitchell[1,2]**

[1]University of Cambridge, UK; [2]University Museum of Zoology, University of Cambridge, UK; [3]Independent

Ediacaran macrofossils (580-539 Ma) represent the earliest-known complex animals, revealing critical insight into the evolution of life. This study focuses on *Charniodiscus*, an upright, sessile, frondose organism morphologically simpler than the iconic rangeomorphs, enabling the refinement of new quantitative techniques. One of the largest *in situ Charniodiscus* populations occurs within the Main E Surface community in the UNESCO Mistaken Point Ecological Reserve (Newfoundland, Canada). This population can be utilized to explore physical variation across specimens, as well as the spatial distributions of variations within a community. We generated a photogrammetric map of E Surface and obtained morphological traits by marking up the branching architecture of 116 well-preserved *Charniodiscus* specimens. We used multivariate cluster techniques to identify different morphogroups and to constrain defining physical traits. We then used random labelling analyses to investigate how the spatial patterns of specific characteristics varied across the population, and to identify the spatial patterns of the different morphogroups identified. We find that traits showing distinctive spatial patterns and defined morphogroups are likely to be

more ecologically significant than those which vary randomly. Therefore, this novel approach is the first step in elucidating which morphological traits, or combinations of traits, are key drivers of Ediacaran evolutionary dynamics.

Day 1, Session 2A, Großer Saal, 11:00 – 11:15
Recording allowed: No

Potential evidence of salt glands in extinct gharial crocodylians provides support for transoceanic dispersal in Gavialoidea

***Paul Burke[1], Carly Pligersdorffer[1,2], Sophie Boerman[3,4], Gwendal Perrichon[5], Jeremy Martin[5], Thierry Smith[4], Johan Vellekoop[3,4], Philip D. Mannion[1]**
[1]University College London, UK; [2]University of Edinburgh, UK; [3]KU Leuven, Belgium; [4]Royal Belgian Institute of Natural Sciences, Belgium; [5]Universite Claude Bernard Lyon, France

Gavialoid crocodylians are represented by two extant species from southeast Asia, *Gavialis gangeticus* and *Tomistoma schlegelii*, which are restricted to freshwater environments and lack the ability for salt excretion. By contrast, their 80-million-year fossil record documents a cosmopolitan distribution, including occurrences recovered from shallow marine deposits. Furthermore, phylogenetic analyses recover closely related gavialoid species from either side of the Atlantic Ocean. All this evidence points to extinct gavialoids being capable of transoceanic dispersal, but morphological features to support this hypothesis have not yet been documented. Based on CT scan data, we reconstructed the internal cranial anatomy of several extinct gavialoids. This reveals several lines of evidence supporting capability for transoceanic dispersal. Most notably, we identify concave depressions on the internal surface of the prefrontals in several taxa, including the Late Cretaceous–early Palaeogene 'thoracosaurs', as well as some Miocene taxa, all of which are recovered from shallow marine deposits. In extant marine reptiles and iguanas, these concave depressions are osteological correlates for nasal salt glands. They have also been interpreted as such in thalattosuchian crocodyliforms, for which a marine lifestyle is unequivocal. Our preliminary conclusions suggest the capacity for salt excretion and therefore transoceanic dispersal might be ancestral for Gavialoidea.

Day 1, Session 2B, Kleiner Saal, 11:45 – 12:00
Recording allowed: Yes

Determining the relative scientific and cultural 'values' of *in situ* dinosaur track sites in the UK

Richard J. Butler[1], Kirsty M. Edgar[1], Jonathan Larwood[2], Joshua Smith[2]
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Fossil tracks are a key means of determining the palaeoecology and distribution of dinosaurs through time and complementary to the skeletal record. They are also amongst the most popular and recognizable trace fossils encountered by the public and are major draw to some areas of the UK. Thus, beyond scientific value, they provide key aesthetic and pedagogic opportunities in the tourism and education sectors. However, the protection, monitoring, communication, and scientific knowledge of dinosaur track sites varies considerably. We reviewed the fourteen *in situ* dinosaur track sites present in the UK today and used an established quantitative system to determine

the relative scientific and cultural 'value' of each. We find that UK track sites vary substantially in scientific and cultural value, with some sites such as Ardley and Bendrick Rocks having high scientific value, whereas sites such as Hanover Point and Spyway have high cultural but low scientific value. We identified inconsistent documentation of sites with substantial knowledge gaps. Ultimately, dinosaur track sites are an important part of the UK's heritage with strong potential to expand our knowledge of past ecosystems and engage the public, and ensuring appropriate protection, regulation and communication of this finite natural resource is important.

Day 2, Session 7A, Großer Saal, 16:45 – 17:00
Recording allowed: No

Deeper than Bolca: the Ypresian fish-bearing Fossil-Lagerstätte of Sòlteri (Trento, northern Italy) and its faunal content

***Pietro Calzoni[1], Luca Giusberti[1], Giuseppe Marramà[2], Alessandro Garassino[3], Giovanni Pasini[4], Eliana Fornaciari[1], Massimo Bernardi[5], Giorgio Carnevale[2]**
[1]Università degli studi di Padova, Italy; [2]Università degli studi di Torino, Italy; [3]Loma Linda University, USA; [4]Indipendent; [5]MUSE, Museo delle Scienze di Trento, Italy

A Ypresian deep-water site was excavated in 1979 at Sòlteri (Trento, Italy), but its fauna, dominated by bony fishes, and secondary by crustaceans and plants remained unexplored for decades despite its potential interest. Sòlteri represents the nearly coeval deep-water equivalent of the Bolca Lagerstätten (Verona, Italy), worldwide renowned for their abundant and diversified, reef-associated fish faunas. Our ongoing studies, also aimed at detailing the stratigraphical position of Sòlteri, are primarily focused at defining the structure and composition of its ichthyofauna that represents a meso-bathypelagic assemblage. It includes stomiiforms (Gonostomatidae, Phosichthyidae), myctophiforms (Myctophidae) and percomorphs (Gempylidae, Stromateoidei), all representing new, undescribed taxa. The crustaceans are ascribable to three new genera belonging to *Pleocyemata*, *Dendrobranchiata* and *Astacida*. Vegetal remains, scarce and badly preserved, are represented by marine angiosperms, red algae and wood remains. Sòlteri is of extreme relevance not only because it is one of the most ancient Cenozoic deep-water Lagerstätten known to date, but it also provides a unique opportunity to understand the structure of the fish assemblage of the deepwater counterpart of the Bolca biota along with reconstructing the palaeoenvironmental and palaeoclimatic responses of marine communities during the demise of the EECO, the longest warm phase of the entire Cenozoic.

Day 2, Session 4A, Großer Saal, 09:45 – 10:00
Recording allowed: Yes

Modelling among-character rate variation with the Mkv model: lessons learned and perspectives for morphological phylogenetics

Alessio Capobianco, Sebastian Höhna
Ludwig-Maximilians-Universität München, Germany

Models used in likelihood-based morphological phylogenetics often adapt molecular phylogenetics models to the specificities of morphological data. Such is the case for the widely used Mkv model—

which introduces an ascertainment bias correction for observing only variable characters—and for models of among-character rate variation (ACRV), routinely applied by researchers to relax the equal-rate assumption of Mkv. However, the interaction between variable character ascertainment bias and ACRV has never been explored before. We demonstrate that there are two distinct ways to condition the likelihood on variable characters when there is ACRV. Far from being just a trivial mathematical detail, we show that the way in which the variable character conditional likelihood is calculated results in fundamentally different assumptions about how rate variation is distributed in morphological datasets. Simulations indicate that tree length and amount of ACRV in the data are systematically biased when conditioning on variable characters differently from how the data was simulated. Moreover, empirical studies with extant and extinct taxa reveal a potential impact not only in the estimation of branch lengths, but also of phylogenetic relationships. This work highlights the need for morphology-specific model development in likelihood-based phylogenetics.

Day 1, Session 2C, Konferenzräume 3&4, 11:15 – 11:30
Recording allowed: Yes

Understanding activity patterns in ancient birds and mammals using eye melanosomes

***Beatriz Carazo del Hoyo[1], Aaron Quigley[1], Daniel Cirtina[1], Catherine McCarney[2], Jane Brennan[2], Soudeh Ziapour Razlighi[2], Maria E. McNamara[1]**
[1]University College Cork, Ireland; [2]University College Dublin, Ireland

The early evolutionary success of mammals has been linked to the adoption of nocturnal lifestyles, which allowed them to avoid competition with the diurnal dinosaurs and early birds. Activity pattern, however, is difficult to determine for fossils, particularly for mammals. We propose a new approach to distinguish between diurnal, nocturnal and crepuscular mammals and birds using the geometry of melanin-rich organelles – melanosomes – in the eye. In the eyes of extant vertebrates, melanosomes function primarily in UV absorption and reduction of photo-oxidative stress. Given that the activity pattern of an animal controls the amount of ambient light available, melanosomes in vertebrate eyes may vary in geometry according to the activity pattern. To test this, eyes were dissected from three replicates of each of six extant mammal species (two diurnal, two crepuscular and two nocturnal) and eight birds (six diurnal and two nocturnal). Melanosomes were extracted using a 12-day enzymatic digestion procedure and imaged using scanning electron microscopy. Multivariate analysis of a suite of melanosome attributes shows that melanosome geometry differs significantly between species with different activity periods. Our study provides a new approach to infer the active period of ancient vertebrates and thus may constrain evolutionary scenarios for different activity patterns.

Day 1, Session 3A, Großer Saal, 14:15 – 14:30
Recording allowed: Yes

talks

Amniote traits and terrestriality in an early amphibian

Michael I. Coates[1], Benjamin Otoo[2], Abigail Caron[1], Kristen Tietjen[3], Marcello Ruta[4]
[1]University of Chicago, USA; [2]Carleton University, CA; [3]University of Kansas, USA; [4]University of Lincoln, UK

Eugyrinus wildi is the second oldest temnospondyl amphibian in the fossil record. Collected from the same Lancashire Coal Measures locality as early actinopterygians with preserved brains, the single *Eugyrinus* specimen delivers a cache of exceptional data. Again, neural tissues are preserved, but here these include evidence of aerially adapted eyes. Furthermore, the articulated limbs bear hooked terminal phalanges signaling claw presence, the limb proportions match those of lepospondyls (putative stem-amniotes), the finely textured scale coverage appears to be terrestrially adapted, and yet the skull, as previously reported, bears anterior lateral line pits and grooves. None of these discoveries excludes *Eugyrinus* from the Temnospondyli, but claw presence implies enhanced keratinization, previously considered a marker of amniote affinity. Instead, we argue that *Eugyrinus* provides a new perspective on general and, in part, terrestrially adapted conditions close to the amniote-amphibian split. Thus, low keratin in lissamphibian integument is a derived trait, consistent with arguments that many aquatic characteristics of early temnospondyls are secondary. Meanwhile, the eyes, claws, limbs, squamation, and gut contents of *Eugyrinus* hint at new emergent activities and niche occupation in coal swamp habitats. Finally, and perhaps of broader relevance, reptiliomorph (claw-marked) trackways are no longer exclusive to amniote track-makers.

Day 2, Session 7A, Großer Saal, 17:00 – 17:15
Recording allowed: No

The oldest phloem: uncovering the history of sugar transport in the early Devonian Rhynie chert

***Laura Cooper, Alexander J. Hetherington**
University of Edinburgh, UK

Phloem, the sugar conducting tissue of vascular plants, is a key innovation in plant evolution. Phloem played an important role in enabling the major increase in size and complexity seen in vascular plants when compared to their nonvascular relatives, and thus is responsible for the revolutionary impacts that vascular plants have had on the Earth's surface – including producing diverse and high-productivity ecosystems. The early Devonian Rhynie chert constitutes an important source of information about early land plants, providing the exceptional cellular preservation required to investigate delicate tissue such as phloem. The "phloem-like" tissue of the early lycopsid *Asteroxylon mackiei* was investigated using high resolution imaging techniques (Confocal Laser Scanning Microscopy and Scanning Electron Microscopy). This tissue was found to have sieve pores in cell walls, and thus was confirmed to be true phloem. This finding in *A. mackiei* represents the earliest known true phloem in the fossil record, and supports a single origin of this tissue in the common ancestor of the extant vascular plants. However, the morphology of *A. mackiei* phloem cells suggests that this was a transitional tissue, not yet fully optimized for its sugar conducting function.

Day 2, Session 6A, Große Saal, 14:45 – 15:00
Recording allowed: No

Changes in redox potential during decay: insights into the preservation of Cambrian animals

***Nora Corthésy, Allison C. Daley, Jonathan B. Antcliffe, Farid Saleh**
University of Lausanne, Switzerland

Exceptional fossil preservation gives a wealth of information about biodiversity in deep time. Biotic and abiotic factors influence anatomy preservation potential. The impact of environmental parameters such as oxygen, clays and bacteria on tissue preservation potential has been previously investigated through decay experiments. However, changes in redox potential surrounding decaying carcasses have never been assessed. This is particularly important because authigenic mineralization, replicating labile anatomies in pyrite and/or phosphate and increasing preservation, requires specific redox conditions. Here, changes in redox potential surrounding carcasses of four different phyla were measured over seven days. We found that redox conditions are heterogenous between the different phyla. Arthropods and molluscs consume oxygen the fastest, consistently reaching redox values corresponding to sulfate reduction (favourable to pyritization) and phosphorus release (favourable to phosphatization). Planarians do not consume much oxygen, and redox values remain stable. Echinoderms consume some oxygen, but do not reach anaerobic conditions. These results could imply that organisms like arthropods and molluscs are more likely to reach conditions facilitating tissue mineralization, thus having higher preservation potentials than other organisms. This means that the dominance of some animals in the fossil record during major evolutionary events, might be partially explained by their higher preservation potential.

Day 1, Session 3A, Großer Saal, 14:45 – 15:00
Recording allowed: No

Extinction magnitude within the graptoloid clade

James Crampton[1], Michael Foote[2], Peter Sadler[3]
[1]Victoria University of Wellington Te Herenga Waka, New Zealand; [2]University of Chicago, USA; [3]University of California, Riverside, USA

Is mass extinction qualitatively and/or quantitatively distinct from 'background' extinction, or do these phenomena occupy a continuous spectrum? Questions on this theme have been persistent in palaeobiological research and have defied simple resolution. We revisit this question using an extremely high-resolution chronology of Ordovician and Silurian graptoloid origination and extinction times that span one of the 'Big Five' mass extinctions and several second-order but severe extinction events within this ecologically dominant zooplankton clade. Previous methods of analysis have averaged extinction rates within fixed and arbitrary windows of observation, and thereby have potentially degraded the signal. Instead, here we use a survivorship curve-based approach that avoids the averaging problem and yields a highly resolved spectrum of extinction rates for the graptoloids over their global distribution and an interval of ~60 million years. Like several previous studies, we find continuity of extinction magnitude from 'background' into severe extinction events and into a mass extinction. Whereas the processes driving extinction vary widely, and some can be considered singular, the simple metric of extinction magnitude would seem to define a continuous spectrum, at least for the graptoloids.

Day 2, Session 7B, Kleiner Saal, 16:30 – 16:45
Recording allowed: Yes

Effects of cryptic diversity on diversification dynamics analyses in Crocodylia

Gustavo Darlim, Sebastian Höhna
Ludwig-Maximilians-Universität München, Germany

The crocodylian fossil record is represented by approximately 140 species, with the earliest unambiguous fossil tracing back to *c.* 85 million years ago, whereas extant diversity has been conservatively represented by 23 species based on morphology-only diagnosis. Advances in molecular studies, however, have recognized multiple cryptic species indicating a considerably higher diversity that is otherwise untraceable by morphological observations. Diversification dynamics studies in Crocodylia using phylogenies with extant-only taxa have recovered a sharp decline in speciation rates following a Miocene diversity peak, leading to the current-day observed diversity. However, cryptic diversity has never been considered by those studies. Here we explore the effects of incorporating cryptic diversity in a diversification dynamics analysis under available protocols in RevBayes. Our results show continuous increase of speciation rates from approximately at 40 Ma to the recent time, contrasting to previous studies. Additionally, extinction rates are virtually zero for the diversification dynamic analysis when excluding cryptic diversity. However, zero extinction rates are clearly unrealistic for crocodylians as the extensive fossil record shows strong evidence of species extinctions. Virtually zero extinction rates likely represent an artifact of underestimating present-day diversity. Efforts on understanding cryptic diversity are valuable for better comprehending macroevolutionary processes underlying diversification dynamics.

Day 2, Session 5A, Großer Saal, 11:00 – 11:15
Recording allowed: No

Occupancy modelling as a novel approach for conservation palaeobiology

Christopher D. Dean, Philip D. Mannion
University College London, UK

Palaeontological data provides a unique avenue to investigate climatic, habitat and ecosystem change over longer temporal scales than typically examined in ecology and conservation, contributing critical data in the face of our current biodiversity crisis. However, it is well known the fossil record is systematically and non-randomly biased by a variety of factors. In particular, the issue of data absence (*i.e.*, does the lack of a fossil occurrence indicate genuine absence or imperfect detection?) causes a genuine concern when attempting to discern the historical distribution of species. Occupancy modelling, a technique commonly applied in the fields of ecology and conservation, provides an avenue to simultaneously estimate the probability of occupancy and detection of fauna, allowing unique insight as to their historic distribution and the factors influencing perceived patterns. Here we use Holocene palaeontological and zooarchaeological records for European mammals and land use data along with two variants of Bayesian occupancy models to establish patterns in the occupancy and detection probability of fauna over the last 40,000 years as well as their potential drivers. Our results highlight the utility of occupancy modelling as a novel approach for understanding for tackling issues of fossil record bias in conservation palaeobiology.

Day 2, Session 5C, Konferenzräume 3&4, 12:15 – 12:30
Recording allowed: Yes

Nothing but the tooth? A total evidence approach to the elasmobranch tree of life

Richard Dearden[1,2], Zerina Johanson[3], Martin Rücklin[1]
[1]Naturalis Biodiversity Center, the Netherlands; [2]University of Birmingham, UK; [3]Natural History Museum, London, UK

The long evolutionary history of elasmobranchs (sharks and rays) is recorded primarily by a rich fossil record of teeth, which show that living families' roots stretch well back into the Mesozoic. However, while some fossil teeth are straightforward to match up to living elasmobranch taxa it is difficult to confidently place others on specific branches deeper in the tree, and early divergence events in the elasmobranch tree of life remain poorly constrained. An alternative is to use data from elasmobranch skeletons, which are cartilaginous and fossilize only rarely. In this talk I describe our ongoing work using a total-evidence approach to better understand the evolutionary history of elasmobranchs incorporating information from the skeletal morphology of elasmobranchs living and extinct, and genomic data for extant taxa. In particular, this is supported by the use of computed tomographic methods to reveal the three-dimensionally preserved skeletal morphologies and phylogenetic affinities of crown-group selachians from the Upper Cretaceous Chalk of the United Kingdom including a three-dimensionally preserved collared carpet shark *Pararhincodon*. Preliminary results indicate that this results in comparatively recent dates for elasmobranch evolution, providing a new perspective on elasmobranchs' evolutionary history independent from and complementary to that provided by the tooth record.

Day 1, Session 2C, Konferenzräume 3&4, 11:45 – 12:00
Recording allowed: No

An ecological network for the Dinosaur Provincial Park biota and its vicinity in Late Cretaceous (Campanian) Canada

***Alexandre Demers-Potvin, Hans C. E. Larsson**
McGill University, Canada

Understanding the structure of ancient ecosystems in deep time can reveal the long-term stability of communities against perturbations, as well as consistent ecological patterns throughout Earth's history. In that respect, Dinosaur Provincial Park and nearby localities provide one of the most comprehensive pictures of Late Cretaceous North American non marine environments. We now present one of the first site-specific quantitative ecological networks ever attempted for a dinosaur-dominated community, using the rich literature on its constituent taxa to infer trophic links connecting them. The DPP network reveals that tyrannosaurids at the top of its food chains were more analogous to Komodo dragons than to terrestrial carnivorans by displaying a pronounced shift in trophic level through ontogeny. As part of a broader palaeoecological project, we laid foundations to investigate variation in the structure of that network through space (from the coastal plain of Laramidia to the Bearpaw Sea) and time (over the 2.5 Myr duration of the Belly River Group in DPP). Large-scale aerial mapping of DPP's outcrops with drones offers new opportunities to refine well sampled species' stratigraphic distributions, and a ceratopsian bonebed in Saskatchewan now reveals a more coastal coeval palaeocommunity at an ecotone between marine and non-marine localities.

Day 2, Session 5A, Großer Saal, 12:00 – 12:15
Recording allowed: Yes

The experimental effects of wave processes on arthropod taphonomy: implications for Lagerstätten and small carbonaceous fossils (SCFs)

***Laura Devine, Nicholas Minter**
University of Portsmouth, UK

Arthropods are one of the most significant groups of animals through Earth history, and so it is important to determine what taphonomic processes affect their fossil record. In taphonomic experiments mimicking the effects of wave processes, we used the arthropods *Ligia oceanica* (sea slater), *Triops longicaudatus* (tadpole shrimp), and *Branchinella thailandensis* (fairy shrimp), as modern analogues to segmented arthropods, bivalved branchiopods, and non-bivalved branchiopods respectively. In addition, we used Energy Dispersive Spectroscopy to identify the levels of mineralization of each arthropod. We found *L. oceanica* and *T. longicaudatus* may have partially mineralized exoskeletons and can withstand 48–72 hours of exposure to wave action before disarticulating and fragmenting; whilst *B. thailandensis* had no evidence of mineralization and began to degrade within 24 hours and fragmented into isolated remains by 48-72 hours. These results suggest that exposure to wave processes and the degree of mineralization of arthropod carcasses may explain why we see fossil arthropods analogous to *L. oceanica* and *T. longicaudatus* regularly in both Lagerstätten and SCF deposits, whereas those analogous to *B. thailandensis* are exclusively found in SCF deposits. The effects of taphonomic processes on the presence or absence of certain groups therefore need to be considered in palaeoecological interpretations.

Day 1, Session 3A, Großer Saal, 14:00 – 14:15
Recording allowed: No

Imputation of missing data for palaeobiological analyses

Harriet B. Drage
University of Lausanne, Switzerland

The incomplete nature of the fossil record requires contention with missing data in analyses, such as by subsampling or data imputation. Data imputation encompasses many methods of varying complexity that use known data to interpolate missing data, but these have seen limited application to palaeobiology. I used several methods to impute trilobite fossil data and compare their efficacy. Data imputed includes categorical variables (*e.g.*, taxonomic assignments, geological range) and continuous data (*e.g.* morphometric landmark data). For dataset one, missing data was systematically created at varying levels (*e.g.* 5 %, 10 %) by stochastically masking existing data. Dataset two has 'real' missing data; a result of the observed fossil record. Efficacy of methods was determined for dataset one by comparing the imputed data to the original observed data, and for dataset two by testing for difference in statistical outcomes. The deep learning method, MIDAS, performed better overall than other imputation methods (*e.g.* random forest), as found for modern biological data, though all data imputation methods could be employed for palaeobiological analyses. This work demonstrates the importance of considering data imputation as a pre-analysis step in quantitative palaeobiological studies, and its applicability to a range of primary data types broadly used by palaeobiologists.

Day 1, Session 1C, Konferenzräume 3&4, 09:15 – 09:30
Recording allowed: No

Evaluating the impact and detectability of mass extinctions on total-evidence dating

***Minghao Du[1,2], Joëlle Barido-Sottani[1]**
[1]Université PSL, France; [2]Central South University, China

Fossils are crucial for accurately dating phylogenetic trees because their ages provide absolute times of macroevolution, and their morphological characters offer key information on evolutionary rates and phylogenetic positions. The fossilized birth-death (FBD) process is a diversification model that incorporates both extant and extinct species, serving as tree priors that seamlessly integrates fossils into phylogenetic inference. While the FBD model can account for mass extinctions, which caused rapid, widespread organismal loss, few studies have utilized FBD models incorporating these events in phylogenetic inference. The detectability of mass extinctions and their impact on phylogenetic inference remain unclear. Through simulations, we assessed the influence of mass extinctions on divergence time and topology inference and evaluated the detectability of mass extinction signals in total-evidence dating. We examined three FBD tree priors: without mass extinction, with known extinction time and probability, and with known extinction time but unknown probability. Our results show similar divergence time and tree topology errors across these models. Moreover, the FBD model with known extinction time but unknown probability effectively detects mass extinctions. We conclude that mass extinctions minimally impact total-evidence dating under accurate clock and substitution models. Additionally, if extinction timing is known, mass extinction signals can be detected.

Day 1, Session 1B, Kleiner Saal, 09:15 – 09:30
Recording allowed: Yes

Origin of fabric-retentive irregular calcite (FRIC) in stromatoporoids

Patrycja Dworczak[1,2], Steve Kershaw[3,4], Axel Munnecke[1]
[1]Friedrich-Alexander-Universität Erlangen–Nürnberg, Germany; [2]Polish Geological Institute-National Research Institute, Warsaw, Poland; [3]Brunel University, UK; [4]Natural History Museum, London, UK

Stromatoporoids are common shallow marine hypercalcified sponges and were the main builders of Palaeozoic reefs. The question of the primary mineralogy of stromatoporoids is, however, still under discussion. The problem is the preservation of the original skeletal structure, because in contrast to low-Mg-calcite skeletons such as brachiopods or trilobites, all stromatoporoid appear diagenetically altered in thin section. Even relatively well-preserved specimens with very dense skeletal structures such as the genus *Densastroma*, show a diagenetic feature characteristic of stromatoporoids – fabric-retentive irregular calcite (FRIC). FRIC crystals normally pass from skeletal element into spaces within the skeleton, in some cases single FRIC crystals can penetrate several skeletal elements and gallery spaces. The origin of FRIC is still unknown. Rare findings of microdolomite inclusion may indicate an original high-Mg-calcite mineralogy. We compared numerous Silurian and Devonian stromatoporoids by using fluorescence microscopy, aiming to reconstruct the original skeletal ultrastructure. Despite very low organic matter content in stromatoporoid skeletons, they display fluorescence, highlighting the original skeleton structures, which appear strongly diagenetically altered in transmitted light. Under fluorescence light the stromatoporoid skeletons display a high

micro- and nanoporosity, which we interpret, enabled the FRIC crystals to grow through skeletal elements that appear non-porous in transmitted light microscopy.

Day 2, Session 7C, Konferenzräume 3&4, 16:15 – 16:30
Recording allowed: No

New insights into marine ray-finned fish evolution: fossil discoveries from the Late Cretaceous and Palaeogene of Egypt

***Sanaa El-Sayed[1,3], Matt Friedman[1,2], Hesham Sallam[3]**
[1]Mansoura University, Egypt; [2]University of Michigan, USA.; [3]American University in Cairo, Egypt

An increasing number of studies highlight the Late Cretaceous and Palaeogene periods as pivotal in the evolution of Cenozoic marine ray-finned fish and the rise of modern fish diversity. However, the fossil record, largely from North America and Europe, limits our understanding, especially in lower latitudes and varied environments. Recent fieldwork by the Mansoura University Vertebrate Paleontology Center in Egypt has revealed new sites that expand this record. The Campanian-Maastrichtian Duwi Formation (~8°N palaeolatitude) in the Western Desert preserves a diverse array of previously unreported actinopterygian fishes, including large-bodied predatory teleosts from groups such as †Pachycormidae, †Enchodontidae, and †Cimolichthyidae. These assemblages resemble those from the Northern Tethys Platform and the Western Interior Seaway, suggesting faunal connections across the Tethys Ocean. Additionally, the Paleocene-Eocene Thermal Maximum (PETM) layers in the Dababiya Quarry Member (~12°N palaeolatitude) of the Esna Shale Formation preserve fauna that share similarities with midlatitude PETM assemblages. This new ichthyofauna provides critical insights into marine fish evolution during these periods, demonstrating that diverse communities thrived in the palaeotropics and highlighting broad latitudinal ranges for certain taxa during warmer climates.

Day 1, Session 1A, Großer Saal, 09:30 – 09:45
Recording allowed: No

Introducing the early high disparity phylogenetic comparative model, with applications to ichthyosaur macroevolution

Ricardo Ely
University of Copenhagen, Denmark

Early high disparity (EHD) is an evolutionary mode frequently encountered in the fossil record, describing a pattern of morphological disparity reaching a maximum in the early portions of a clade. Methods for modelling processes resulting in EHD patterns are currently lacking, leading to the development of a novel phylogenetic comparative method (PCM) presented here. This PCM combines two modes of evolution: the Ornstein-Uhlenbeck (OU) and Early Burst (EB). Presented here are the theoretical statistics and model adequacy tests using Monte Carlo simulations (~Type I/Type II error rates) to interrogate the performance of this method when the generating (simulating) modes are EHD and alternative modes (including OU and EB alone). To test the method on an empirical case, EHD model fitting is performed on ichthyosaur size datasets, a group of Mesozoic marine reptiles which seemingly display a EHD pattern. Compared to alternative evolutionary

modes, the EHD mode is recovered as best fitting in nearly all ichthyosaur datasets tested (ΔAICC < 2). Possible environmental factors driving an EHD mode in ichthyosaurs are investigated, along with the potential role for geological preservation biases in producing apparent EHD patterns.

Day 1, Session 1B, Kleiner Saal, 10:00 – 10:15
Recording allowed: Yes

Innovation in chondrocranial morphogenesis underpins the origin of the avian beak

Matteo Fabbri
Johns Hopkins University, USA

Contrary to most extant tetrapods, birds possess and enlarged, edentulous premaxillae forming the avian beak. Whether this trait appeared in a stepwise evolutionary fashion or a sudden shift, and how developmental changes might have played a role into its origin remain unclear. Application of 3D geometric morphometrics on a broad range of skulls representing extant and extinct reptiles, including birds, show the lack of intermediate phenotypes between the avian beak and reptilian face, supporting a sudden evolutionary shift characterizing the appearance of this trait. To evaluate potential variables underpinning this evolutionary shift, the morphogenetic patterning of the beak was investigated with a focus on the early moments of organogenesis starting from the phylotypic stage within an evolutionary framework including non-model organisms. Immunostaining and confocal imaging of developmental series of nine species, including avian and non-avian reptiles, cleared with CLARITY show negative and positive allometry of the prenasal condensation among non-avian reptiles and birds, respectively. The prenasal condensation, and the chondrocranium in general, is therefore acting as a scaffold upon which dermatocranial ossification appear, eventually leading to the evolutionary significant, strikingly different skeletal features, such as the avian beak.

Day 2, Session 7A, Großer Saal, 17:15 – 17:30
Recording allowed: No

The oldest three-dimensionally preserved actinopterygian hearts: soft tissue preservation in a stem teleost

***Sophie Fasey[1], Jake Atterby[1], Rodrigo T. Figueroa[2,3], Matt Williams[4], Sam Giles[1,5]**
[1]University of Birmingham, UK; [2]Harvard Museum of Comparative Zoology, USA; [3]Harvard University, USA; [4]Bath Royal Literary and Scientific Institution, UK; [5]Natural History Museum, London, UK

Teleost fishes exhibit distinctive soft tissue specializations, including elaboration of the eye vasculature and changes to heart morphology. There is relatively little published data on soft tissue anatomy in fossil actinopterygian taxa, due both to the rarity of this style of fossil preservation and a poor understanding the required taphonomic processes. Consequently, there is a gap in knowledge regarding the acquisition of key soft tissue characters in early actinopterygian evolution. Here we present microcomputed tomography (CT) and synchrotron tomography data of three specimens of the stem teleost *Pachycormus macropterus* from the Toarcian (Jurassic) Strawberry Bank Lagerstätte of southwest England. These data reveal extensive, phylogenetically informative three-dimensional soft tissue preservation, including orbital vasculature and heart tissues. Additionally,

iodine-enhanced CT scanning of a phylogenetically broad sample of extant Actinopterygii is used to aid anatomical and phylogenetic interpretation and build up a comparative dataset of soft tissue anatomy in ray-finned fishes. *Pachycormus macropterus* represents the oldest and most phylogenetically basal three-dimensionally preserved actinopterygian heart, with implications for the sequence of character acquisition during the evolution of the teleost heart. These data provide an important comparison to Palaeozoic reports of three-dimensional cranial soft tissue preservation, and appear to represent distinct taphonomic preservation pathways.

Day 2, Session 4A, Großer Saal, 10:00 – 10:15
Recording allowed: Yes

Extinction vulnerability of foraminiferans of differing body sizes

***Yan Feng[1], Lee Hsiang Liow[2], Haijun Song[1]**
[1]China University of Geosciences (Wuhan), China; [2]Natural history Museum, University of Oslo, Norway

Throughout Earth's history, numerous extinction events have occurred, with mass extinctions revealing a notable pattern: different biological groups experience distinct extinction risks. Palaeontologists have long been curious about which traits determine the likelihood of species extinction. This study investigates the role of three specific traits—body size, species richness, and geographic range—in influencing the extinction risk of foraminifera across a total of 12,701 specimens. The results highlight body size as a critical determinant of extinction risk, with larger foraminifera exhibiting heightened vulnerability. This size selectivity was particularly pronounced during the Guadalupian-Lopingian (259.51 Ma), Permian-Triassic (251.902 Ma), and Cretaceous-Palaeogene (66.1 Ma) mass extinctions. One possible explanation for this pattern is the increased difficulty of oxygen diffusion within larger foraminifera, which may have made them more susceptible to extinction. In contrast, species richness and geographic range showed no statistically significant effects on extinction risk. We hence propose a hypothesis to explain size-selective extinction and the Lilliput effect in diffusion-dependent organisms in past extinctions, which may also apply to future anoxic conditions. We also use newly compiled data to explore the temporal patterns of foraminiferan size evolution beyond mass extinction events.

Day 2, Session 6B, Kleiner Saal, 14:00 – 14:15
Recording allowed: Yes

Developmental biology of *Megaclonophycus* from Ediacaran Weng'an biota

***Kirsten Flett[1], Kelsie Cracknell[1], Johnny C. Yamahuchi[1], Zongjun Yin[2], Maoyan Zhu[2], Philip C. J. Donoghue[1]**
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The Ediacaran Weng'an biota from the Doushantuo Formation of China yields embryo-like microfossils preserved with sub-cellular fidelity previously interpreted as the oldest evidence of animals in the fossil record. Megasphaera dominates the assemblage and preserves the earliest stages of binary reductive division. It is assumed to develop into *Megaclonophycus*, which is composed of hundreds to thousands of cells, however a developmental link has not

been demonstrated. We used synchrotron tomography to characterize hundreds of specimens of *Megaclonophycus* to submicron resolution and used computed tomography to determine the pattern of cell division among these taxa. Cell counts clustered at 2048 and 4096 indicating binary division, a characteristic associated with animals, however the specimens have asynchronous binary cell division with cells within the same specimen varying in size by 2 to 3 times. *Megaclonophycus* increases in volume as cells divide and lacks morphological features like gastrulae formation indicating it does not exhibit reductive cleavage or synchronous division, both of which are characteristic of metazoan development. These findings refute the stem group metazoan affinity suggested for this taxon, therefore molecular clock estimates for the origin of animals must rely on fossil calibration from sources other than *Megaclonophycus* but possibly still from the Weng'an biota.

Day 1, Session 2A, Großer Saal, 11:15 – 11:30
Recording allowed: Yes

Predators, zooplankton, and the origins of ecosystem stability

***Euan N. Furness[1,2], Nicholas J. Butterfield[1], Emily G. Mitchell[1,2]**
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The first macroscopic animal ecosystems arose in the late Ediacaran (~575Ma). However, these ecosystems lacked many of the functional groups present in modern marine ecosystems, such as predators, burrowers, and zooplankton. The ecological diversity of modern ecosystems is key to maintaining stability, but it is unclear how the evolution of ecologies in the Ediacaran and Cambrian impacted the stability of marine ecosystems. We employ biomass-based ecological network modelling techniques, parameterized using data from the fossil record, to assess the ecological stability of Ediacaran ecosystems. We assess how this stability changes in response to the addition of model predators and zooplankton to these ecosystems, mimicking the evolution of ecologies into the early Cambrian. We find that introducing predators to these early ecosystems tends to destabilize them, but the exact effect is dependent upon the state of the ecosystem prior to perturbation. Zooplankton, on the other hand, often stabilize ecosystems, but this effect is dependent upon an increase in the speed of ecological feedback loops within the ecosystem. These results demonstrate that particular events in the progressive complexification of ecosystems in the Ediacaran-Cambrian would have been associated with restructuring of marine ecosystems, with the potential to drive both extinctions and evolutionary innovation.

Day 1, Session 2A, Großer Saal, 11:30 – 11:45
Recording allowed: No

A global comparison of functional trait extinction selectivity across the rapid climatic change of the Pliocene-Pleistocene transition

***Sarah Gale[1], Katie Collins[2], Stewart Edie[3], David Jablonski[4], Shan Huang[1]**
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Recent work has shown that bivalve extinction through the Cenozoic is tied to the magnitude of temperature change, regardless of warming or cooling. The Plio-Pleistocene transition is of

particular interest as the most recent major shift in climate state and offers a valuable test for the response of both taxonomic and functional diversity to rapid changes in climate. These biodiversity currencies across this event may model changes in modern fauna in the changing climate of the near future. Here we compare extinctions and the resulting changes in functional diversity in 8 regions across the world with well-documented Pliocene records of marine bivalves. By comparing these fossil occurrences and functions with an extensive global database of marine bivalve occurrences and life habits, we test the hypothesis that extinctions select for functional groups with lower taxonomic redundancy, such that taxa with "rare" functions have a higher likelihood of persisting within their Pliocene regions. Our dataset includes 1 tropical, 5 warm-temperate, and 2 cold-temperate regions, additionally allowing analysis of variation in selectivity with the magnified intensity of climate change with latitude. We will discuss the extinction mechanisms suggested by out findings and implications for conserving taxonomic diversity as the core value of biodiversity.

Day 1, Session 3B, Kleiner Saal, 14:45 – 15:00
Recording allowed: Yes

The enigma of Mother's Day: exploring the taphonomy of porous *Diplodocus* scales

Tess Gallagher[1], Michael Pittman[2], Thomas G. Kaye[3], Jason P. Schein[4]
[1]University of Bristol, UK; [2]The Chinese University of Hong Kong, Hong Kong SAR, China; [3]Foundation for Scientific Advancement, USA; [4]Elevation Science Institute, USA

The Mother's Day Quarry, Montana, USA is a scientifically rich site for sauropod research. It harbours a multitude of juvenile *Diplodocus* material which accumulated after multiple individuals died and their remains buried during a debris flow 150 million years ago. The animal's remains buried in an anoxic environment allowing for the rare preservation of integument. These animals possessed a diversity of scale patterns similar if not more diverse than crocodiles and other modern reptiles. The skin also preserves microscopic three-dimensional detail including the original keratinous epidermis, now turned to aluminosilicates, and melanosomes. Some of the integumentary specimens from this quarry also preserve a bizarre morphology, in which the scale 'cap' has branching tendrils beneath that combine and form a sponge-like medium. Our research asks the question: are these structures taphonomic artifacts or complex integumentary structures that were present in life? Tendrils vary in size between specimens of different sizes. For instance: ~3mm wide porous scales average tendril width of 130 µm while ~1mm wide porous scales average 34 µm tendril width. The tendrils possess a similar keratinous-like layer made of aluminosilicates and melanosome impressions, confirming that these structures are integumentary in nature.

Day 2, Session 4B, Kleiner Saal, 09:30 – 09:45
Recording allowed: No

From Darwin finches to giant pterosaurians – using geometric morphometrics to attempt reconstructing flying ornithodiran feeding ecology in deep time

***Joshua Gauweiler[1], Florian Braig[2], Carolin Haug[2], Joachim T. Haug[2], Marie K. Hörnig[1,3]**
[1]Greifswald University, Germany; [2]Ludwig-Maximilians-Universität München, Germany; [3]University Medical Centre Rostock, Germany

To understand the ecological role of an animal, we have to, among other things, understand the animals diet. In extant animals we might be able to observe their feeding habits, but understanding the diets of extinct animals is quite difficult. In an attempt to shed further light on the diet of pterosaurians and early ancestors of modern birds, we examined whether the skull shape of extant birds are a usable proxy for their diet and if this technique is applicable to fossil ornithodirans as well. By quantifying the outline of over 300 extant bird skulls using Elliptic Fourier Analysis (EFA) we tested for possible correlations between shape and diet. Our results show that the skull shape is influenced both by diet and by the mode of foraging. We then used the same method to analyze over 120 skulls of pterosaurians and fossil birds. Our results support some of the previously theorized diets for fossil ornithodirans, but also point towards niche differentiation between different stages of the same species in some early branching pterosaurians. Furthermore we discuss whether these results can help us understanding possible niche competition between pterosaurians and birds affecting their groups diversities during the Mesozoic.

Day 2, Session 5A, Großer Saal, 12:15 – 12:30
Recording allowed: No

Lateglacial to Holocene climate changes in the Upper Lena Region of Eastern Siberia inferred from a multi-component stable isotope analysis

Jana Gliwa[1], Franziska Kobe[1], Pascal Olschewski[2], Svetlana Kostrova[1], Aleksandr A. Shchetnikov[3], Aleksandra I. Krikunova[1], Stefan Lauterbach[4], Christian Leipe[1], Philipp Hoelzmann[1], Birgit Schröder[5], Pavel E. Tarasov[1]
[1]Freie Universität Berlin, Germany; [2]Memorial University of Newfoundland, Canada; [3]Institute of the Earth's Crust, Russian Academy of Sciences, Russia; [4]Polish Academy of Sciences, Poland; [5]Helmholtz-Zentrum Potsdam – Deutsches GeoForschungsZentrum, Germany

With its comprehensive pollen record and its precisely dated sediment, Lake Ochaul is one of the key sites in the Upper Lena Region for investigating past climate changes. To reconstruct local, long- and short-term temperature and precipitation changes together with environmental peculiarities of the lake during the past 13,500 years, we measured the stable isotope composition ($\delta^{18}O$, $\delta^{13}C$) from endogenic and biogenic (ostracod and bivalve) carbonates. Large-scale climate variations across the Lateglacial-Holocene transition, including a temperature decrease during the Younger Dryas and the following early Holocene warming, are reflected in the $\delta^{18}O$ record and correspond well to the existing vegetation reconstructions from the same sediment core. Stable isotope signals ($\delta^{18}O$, $\delta^{13}C$) of endogenic carbonates and the element analyses from early Holocene samples indicate a major increase of temperature and evaporation, which exceeded the precipitation amount during the summer season. Early Holocene $\delta^{13}C$ values imply significant changes in the trophic state of Lake Ochaul, which was mainly influenced by the establishment of boreal trees and the associated soil stabilization in the catchment area. By substantiating our findings with results from pollen and

element analysis, we were able to make reliable conclusions about distinct regional climate changes over the last 13,500 years.

Day 2, Session 4C, Konferenzräume 3&4, 10:00 – 10:15
Recording allowed: No

Adaptive response of shallow-marine ostracods during the Permian–Triassic climate crisis

***Monica Alejandra Gomez Correa[1], Christoph Bonow[1], Jana Gliwa[2], Dieter Korn[3], Evelyn Kustatscher[4], Herwig Prinoth[5], Anja Frank[1], Marie-Béatrice Forel[6], William J. Foster[1]**
[1]Universität Hamburg, Germany; [2]Freie Universität Berlin, Germany; [3]Museum für Naturkunde, Berlin, Germany; [4]Museum of Nature South Tyrol, Italy; [5]Museum Ladin Ursus ladinicus, Italy; [6]Muséum national d'Histoire naturelle, Paris, France

Ostracoda represents one of the most diverse and abundant groups of metazoans preserved in the fossil record and is crucial for understanding the impacts of the Permian-Triassic climate crisis, a period characterized by drastic environmental changes, including thermal stress, deoxygenation, and potential ocean acidification that led to a mass extinction. This study evaluates ostracod diversity patterns across four sections in the Dolomites, spanning the Permian/Triassic boundary at different water depths. By examining various sections deposited along the carbonate ramp, this research provides the first regional-scale analysis of ostracod diversity dynamics during this climate crisis. Our findings highlight a significant turnover in ostracod communities in shallow sections coinciding with intense dolomitization phases, impacting fossil preservation and yielding few well-preserved specimens. In contrast, deeper sections show little evidence of a drastic turnover and less drastic effects of dolomitization in the fossil record. This variation emphasizes the significant impact of dolomitization and sedimentary alterations on fossil preservation and turnover rates. Overall, our results show that dolomitization exaggerates the turnover signal we recorded in the shallower sections. While in deeper and less dolomitized sections, the turnover in the ostracod community is less pronounced, suggesting a potentially more stable environment during this climatic crisis.

Day 2, Session 6B, Kleiner Saal, 15:00 – 15:15
Recording allowed: No

Evolution and development of early chondrichthyan teeth: Histological observations from three Devonian key taxa from Morocco

***Merle Greif[1], Héctor Botella[2], Torsten M. Scheyer[1], Christian Klug[1]**
[1]University of Zurich, Switzerland; [2]University of Valencia, Spain

Throughout chondrichthyan evolution, significant adaptations have led to the establishment of rapid tooth replacement and the development of highly differentiated tooth mineralogies in modern sharks. By contrast, in some early chondrichthyans, tooth replacement was evidently much slower. Specifically, cladodonts are known to retain their teeth instead of shedding them. Despite this, our understanding of the overall tooth histology in these early chondrichthyans remains limited, raising further questions about the mineralization processes within the individual teeth of one tooth file. Chondrichthyan teeth are arranged in files and rows approximately perpendicularly aligned along the jaws, including both functional and replacement teeth. Therefore, teeth of

different ontogenetic stages are present in the jaws at any post-embryonic developmental stage. This allows us to study the ontogenetic development of the mineralized tissues that form the teeth, *i.e.*, enameloid and different types of dentine, from a single arcade. We report the general histology as well as tooth development in three taxa *Ctenacanthus*, *Maghriboselache*, and *Phoebodus* from the Devonian of Morocco. All taxa preserve tooth files *in situ*. The development of the mineralization can be traced in all three taxa, starting with the outer enameloid layer and finishing with the mineralization of 'osteodentine' in the tooth base.

Day 2, Session 4A, Großer Saal, 09:00 – 09:15
Recording allowed: No

Using methods from computational palaeobiology to elucidate the evolutionary origin of teeth

***Madleen Grohganz[1], Antonio Ballell Mayoral[1], Benjamin Griffin[1,4], Humberto G. Ferron[1,3], Zerina Johanson[2], Emily J. Rayfield[1], Philip C. J. Donoghue[1]**
[1]University of Bristol, UK; [2]Natural History Museum, London, UK; [3]University of Valencia, Spain; [4]Liverpool John Moores University, UK

Teeth constitute a key innovation underpinning the evolutionary and ecological development of jawed vertebrates. To learn more about the evolutionary origin of teeth, we must study the tooth-like structures of their jawless ancestors. We integrate evidence from different computational biomechanics methods and histology to test hypotheses of feeding, function, and growth of the tooth-like structures of heterostracans. Computational fluid dynamics (CFD) analysis allows us to reject the hypothesis of the anteriorly-facing denticles on the oral plates being an adaption to suspension feeding. Internal growth dynamics analysis indicates that heterostracan oral plates grew in a similar way to the dermal skeleton and does not show patterns of replacement in the denticles, which we expect if they were homologous to teeth. We use finite element analysis (FEA) and bone density calculations to test the mechanical function hypothesis. FEA stresses in the shaft of the oral plate are correlated with bone density. The anterior part of the oral plate shows the highest bone density, indicating a specific adaption of the microstructure to a mechanical function. Range of motion (ROM) analysis allows us to constrain the movement and opening angle of the oral plates, indicating deposit feeding as the most likely mechanical feeding mode.

Day 1, Session 1A, Großer Saal, 09:45 – 10:00
Recording allowed: No

Investigating global plate models and diversity metrics to decipher the spatio-temporal evolution of Cambrian echinoderms

Pauline Guenser[1], Léa Tremeau[1], Melly Lauze[1], Claude Monnet[2], Elise Nardin[3], Martina Nohejlová[4], Bertrand Lefebvre[1]
[1]Université Claude Bernard Lyon 1, France; [2]Université de Lille, France; [3]Université Toulouse III – Paul Sabatier, Toulouse, France; [4]Czech Geological Survey, Czechia

The early Palaeozoic biodiversification is the most significant radiation of marine ecosystems of Earth's history. It started with the apparently sudden appearance of major phyla of metazoans during the 'Cambrian Explosion' (*c.* 540 Ma) and followed by a significant diversification during

the Great Ordovician Biodiversification Event (*c.* 470 Ma). These two events appear today to be part of a single and long-term early Palaeozoic biodiversification. Recent investigations even suggest a progressive set up of a bimodal latitudinal diversity gradient (LDG). However, the choice of global plate models can impact deep-time palaeobiological studies, shifting the palaeolatitudinal locations of early Palaeozoic fossil occurrences up to 30°. We aim to investigate these biases by quantifying the evolution of latitudinal distribution of Cambrian echinoderms using different global plate models and diversity metrics. We then compute and compare different latitudinal diversity curves in order to find a common pattern by calculating an average location of each fossil occurrence based on permutation methods.

Day 2, Session 7C, Konferenzräume 3&4, 16:30 – 16:45
Recording allowed: No

A facilitated grouped access route for major-to-trace elemental mapping and speciation of flat fossils at the PUMA beamline of the SOLEIL synchrotron, France

Pierre Gueriau[1,2], Sebastian Schöder[3]
[1]Université Paris-Saclay, France; [2]University of Lausanne, Switzerland; [3]Synchrotron SOLEIL, France

Synchrotron-based X-ray fluorescence major-to-trace elemental mapping and chemical speciation of elements of interest using X-ray absorption spectroscopy are increasingly used for the anatomical and/or taphonomic study of flat fossils. The standard route for obtaining beamtime at the synchrotron can, however, prove complicated for 'novice' users and poorly adapted to the timing of some palaeontological research: access is allocated based on highly technical calls for proposals that are open twice per year and typically require 6–12 months from submission to experiment. As an alternative, we used the 'block allocation group (BAG)' route to implement facilitated access at the PUMA beamline (SOLEIL synchrotron, France). This grouped proposal framework aims to provide access for studies relying on only one or too few fossils to justify individual beamtime, as well as easier and more efficient access for new groups, while also benefiting the 'synchrotron palaeontology' community by enhancing synergy among existing 'expert' user groups. In this contribution, we will present the workflow of this BAG and detail the technical capabilities and constraints of the instruments available at the PUMA beamline, particularly regarding sample size and preparation, illustrated by recently collected data. We will also address possible future directions.

Day 2, Session 4B, Kleiner Saal, 10:15 – 10:30
Recording allowed: Yes

Top 10 disparity metrics you can use; number 10 will surprise you!

Thomas Guillerme
University of Sheffield, UK

Disparity metrics are a common tool in palaeobiology to measure biodiversity changes in the past focusing more on species traits rather than on species numbers (diversity). This can be used to measure summarize complex occupancy patterns in space and/or time across communities and/or populations in response to some stressors such as competition, climate change or mass extinctions. For the last 20 years, theory regarding the link between disparity and biological mechanisms has thrived in palaeobiology yet surprisingly little research has been done on what the disparity metrics

are actually capturing, often focusing on a handful of metrics. In the meantime, in ecology, a rich literature has been published on functional ecology (the equivalent of disparity) focusing of different properties of numerous metrics but often with little emphasis on linking them to long term biological mechanisms. By summarizing the work from both rich fields and through theoretical work with colleagues I propose a more comprehensive protocol to select disparity metrics based on both which mechanism one wants to research and the properties of different broad categories of metrics. Spoiler alert: there is no one-metric-fits-all (or 10 for that matter).

Day 2, Session 7B, Kleiner Saal, 16:15 – 16:30
Recording allowed: Yes

Colonial green algae in the Cambrian plankton: 'acritarchs' shaped by animal grazing

Thomas H. P. Harvey
University of Leicester, UK

The pre-Mesozoic phytoplankton is represented largely by acritarchs, a mixed group of organic-walled microfossils of poorly resolved affinities and ecologies. A major turnover in acritarchs across the Ediacaran–Cambrian transition implies a reshaping by escalating animal interactions. However, this hypothesis is difficult to test without better knowledge of acritarch biology. Here I describe exceptionally preserved acritarchs from the Forteau Formation, Newfoundland and Labrador, Canada (Cambrian Stage 4, *c.* 510 Ma). Alongside typically cyst-like acritarchs are specimens with colonial organization. The colonies consist of rings or plates of interconnected, geometrically arranged cells, supporting a determinate (coenobial) mode of colony formation known only among green algae. The fossils differ in detail from modern freshwater groups and apparently represent an earlier convergent radiation in marine settings. Known trade-offs between sinking risk and predator avoidance in colonial phytoplankton point to adaptations against grazing by Cambrian animals. The new fossils reveal that not all Cambrian acritarchs are unicellular resting cysts, and support molecular biomarker evidence for green algae in the early Palaeozoic phytoplankton. They raise the question of how widespread such colonies might have been: a review of the literature suggests that fragmentary colonies might occur more widely in palynology collections and deserve further scrutiny.

Day 2, Session 7C, Konferenzräume 3&4, 17:15 – 17:30
Recording allowed: No

Convergent evolution and ecological substitution: a quantitative morphological approach

Carolin Haug
Ludwig-Maximilians-Universität München, Germany

Convergent evolution is more than an ad hoc explanation of difficult homoplasies in phylogenetic reconstructions. Modern conservation biology has recognized that convergent evolution strengthens ecosystems by enhancing their resilience. If several lineages with comparable ecological functions are present within a specific habitat, this represents a case of redundancy: if one becomes extinct, the ecological function can still be fulfilled by the second one. In the fossil record, this phenomenon can lead to faunal turnovers and ecological substitutions, yet making good cases for

such a substitution is often not simple. I will discuss several candidate cases, especially of Insecta. For example, the group of lacewings, Neuroptera, has played a major role in the early diversification of Holometabola and flowering plants in the Mesozoic, but has decreased since then. Many ecological functions have therefore, supposedly, been taken over by various other groups, such as moths, rove beetles, praying mantises, or also other lacewing groups. I will present evaluations of these cases based on a quantitative morphological comparison using multivariate statistics. This approach puts convergence as a phenomenon into a more scientific framework, allowing to apply strict criteria and objective views so far not available.

Day 2, Session 7B, Kleiner Saal, 16:45 – 17:00
Recording allowed: Yes

Thermal taphonomy experiments challenge ultrastructural preservation in the Chengjiang yunnanozoans

***Kaiyue He[1,2], Jian Han[2], Jianni Liu[2], Qiang Ou[3], Giovanni Mussini[4], Mike Reich[1,5], Degan Shu[2]**
[1]Staatliches Naturhistorisches Museum Braunschweig, Germany; [2]Northwest University, China; [3]China University of Geosciences, China; [4]University of Cambridge, UK; [5]Ludwig-Maximilians-Universität München, Germany

Yunnanozoans from the Chengjiang fossil Lagerstätte (Cambrian Stage 3) are a highly controversial group of fossil deuterostomes. Recent studies have claimed the observation of ultrastructures including cellular cartilage and microfibrils in yunnanozoan branchial arches. However, the presence of these micron to nano-scale details has been questioned on taphonomic and morphological grounds. Scanning electron microscopy (SEM) analyses reveal that the organic matter in yunnanozoan gill arches is preserved as homogeneous carbonaceous films, and Raman spectroscopy indicates that these structures were subject to maximum burial temperatures of approximately 261–306°C. To test the impact of these post-depositional conditions on centimetre-scale to ultrastructural preservation in yunnanozoans, we present a set of thermal taphonomy experiments on the cartilages of amphioxus and living vertebrates at temperatures ranging from 150°C to 300°C, each lasting 48 hours. Centimetre to micrometre-scale structures remained visible at temperatures up to 300°C. By contrast, cartilage ultrastructures including the iconic paired, septum-bearing cartilage lacunae and bundles of collagen fibers were partially preserved in thermal experiments at and below 250°C, but not recognizable after 48 hours of exposure at 300°C. Considering the highest temperatures experienced by yunnanozoan fossils, these results fail to support cellular-scale preservation of cartilaginous tissues in the Chengjiang biota.

Day 1, Session 3A, Großer Saal, 15:15 – 15:30
Recording allowed: No

Diversity and biogeography of Old-World killifish from the Oligocene until today

***Andrea Herbert Mainero, Bettina Reichenbacher**
Ludwig-Maximilians-Universität München, Germany

Present-day toothcarps (Cyprinodontiformes, killifish) are famous for their amazing diversity. Numerous fossils are known from Oligocene and Miocene sediments from the Old-World (Eurasia and Africa). However, details on species, their distribution and timelines remain unclear. Here we

present a literature-based review to uncover ancient species diversity and historical biogeography of Old-World killifish. We focus on the skeleton-based fossil record, which comprises 38 species from the Lower Oligocene to the Upper Miocene. The species belong to the Eurasian families Aphaniidae and Valenciidae (29% each), the African family Pantanodontidae (13%), and to some unknown lineages (29%). Valenciidae and Aphaniidae have their first appearance in the Central Paratethys and Iberian Peninsula, and later they dispersed towards the Eastern Paratethys. Ancient Valenciidae diversity was high during the Oligocene up to the Middle Miocene, whereas the Aphaniidae, today a diverse and adaptable family, only diversified in the Middle Miocene, likely due to climate and palaeogeographical events. The Pantanodontidae appeared during the Upper Oligocene and remained in the Central Paratethys and Iberian Peninsula up to the Middle Miocene. If they came from Africa or were already in Europe is unknown. The results suggest that the Paratethys was an important area for the evolution of Old-World killifish.

Day 2, Session 4A, Großer Saal, 10:15 – 10:30
Recording allowed: No

Evolution of growth in alligators and caimans informed by osteohistology of the Eocene alligatoroid *Diplocynodon hantoniensis*

Devin Hoffman[1], Erika Goldsmith[2], Alexandra Houssaye[3], Susannah C. R. Maidment[4], Ryan N. Felice[1], Philip D. Mannion[1]
[1]University College London, UK; [2]Virginia Tech, USA; [3]Muséum national d'Histoire naturelle, Paris, France; [4]Natural History Museum, London, UK

Osteohistological studies on extant alligatoroids show living alligators and caimans exhibit seasonal growth, with comparable growth rates. However, the dearth of studies on extinct alligatoroids makes it unclear if this shared condition indicates convergent evolution or the ancestral condition in alligatoroids. To address this discrepancy, we conducted the largest monospecific osteohistological studies of fossil crocodylians to date, providing unique insight into the intraspecific variation in growth of a fossil taxon. We describe the bone microstructure and histology of the early-diverging alligatoroid *Diplocynodon hantoniensis* from the late Eocene of the UK, based on a sample of nine femora and quantitatively reconstruct growth rates. The microanatomy of *D. hantoniensis* shows moderate bone compactness and histologic features consistent with those of extant alligatoroids. Samples vary greatly in the degree of remodelling and vascularity, as well as preserving features such as Sharpey's fibres, highlighting the importance intraspecific variation. Our ontogenetic assessment indicates our sample captures a range of skeletally immature to mature individuals. Growth reconstruction shows determinate growth with strong seasonality. This in-depth look into a fossil alligatoroid indicates seasonality and growth rates were established near the base of Alligatoroidea and predicts that other extinct species of the clade likely exhibited similar growth.

Day 1, Session 3C, Konferenzräume 3&4, 14:45 – 15:00
Recording allowed: No

talks

Comparison of model-based predictions of body size and body proportions with empirical data reveals differential sets of growth rate parameters across trilobites

Melanie J. Hopkins
American Museum of Natural History, USA

Trilobites had a heavily biomineralized exoskeleton for almost the entirety of their post-hatching life history. Based on this record, it is evident that trilobites underwent an interval where body segments and articulation points were still being generated followed by an interval where both had ceased but the individual continued to molt and grow. The number of thoracic tergites thus provides a size-independent measure of relative time, making it possible to estimate growth rates for species with large samples of articulated specimens. Using the results of these studies, I created a generative model of trilobite growth. Focusing on a universally shared transition in life history as a comparison point between model output and empirical data, I find that even with conservative parameter ranges, a large range of body sizes and proportions are theoretically achievable, while realized body sizes and proportions are constrained in comparison. Approximate Bayesian computation indicates that while the shape of the best-fit growth gradient is similar, body size and body proportions in trilobites with low numbers of thoracic tergites are best fit to model output run using higher initial sizes (*e.g.* large size at hatching) and higher growth rates compared to trilobites with larger numbers of thoracic tergites.

Day 2, Session 7B, Kleiner Saal, 17:00 – 17:15
Recording allowed: No

A revision of *Praearcturus gigas* and a critical review of Palaeozoic scorpion gigantism.

Richard J. Howard[1], Gregory D. Edgecombe[1], David A. Legg[2]
[1]Natural History Museum, London, UK; [2]Independent

Praearcturus gigas is a large arthropod of disputed affinity from the fluvial St. Maughans Formation (Lower Devonian, Lochkovian) of the Old Red Sandstone (Anglo-Welsh basin). Originally described as an isopod in 1870s, and subsequently compared with various groups, it was re-described with limited illustration as a gigantic scorpion in the 1980s. Recently, this interpretation has again been challenged, warranting a more substantial revision of the material. We present a re-description of the *P. gigas* type material and assign several other specimens, including new junior synonyms, from the St. Maughan's Formation to this taxon. We illustrate several characters supporting a scorpion affinity for *P. gigas*, including a sternum which is synapomorphic with the Silurian stem-group scorpions *Eramoscorpius brucensis* (Wenlock, Canada) and *Palaeophonus caledonicus* (Llandovery, Scotland), in addition to autapomorphic lateral epimera that demonstrate its atypical, perhaps amphibious ecology. Furthermore, we collected size data pertaining to all other supposed examples of Palaeozoic scorpion gigantism, and critically assess their prevalence in the fossil record. *P. gigas* is unique among these. At around 1m in length it is the largest scorpion by a considerable margin and was adapted to a much younger and less developed terrestrial biosphere than its wholly Carboniferous relatives.

Day 1, Session 1C, Konferenzräume 3&4, 09:00 – 09:15
Recording allowed: Yes

Born for greatness: On the origin and body size evolution of lamniform sharks (Chondrichthyes; Elasmobranchii)

***Patrick L. Jambura[1], Julia Türtscher[1], Eduardo Villalobos-Segura[1], Manuel A. Staggl[1], René Lauer[2], Bruce Lauer[2], Kenshu Shimada[3,4], Gavin J. P. Naylor[5], Charlie J. Underwood[6], Christopher J. Duffin[7], David J. Ward[7], Jürgen Kriwet[1]**

[1]University of Vienna, Austria; [2]Lauer Foundation for Paleontology, Science & Education, USA; [3]DePaul University, USA; [4]Sternberg Museum of Natural History, USA;[5]Florida Museum of Natural History, USA; [6]Birkbeck, University of London, UK; [7]Natural History Museum, London, UK

In the current genomic era, palaeontology remains crucial for understanding macroevolutionary patterns and dynamics. Despite a relatively rich fossil record, the early evolution of lamniform sharks, a group including iconic predators like the white shark and the extinct †*Otodus megalodon*, remains poorly understood due to the scarcity of complete fossils. The Late Jurassic shark †*Palaeocarcharias stromeri*, currently considered the oldest lamniform, displays a mosaic of orectolobiform (body) and lamniform (dental) traits, complicating its classification. Our revized morphological and phylogenetic analysis of †*P. stromeri* from the Solnhofen Archipelago confirms it as a stem-group lamniform, with orectolobiform features likely being adaptations to a benthic lifestyle. Ancestral state analyses suggest that lamniform sharks originated in the early Middle Jurassic as small, benthic coastal sharks. In contrast to previous studies, our results show that the shift towards larger body size in lamniform sharks was not abrupt, but gradual and was linked to the transition into the pelagic realm during the Early to early Late Cretaceous. This study highlights the importance of integrating fossil data into macroevolutionary analyses to improve ancestral state reconstructions. We thus advocate for future studies to combine molecular and fossil data, to improve the accuracy of evolutionary trait analyses.

Day 2, Session 4A, Großer Saal, 09:15 – 09:30
Recording allowed: No

The structure of the marine carbonate record: implications for reconstructing evolutionary processes

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Reconstructing processes and their rates from the rock record requires a model of how time is preserved in it. Currently we do not know: experiments over human timescales yield disparate models for different depositional environments. Extrapolating rates obtained from experiments to geological time scales clearly yields incorrect results. We put forward a set of methods that allow formulating testable hypotheses about the structure of the rock record and processes reconstructed from it. We focus on tropical carbonate platforms, because of the strong contribution of biological and diagenetic self-organization, not addressed by models pertaining to siliciclastic systems studied so far. The proposed methods include a stratigraphic forward model of carbonate platforms, a model of a dynamic diagenetic system of aragonite dissolution, and a non-parametric method of

age-depth model estimation. We illustrate how the mode and tempo of evolution, simulated and empirical, can be evaluated under a multiple hypotheses framework.

Day 2, Session 7B, Kleiner Saal, 17:15 – 17:30
Recording allowed: No

Metacommunity structural changes of Antarctic invertebrates over the latest Maastrichtian (72.1 to 66 million years ago)

***Tasnuva Ming Khan[1,2,3], Rowan J. Whittle[2], James D. Witts[4], Huw J. Griffiths[2], Andrea Manica[1], Emily G. Mitchell[1,3]**
[1]University of Cambridge, UK; [2]British Antarctic Survey, UK; [3]Museum of Zoology, University of Cambridge, UK; [4]Natural History Museum, London, UK

Seymour Island, Antarctica has one of the most expanded onshore Maastrichtian-Danian sedimentary successions in the world. The López de Bertodano (KLB) Formation (~70-65.6 Ma) covers fluctuating sea temperatures, including cold snaps, and warming from Deccan Trap volcanism. Here we study community dynamics of latest Cretaceous Antarctic invertebrates using fossils from the Zinsmeister Collection, Paleontological Research Institution, USA. Our data set consisted of 7400 fossils from 85 genera across bivalves, gastropods, cephalopods, echinoderms, brachiopods, scaphopods, polychaetes and octocorals, from 324 localities spanning six informal sub-units, KLBs 4-9. Due to positional uncertainty of the KLB boundaries, we performed sensitivity analyses to ensure robust results. We found that the number of significantly non-random taxonomic co-occurrences increased throughout this period. To investigate metacommunity structure that may arise from taxa interactions or environmental filtering, we used the Elements of Metacommunity Structure framework. We found quasi-nested clumped metacommunities in KLBs 7-8, suggesting sites contain a subset of species from a larger pool, developing into quasi-Clementsian metacommunities in KLB 9, where similar taxa respond synchronously to environmental gradients, thus showing more specialization. Our results demonstrate increasing ecological complexity throughout the Cretaceous and reinforces the presence of a single, rather than two-fold, Cretaceous-Palaeogene extinction in the Southern Hemisphere.

Day 2, Session 6B, Kleiner Saal, 14:30 – 14:45
Recording allowed: Yes

Stratigraphic trends in chitinozoan teratology across the Silurian Mulde Event in the distal Baltic Basin (Gotland, Sweden)

***Carolina Klock[1], Mikael Calner[2], Patrick I. McLaughlin[3], Poul Emsbo[4], Thijs R. A. Vandenbroucke[1]**
[1]Ghent University, Belgium; [2]Lund University, Sweden; [3]Illinois State Geological Survey, USA; [4]United States Geological Survey, USA

The middle Silurian Mulde Event, or 'Big Crisis', was responsible for the global near-extinction of graptolites and significant turnover of most pelagic fossil groups. The Mulde Event was first described from outcrops in Gotland where the exposed units have been exhaustively studied. Here we focus on the new Stora Sutarve core, accessing the deeper water Homerian facies of the island. This study is part of a wider research effort using stress-induced chitinozoan teratology and

geochemistry to probe the causal mechanisms of biogeochemical events. Chitinozoan teratology has been observed in most Silurian Events, but not yet for the Mulde. We confirm its presence, and test for spatial gradients across onshore-offshore facies. Bulk rock $\delta^{13}C$ through 46 m of the core rise to +3 ‰. Chitinozoan species *Conochitina pachycephala* and *Margachitina margaritana*, confirm a lower Homerian age and that the carbon isotope excursion represents the Mulde Event. Teratological specimens associated with and constrained within the event include double-chambered specimens of *Ancyrochitina* and miniaturized *Linochitina*. This establishes chitinozoan teratology as a feature of the Mulde Event, which can now be used to ground-truth geochemical (trace metal) data that is being generated to better understand the root causes of the extinction.

Day 2, Session 6A, Großer Saal, 14:30 – 14:45
Recording allowed: No

Estimating lineage-specific diversification rates on phylogenies

***Bjørn Tore Kopperud, Sebastian Höhna**
Ludwig-Maximilians-Universität München, Germany

Investigating species diversification is one of the key interests in macroevolution. Do some clades in a phylogeny speciate more often than others? To answer this question, we use the birth-death-shift process to model shifts in the tempo of origination. We present Pesto, a new software and method for estimating lineage-specific diversification rates, that is viable for extant phylogenies with thousands of species. In validating against simulated phylogenies, we recover precise estimates of lineage-specific diversification rates, and we find few to zero false positive inferences of rate shifts. In empirical phylogenies spanning major groups across the Tree of Life, we find support for rate shifts across all groups. Notably, younger groups exhibit more frequent diversification rate shifts than older groups. Additionally, most phylogenies experienced an overall increase in net diversification. Moreover, we explore the use of the fossilized-birth-death-shift process, and assess the impact of modelling fossil sampling on estimates of extinction, as well as estimates of lineage-specific shifts in diversification rates.

Day 1, Session 1B, Kleiner Saal, 09:30 – 09:45
Recording allowed: No

Do ecological communities age?

Björn Kröger[1], Alexis Rojas[2]
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Ecological communities change over geological time. They emerge, flourish and perish with intervals of temporal consistency and transience at multiple spatial and temporal scales. Palaeontologists are since a long time aware of the spatio-temporal granularity of change in ecological communities. This is reflected in concepts, such as Arthur J. Boucot's 'Ecologic-Evolutionary Units' and Jack Sepkoski's evolutionary faunas. The empirical patterns on which they are based have been confirmed many times since, but their theoretical explanation has changed over time. Increasing attention is being paid to the dynamics of transience, known from complex systems. The contingency and irreversibility inherent in the dynamics of complex systems

leads to phenomena of ageing, which may also occur in ecological systems. Here we analyse the temporal change within Phanerozoic fossil marine assemblages, identified by multilevel clustering on a multilayer network representation of fossil occurrences, and interpreted as eco-evolutionary communities. We refer to the concept of ecological memory and treat the median age of the Linnean taxa present in each geological stage as a proxy for the memory length of the communities. The results show that changing ecological memory must be considered as a factor in the evolutionary dynamics of ecological communities.

Day 2, Session 4C, Konferenzräume 3&4, 10:15 – 10:30
Recording allowed: Yes

Synchrotron X-ray tomography sheds light on the anatomy and the phylogenetic affinities of the enigmatic Thylacocephala

Thomas Laville[1,2], Marie-Béatrice Forel[2], Sylvain Charbonnier[2]
[1]Ludwig-Maximilians-Universität München, Germany; [2]Muséum nationald'Histoire naturelle, Paris, France

Known from at least the Silurian to the Late Cretaceous, thylacocephalans are enigmatic fossil euarthropods characterized by a folded shield, hypertrophied compound eyes, three pairs of raptorial appendages, eight pairs of gills and an eight to 22-segmented posterior trunk. Many questions remain concerning their phylogenetic affinities. They have been tentatively placed within various pancrustacean groups such as thecostracans, malacostracans or remipeds. These uncertainties on their phylogenetic relationships is mostly due to a lack of knowledge on their tagmatization, especially on the number, nature and morphology of their various appendages.Conventional micro-computed X-ray tomography has proven to be efficient in order to reconstruct the internal anatomy of thylacocephalans. However, it did not provide insight into their various kinds of appendages. Thus, we decided to apply Synchrotron X-ray tomography to *Dollocaris ingens* Van Straelen, 1923 from the La Voulte-sur-Rhône Lagerstätte, Ardèche, France (Callovian, Middle Jurassic). The presence of cephalic appendages, including mandibles, an anterior trunk, including the three raptorial appendages, and a posterior trunk has been demonstrated. The anatomical work produced new characters which could be used to test their phylogenetic affinities. The phylogenetic analyses suggest that thylacocephalans form a pancrustacean monophyletic group, related to malacostracans.

Day 2, Session 4B, Kleiner Saal, 10:00 – 10:15
Recording allowed: No

Crushing 3D-printed ammonites to study the relationship between curvature and failure

Robert Lemanis[1], Erynn Johnson[2], David Peterman[3], Karsten Tittmann[4]
[1]Universität Bonn, Germany; [2]Yale University, USA; [3]The Pennsylvania State University, USA; [4]Technische Universität Dresden, Germany

Physical replicas of the shells of extinct cephalopods have been used in experimental studies since at least the 1970s, and mathematical models were some of the first subjects of computational mechanical studies in palaeontology. While historically, modelling clay has been used to build these

shells, today 3D printing allows us to build models with greater precision, more detail, and in less time. We exploit this technology to print a range of cephalopod shells with variable morphology in order to test the potential impact of curvature on the failure mechanics of the shells. Quasi-static compression tests are performed to compare failure patterns and the work needed to break different morphologies. We can show that by changing the morphology of the internal shell walls, initial failure can be localized to non-fatal regions: explainable through a potential relationship between curvature, out-of-plane displacement, and initial crack location. A quantitative relationship between work and morphology is hampered by highly variable, and inconsistent performance of 3D printed models. Diagnosing the functional implications of changes in septal geometry is the first step towards understanding the proximal causal aspects of the long-term trends towards higher morphological complexity and its covariation with environmental parameters.

Day 1, Session 3C, Konferenzräume 3&4, 14:00 – 14:15
Recording allowed: Yes

New taxa and palaeoecological insights from the latest Ediacaran Aar Member of southern Namibia

Alexander G. Liu[1], Elkan Utoni[2,3], Buck Blake[1], Brennan O'Connell[1], William J. McMahon[1], Catherine E. Boddy[1], Sean McMahon[4], Helke Mocke[2], Simon A. F. Darroch[5], Susannah C. J. Scott[1], Collen-Issia Uahengo[3], Philip B. Vixseboxse[1], Xiaopeng Wang[1,6]
[1]University of Cambridge, UK; [2]Geological Survey of Namibia, Namibia; [3]University of Namibia, Namibia; [4]University of Edinburgh, UK; [5]Senckenberg Forschungsinstitut und Naturmuseum Frankfurt, Germany; [6]Nanjing Institute of Geology and Palaeontology, CAS, China

The terminal Ediacaran Period (~550–538 Ma) lies squarely between diverse fossil assemblages of the Ediacaran macrobiota, which include stem-group metazoans, and early Cambrian crown-group representatives of most animal phyla. Terminal Ediacaran strata should therefore be expected to contain fossils that offer direct insight into the establishment of the major animal body-plans. Fieldwork within the ~548 Ma Aar Member of the Nama Group, southern Namibia, has yielded a remarkable array of new specimens and fossil-bearing bedding planes. A large stem-group hexactinellid with distinct layers of unfused, non-mineralized skeletal elements sheds new light on the Ediacaran evolution of sponges. Exceptionally preserved matground ecosystems reveal novel tubular and branching taxa, and for the first time permit palaeoecological study of demonstrably in situ 'Nama type' matground palaeocommunities. Comparison with Ediacaran matground fossil assemblages from Australia and Russia reveals clear differences in community composition, potentially supporting a biotic turnover around 550 Ma. However, recognition of abundant new taxa suggests that the terminal Ediacaran biosphere was considerably more taxonomically diverse than has previously been claimed. These discoveries allow us to track character acquisition amongst specific groups, and fill a key gap in knowledge regarding the initial radiation of early animal clades.

Day 2, Session 7C, Konferenzräume 3&4, 16:45 – 17:00
Recording allowed: No

talks

Biogeographic shifts driven by faunal turnover during the Ordovician-Silurian transition

Shasha Liu[1], Qijian Li[1], Lin Na[1], Wolfgang Kiessling[2]
[1]Nanjing Institute of Geology and Palaeontology, China; [2]Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

The first of the five major Phanerozoic extinctions unfolded near the Ordovician/Silurian boundary, leading approximately to an 85 % decline of marine species. The impact of the extinction varied across higher taxa, with complete loss in some groups, partial declines in many, and others navigating through the end-Ordovician extinctions relatively unscathed. However, the translation of these changes into first-order biogeographic patterns remains elusive. Using network analysis and a large compilation of fossil occurrences, we delineate bioregions of marine invertebrates across the Ordovician/Silurian boundary. Simultaneously, by integrating the spatial and temporal dynamics of diverse biological assemblages, including global diversity, beta diversity, and alpha diversity, we scrutinize how faunal turnover and nestedness influence palaeontological spatial patterns. Our findings indicate that the decline in beta diversity during the Hirnantian and Rhuddanian stages was primarily driven by a significant drop in faunal turnover. Environmental stress during the main pulses of the extinction even led to an increase in nestedness, similar to modern cases where fish communities affected by agricultural pollution show higher nestedness. These results unveil crucial environmental drivers, providing insights into the co-evolutionary mechanisms of life processes and the environment during mass extinctions.

Day 2, Session 5B, Kleiner Saal, 11:00 – 11:15
Recording allowed: No

Theoretical and functional analysis of insect wings reveals attraction to functionally-adequate not functionally-optimal morphologies

***Yuming Liu, William J. Deakin, Pablo Milla Carmona, Emily J. Rayfield, Philip C. J. Donoghue**
University of Bristol, UK

Insects are the earliest flying animals and, ultimately, the most diverse animal lineage. Aerodynamic performance is presumed to impose intense selection pressure on wing morphology and therefore many studies assume that insect wing morphology has also evolved to be optimal for flight. We test this hypothesis using a theoretical morphospace approach to characterize morphological and functional variation of wing shape, sampling over 4,000 species of insects to derive a theoretical morphospace that expanded beyond realized variation, from which theoretical wing shapes could be interpolated and analysed functionally. We tested the functional performance of theoretical wings through blade element analysis and finite element analysis to estimate aerodynamic force and breakage resistance, and then used a Pareto ranking approach to identify the optimal wing shape for the trade-off between these metrics. Additionally, we conducted a series of macroevolutionary analyses to explore the relationships between phylogeny, wing morphology, and functional optimality. Our results show that sampled wings perform highly for breakage resistance and moderately for aerodynamic performance, and moderately for their trade-off. This

observation implies that natural selection has not led to the evolution of functionally optimal wing morphologies but, rather, toward local adaptive solutions that are functionally adequate.

Day 1, Session 1A, Großer Saal, 10:00 – 10:15
Recording allowed: No

Exceptional preservation of soft-tissues in late Palaeozoic amphibians documents terrestrialization and life cycle changes

***Antoine Logghe [1], Pierre Gueriau[2,3], François Clarac[1], Jean-Sébastien Steyer[1], Sophie Sanchez[4]**
[1]Muséum national d'Histoire naturelle, France.; [2]Université Paris-Saclay, France.; [3]University of Lausanne, Switzerland.; [4]Uppsala University, Sweden

Despite a scarce fossil record, particularly for Palaeozoic vertebrates, soft tissue remains are crucial for revealing key aspects of palaeobiology and ecology. We present here unprecedented occurrences of both skin and eye soft tissue remains in both Carboniferous and Permian amphibians from France. This discovery sheds new light on the evolution of early amphibians. We describe in detail the first preserved inner-structure of epidermal skin in a 'metamorphic stage' eryopoid temnospondyl from the Permian of Franchesse (Aumance Basin), which offers novel information on the transition of life to land through ontogeny. We also document possible morphological variations of epidermal scales along the body (*i.e.* belly, tail, limbs) in dissorophoid temnospondyls from the late Carboniferous (Kasimovian) of Montceau-les-Mines (Massif Central, France) using advanced imaging techniques, particularly synchrotron-based X-ray fluorescence major-to-trace elemental mapping. Such a regionalization pattern of epidermal scales is only known from Sauropsida, thus questioning the idea that the epidermis of tetrapods evolved from a 'naked skin' to a cornified 'scaly skin'. Lastly, we report the oldest preliminary evidence of a tetrapod eye-structuration in these amphibians, on which further investigations could enhance our understanding of visual capacities and changes in the eye from aquatic to terrestrial lifestyles.

Day 1, Session 2B, Kleiner Saal, 11:15 – 11:30
Recording allowed: No

Cuticle ultrastructure of the Early Devonian trigonotarbid arachnid *Palaeocharinus*

***Emma J. Long[1,2], Gregory D. Edgecombe[1], Paul Kenrick[1], Xiaoya Ma[2]**
[1]Natural History Museum London, UK; [2]University of Exeter, UK

The cuticle is a key evolutionary innovation that played a crucial role in arthropod terrestrialization. Extensive research has elucidated the chemical and structural composition of the cuticle in extant arthropods, while fossil studies have informed our understanding of cuticle evolution. This study examines the three-dimensionally preserved cuticular structure of the Early Devonian trigonotarbid arachnid genus *Palaeocharinus*, from the Rhynie chert of Scotland (~408 Ma). Trigonotarbids, an extinct group of tetrapulmonate arachnids, are among the earliest known unequivocally terrestrial arthropods, and thus may shed light on the evolution of terrestriality. Using high-resolution confocal laser scanning microscopy (CLSM), we reveal detailed morphological features at the nanometre

level. The external cuticle surface of *Palaeocharinus* is characterized by polygonal scales, sensilla, and small pores identified as the openings of dermal glands and wax canals. Internally, the cuticle exhibits polygonal clusters of pore canals, through which wax was transported from the epidermis to the surface. The pore canals twist along their vertical axes, reflecting the 'twisted plywood' or Bouligand arrangement of chitin-protein microfibril planes characteristic of modern arthropod cuticles. Overall, the cuticle of *Palaeocharinus* is characteristically thick relative to those of other extinct and extant chelicerates, such thickening being a possible adaptation to terrestrial life.

Day 1, Session 3B, Kleiner Saal, 14:00 – 14:15
Recording allowed: Yes

Selecting genes for phylogenetic analysis based on the geometry of gene-treespace

Xiumei Lu
University of Bristol, UK

Most gene families have a complex evolutionary histories that differ from one another and from species phylogenies because of events including gene deletions, transfers and duplications. Consequently, they are not equally informative of species phylogeny: how should we identify the most informative markers for inferring species phylogenies? Our approach is based on the idea that, given a set of species, every gene trees can be seen as the result of a distortion-inducing taxon subsampling strategy from the species tree. The overall similarity – shared evolutionary history, of all gene trees is therefore a function of the extent to which the considered gene trees resemble the unknown species tree. A *n*-dimensional treespace was constructed to represent the similarity of each gene tree to any other gene tree. We show that criteria that previous studies have proposed for identifying informative genes for phylogenomic analyses (*e.g.* high bootstrap support), tend to map close to the centre of treespace. Conversely, gene families that exhibit the characteristics anticipated of poor phylogenetic markers tend to map away from the centre. Accordingly, we suggest that the most efficient way to sample genes for phylogenomic analyses is to select them based on their occupation of treespace.

Day 1, Session 2C, Konferenzräume 3&4, 11:30 – 11:45
Recording allowed: No

Moulting and development in a freshwater prawn from the Late Cretaceous of Morocco

***Sinéad Lynch[1], Pierre Gueriau[1], Harriet B. Drage[1], Didier B. Dutheil[2], Sylvain Charbonnier[2], Allison C. Daley[1]**
[1]University of Lausanne, Switzerland; [2]Muséum national d'Histoire naturelle, Paris, France

Cretapenaeus berberus Garassino, Pasini and Dutheil, 2006 is a freshwater prawn (Dendrobranchiata, Penaeidae) from the Upper Cretaceous (Cenomanian) Kem Kem Group of Morocco. *C. berberus* is the only known freshwater penaeid, among the uncommon freshwater taxa in Dendrobranchiata. Newly discovered specimens allow us to analyse its growth patterns. Among the ~60 specimens of *C. berberus* examined, only a few are moults. Moults can be identified by their displaced carapace, resulting from an opening at the carapace posterior to enable shedding of the old exoskeleton.

Exceptionally preserved muscles in carcasses provide additional evidence to distinguish them from moults. Scanning electron microscopy revealed preserved endocuticle lamination, and will be used to investigate differences in cuticular microstructure between moults and carcasses. Differences in UV-photoluminescence between moults and carcasses were also tested for, but none were observed. Carapace lengths of *C. berberus* range from ~2 to 20 mm. Early larval stages are absent, with the smallest specimens being either late larval or early juvenile stages. The rostrum and fifth pereiopod get elongated in adults, and the pleopods become more curled and annulated. *Cretapenaeus berberus* provides Late Cretaceous evidence of a common moulting mechanism known from modern decapods and insights into the development of freshwater penaeids.

Day 1, Session 3B, Kleiner Saal, 14:15 – 14:30
Recording allowed: No

Osteosclerotic bone in a *Spinosaurus* vertebra supports an aquatic mode of life

Susannah C. R. Maidment[1,2], Zichuan Qin[2], Kathleen N. Dollman[3], Richard J. Butler[2]
[1]Natural History Museum, London, UK; [2]University of Birmingham, UK; [3]European Synchrotron Radiation Facility, France

The giant theropod *Spinosaurus* from the Late Cretaceous of Morocco is one of the most iconic dinosaurs, with heated debate about its mode of life. Traditionally considered to be a piscivorous terrestrial biped, the discovery of new specimens has led to a radical reinterpretation of its mode of life as the first known fully aquatic non-avian dinosaur. However, this interpretation has been challenged and remains highly controversial. Limited previous histological work has documented dense bone tissue similar to that found in marine tetrapods in the femora and neural spines. However, clear vertebral fossae and foramina have been interpreted to indicate conventional pneumatization of the vertebral column by an air sac system which would have counteracted osteosclerosis in other parts of the skeleton. We conducted the first high-resolution synchrotron micro-CT scanning of a *Spinosaurus* cervical vertebra and found a highly reduced pneumatic system and exceptionally dense internal osteosclerotic bone reminiscent of penguins and some modern crocodilians. Previous attempts to model aquatic habits in *Spinosaurus* have overestimated the extent of the air sac system, and its reduction and the likelihood of widespread, extremely dense bone throughout the skeleton is strongly supportive of an aquatic mode of life for this dinosaur.

Day 1, Session 3C, Konferenzräume 3&4, 15:00 – 15:15
Recording allowed: No

Climate change drives neoselachian extinctions over geological timescales

Gregor Mathes[1,2], Daniele Silvestro[3,4,5], Kristína Kocáková[1], Jaime Villafaña[6,7], Catalina Pimiento[1,8]
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Understanding what drives extinction in deep time is a major challenge in palaeontology due to the many biases and confounders in the fossil record. Neoselachians (modern sharks, rays, skates, and

their extinct relatives) have survived multiple environmental changes during their long evolutionary history, but experienced several episodes of elevated extinction. However, the causes behind these extinction patterns remain unclear. In this study we use a structural causal inference framework, specifically designed to account for fossil record biases, to analyse a comprehensive dataset of fossil neoselachian occurrences spanning the past 145 million years. Our findings reveal a strong link between global temperature and extinction risk, with extinction rates consistently increasing as global temperatures decrease. This relationship can be attributed to temperature's downstream effects on sea level and ocean productivity. Notably, the negative temperature-extinction relationship holds consistently across different time periods and taxonomic groups. This long-standing climate-driven extinction pattern contrasts sharply with modern extinction risks, where overfishing, not climate change, has emerged as the dominant threat to sharks and rays today. Our results suggest a significant shift in extinction dynamics, with human exploitation now shaping the fate of these species' evolutionary trajectories.

Day 2, Session 4C, Konferenzräume 3&4, 09:00 – 09:15
Recording allowed: No

talks

A new perspective on reduced squamation in Pachycormidae (Actinopterygii)

Erin E. Maxwell[1], Samuel L. A. Cooper[1], Giovanni Serafini[2], Günter Schweigert[1]
[1]Staatliches Museum für Naturkunde Stuttgart, Germany; [2]University of Modena and Reggio Emilia, Italy

Amongst early-diverging neopterygians, heavy, lepisosteoid-type rhomboid scales are typical, and likely represent the primitive condition in the clade. However, in many lineages scale reduction has occurred, resulting in the evolution of lighter, more flexible squamation. Pachycormidae is such a lineage of Mesozoic teleosteomorphs, characterized by a trend towards decreased mineralization of the body scales. However, in this group the presence of external hypermineralized tissues such as ganoine has usually been assessed macroscopically, and discussion of scale variation has lacked a phylogenetic context. Histological sections are described only for the asthenocormine *Pachycormus*; scales were observed to lack both ganoine and peg-and-socket articulation. We re-evaluated scale organization in Pachycormidae based on a new early-diverging hypsocormine from the Late Jurassic Nusplingen Plattenkalk, southern Germany. We assessed the presence of ganoine using direct observation, UV-fluorescence, and histological sections. Of these techniques, only histology revealed a ~2.5 µm-thick layer of ganoine. Based on these results, early-diverging hypsocormines retained very thin, lepisoteoid-type squamation, including ganoine on the surface of the body scales. The ganoine layer was therefore lost independently in the major pachycormid subclades. Future work on scale reduction and composition in fishes should emphasize comparative histology as the most reliable way to infer tissue organization.

Day 2, Session 5C, Konferenzräume 3&4, 11:30 – 11:45
Recording allowed: Yes

Decay experiments and the preservation potential of marine algae in the fossil record

***Rut Mayo de la Iglesia, Farid Saleh, Jonathan B. Antcliffe, Pierre Gueriau, Allison C. Daley**
University of Lausanne, Switzerland

Algae are a main constituent of modern and ancient ecosystems. Investigating their evolutionary history relies on understanding their past morphologies as preserved in the fossil record. This is challenged by the soft nature of algal cells, being subject to post-mortem decay before stabilizing as fossils. Yet, no work ever investigated the decay of algae in controlled experimental settings. Here, 36 algal samples of separate morphogroups were left to decay while buried in clay sediments for nine weeks. Cutting-edge multispectral imaging revealed that morphologies were stabilized shortly after death, regardless of the morphological complexity of the investigated taxon. Nevertheless, chemical compounds decayed over time, and pigments such as phycoerythrin and chlorophyll became almost undetectable after four and seven weeks of decay, respectively. An interesting finding is that some algal morphogroups showed cell compressions, or taphonomic artefacts, resembling structures previously described as fossilized nuclei in the rock record. As such, this study is a cornerstone for understanding the accuracy of the algal fossil record and offers insights into our interpretation of early life.

Day 1, Session 3A, Großer Saal, 15:00 – 15:15
Recording allowed: No

Neuroanatomy of a new galeaspid from the Silurian of Anhui (China) and implications for the evolution of the vertebrate head

***Xinyuan Meng[1], Davide Pisani[1], Zhikun Gai[2,3], Philip C. J. Donoghue[1]**
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The origin of jawed vertebrates is characterized by reorganization of the brain and sensory organs from the ancestral vertebrate condition. Constraining the pattern and sequence of these changes is challenged by scarce preservation of brain cases such that, for example, the condition in galeaspids is known in detail for only one species, *Shuyu zhejianensis*. To resolve the general condition of galeaspid head and sensory organs, we used synchrotron radiation X-ray tomographic microscopy to investigate the neurocranium of a new species from the Tangchiawu Formation (Silurian) of Anhui Province in China. Like Shuyu, the new species exhibits separation of the nasohypophyseal duct from the nasal sacs. However, the ends of the olfactory tracts are divergent, which is a feature previously found only in crown gnathostomes. A number of nerves arise from the optic tectum, connecting to the ophthalmic branch of the trigeminal nerve and other small nerves, reflecting a well-developed sensory modality. The vestibular region of the inner ear is more developed that in Shuyu. Our new data reveals neuroanatomical diversity among galeaspids, underlining the peculiar nature of osteostracan neuroanatomy and the more gnathostome-like condition of galeaspids which may reflect closer kinship than has been perceived hitherto.

Day 1, Session 2B, Kleiner Saal, 11:00 – 11:15
Recording allowed: No

talks

Fossil biomolecules illuminate biological affinities of enigmatic acritarchs

***Pjotr Meyvisch[1], Viktoria Baranyi[2], Ferenc Borondics[3], Manuel Bringué[4], Vânia Correia[4], Robert A. Fensome[4], Carolina Fonseca[5,6], Victoria J. García Muro[7], Pieter R. Gurdebeke[1], Stephen Louwye[1], Sandy M. S. McLachlan[8], Mariusz Niechwedowicz[9], Renaud Podor[10], Vera Pospelova[8], Christophe Sandt[3], Thomas Servais[11], Kasia K. Śliwińska[12], Henk Vrielinck[1], Jasmina Wiemann[13], Kenneth N. Mertens[14]**

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Understanding biological affinities of enigmatic organic-walled microfossils is crucial for reconstructing eukaryotic diversity, primary productivity, and environmental changes through time. Among these microfossils, acritarchs have long posed a challenge due to their, by definition, unknown or unconfirmed affinities with various eukaryotic groups. Modern eukaryotes with a significant microfossil record, such as dinoflagellates, pollen and spores of plants, and green algae, produce decay-resistant organic biomolecules (dinosporin, sporopollenin, and algaenan) that possess distinct molecular fingerprints. However, the extent to which these biosignatures can survive geological processes over time remains uncertain. We conducted infrared spectroscopic analyses on single-specimen Middle Ordovician–Holocene microfossils, including 86 acritarchs and 432 elements with known affinities, to assess the preservation and chemotaxonomical value of molecular biosignatures during natural and artificial thermal maturation. Our results show that taxonomically informative biosignatures from dinosporin, sporopollenin and algaenan can preserve well into the Palaeozoic and occasionally match those of coeval acritarchs. These new insights allow to ally some Palaeozoic acritarchs with prasinophytes and—likely—dinoflagellates (implying a significant extension of their fossil record). This study highlights the potential of deep-time biosignatures to improve our understanding of eukaryotic diversity, evolutionary timelines, and the ecological roles of extinct microeukaryotes in Earth's history.

Day 2, Session 6A, Großer Saal, 14:15 – 14:30
Recording allowed: No

Time-integrated biosignatures applied to new fossils combined with genomic evidence suggest an archosaurian origin of avian endothermy.

***Megan Miller, Jasmina Wiemann**
Johns Hopkins University, USA

Birds evolved the highest metabolic rates amongst extant animals, a trait that defines their ecological niches. However, the timing and origin of their metabolic endothermy is obscured in deep time; here we interrogate avian metabolic evolution via directional genomic insights and complimentary, geochemical fossil data. We surveyed n=17 amniote genomes for evidence of selection within n=7 protein-encoding orthologous genes of key enzymes involved with

mitochondrial aerobic respiration. Gene sequences were collected from NCBI, multi-aligned using PRANK, then converted to codon format via PAL2NAL and screened for selection in aBSREL. Positive selection was recovered in the archosaurian, varanid, and mammalian stem lineages. Negative selection in the crocodilian stem supports secondary metabolic reduction as previously indicated by histology. We expanded our taxon sample in these regions of interest across the amniote tree, using Raman and Fourier-Transform Infrared Spectroscopy to chemically fingerprint n=80 Palaeozoic to Recent members of Archosauromorpha with carbonaceous preservation. Tracing changes of time-integrative molecular metabolic signals over an amniote phylogeny indicates an archosaurian origin of avian-style metabolic endothermy. Geochemistry allows testing of genomic hypotheses and constrains archosaurian metabolic upregulation to the aftermath of the P-T mass extinction, revealing a shared metabolic legacy for secondarily ectothermic crocodiles and endothermic birds.

Day 2, Session 5A, Großer Saal, 11:15 – 11:30
Recording allowed: No

Triassic Temnospondyls of the Central European Basin: biogeography, diversity and ecological insights

***Raphael Moreno**
Staatliches Museum für Naturkunde Stuttgart, Germany

Wedged between two mass extinctions, the Triassic marks an interesting period of significant environmental and biotic changes. Temnospondyls, with 29 species across 20 genera, are diverse and abundant throughout the German Triassic continental deposits. Their diversity peaks in the Anisian (Röt Formation), Ladinian (Erfurt Formation), and Carnian (Stuttgart Formation). The Röt Formation is notable for its locally exclusive capitosaur dominance, highlighting unique ecological dynamics. In contrast, the Ladinian Erfurt Formation (Lower Keuper) features the most diverse temnospondyl fauna of Europe, including capitosauroids (*Mastodonsaurus*, *Tatrasuchus*), trematosauroids (*Trematolestes*, *Callistomordax*), and plagiosaurids (*Gerrothorax*, *Plagiosuchus*, *Plagiosternum*, *Megalophthalma*). With the deposition of the Grabfeld Formation (Gipskeuper) in the early Carnian environmental conditions shifted towards a more hostile arid climate with the formation of large playa lakes and sabkhas. Despite these harsh conditions, recent studies indicate higher temnospondyl diversity than previously reported, with new finds of *Metoposaurus*, *Gerrothorax*, *Plagiosternum*, and an indeterminate capitosauroid. The overlying Stuttgart Formation (Schilfsandstein) marks a return to humid climates with fluvial or deltaic environments. Subsequent Upper Keuper formations continue to reflect dynamic environmental shifts, significantly influencing temnospondyl diversity and distribution, thus offering further insights into their evolutionary trajectory during the Late Triassic, a period of profound ecological transformation.

Day 2, Session 5A, Großer Saal, 11:30 – 11:45
Recording allowed: No

Fin(e) tuning echoes from the past – Should *Albertocetus meffordorum* (Odontoceti: Xenorophidae) have practiced his scales?

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Underwater echolocation is the hallmark of all modern odontocetes (toothed whales) and has long been regarded as the ancestral state of the whole clade. Nevertheless, a recent study on the simocetid *Olympicetus* (stem odontocete) questioned the validity of this synapomorphy, implying that echolocation emerged convergently several times in their early evolutionary history. The Xenorophidae form a family of early-diverging odontocetes from the Oligocene of the east coast of North America. This family arguably form the first odontocete offshoot and comprises at least five genera. Two of the most apical taxa, *Cotylocara* and *Echovenator*, have been found to be capable of echolocation. Yet hearing among basal xenorophids remains poorly documented. Here we describe the periotic inner anatomy of the xenorophid *Albertocetus meffordorum* (CCNHM303) from the lower Oligocene (Rupelian) of Charleston, South Carolina (USA). Through the light of a µCT-scan investigation, we perform a virtual dissection of its bony labyrinth, followed by functional studies based on nine cochlear parameters. Interestingly, *Albertocetus* presents a low axial pitch and cochlear slope, similar to *Olympicetus*, and a relatively small Rosenthal's canal for an echolocating taxon. This questions *Albertocetus* hearing abilities and sheds new light on the heart of the emergence of echolocation in early odontocetes.

Day 2, Session 5C, Konferenzräume 3&4, 11:00 – 11:15
Recording allowed: No

The Upper Triassic dinosaur beds of Trossingen, Germany: taphonomy of a mega-scale fossillagerstätte

Eudald Mujal[1,2], Joep Schaeffer[1,3], Orla G. Bath Enright[1,4], Samuel L. A. Cooper[1,3], Volker Neipp[5], Rainer R. Schoch[1,3]
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The Trossingen fossillagerstätte of Germany yielded 108 skeletons and disarticulated finds of reptiles, with the dinosaur Plateosaurus and the stem-turtle *Proganochelys* as the most prominent taxa. Field campaigns in 1911–1932 and 2007–2024 produced a wealth of specimens and geological data, here analysed as a whole. The fossiliferous section includes: 2-3 m thick dark purple calcareous mudstones; 25 cm thick green dolostones and mudstones; 3-4 m thick massive orange-brown argillaceous mudstones; and up to 6 m of light purple mudstones. Taphonomic analysis of skeleton decay gave four principal preservation modes: skeletons buried rapidly; mummified carcasses; partial skeletons in various disarticulation stages; and single elements or fragments. This Fossil Lagerstätte formed under mixed climatic and environmental conditions: located on a distal alluvial plain; composed of Vertisol clay; forming a wet savanna-like environment with bushy plants; seasonally browsed by large megaherbivores that in rainfall periods furthered the formation of gilgai mud traps and mud flows that conserved skeletons, as well as droughts in which

mummification of carcasses occurred. Predation may have played a further, essential role in the distribution of dismembered body parts and disarticulation of carcasses.

Day 2, Session 4B, Kleiner Saal, 09:45 – 10:00
Recording allowed: No

Cohabitation patterns in Cretaceous chondrichthyan ecogroups

Emma Nicholls
Oxford University Museum of Natural History, UK

Continual tooth replacement combined with the low preservation potential of prismatic cartilage mean the chondrichthyan fossil record primarily comprises dental material. However, the close relationship between tooth morphology and life-habit (environmental preference, predation technique and prey type) allows use of isolated teeth as reliable indicators of prehistoric trophic structures. Using the eight previously established dentition types, I used life-habit data to identify 27 ecogroups within Recent non-holocephalan chondrichthyans. I then built datasets using primary data from published Cretaceous field-sites, for which information on sample size, biodiversity, geological age and palaeoenvironment was available. Studies with clear sampling biases (preferential taxonomic sampling, surface collecting, minimal sieve size range, etc.) were discarded, resulting in datasets for three palaeoenvironments so far: brackish, nearshore and deep water. Using modern analogues, I identified the ecogroup of each fossil taxon and calculated the ratios of ecogroups present at each field-site, enabling comparison of ratios of cohabiting ecogroups across geological time and geographical space. Results show that every environment exhibits a spike in the same few ecogroups in the 'mid' Cretaceous, followed by diversification in the Upper Cretaceous, and that individual faunas were dominated by one of the same three ecogroups of the 27, across all environments.

Day 2, Session 5C, Konferenzräume 3&4, 12:00 – 12:15
Recording allowed: No

Combining fossil taxa with and without morphological data improves dated phylogenetic analyses

Mark Nikolic[1], Rachel C. M. Warnock[2], Melanie J. Hopkins[1]
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The fossilized birth death (FBD) model allows researchers to more completely incorporate the intricacies of fossil data into phylogenetic inference. Particularly for analyses of only fossil taxa, temporal information is usually only included for taxa in which morphological information is also available, or only for a few fossils as calibrations. Here we tested the impact of including relatively large amounts of fossil taxa with only temporal data (*i.e.* without morphological data), along with those for which morphological data have been collected. We tested for impact on phylogenetic analyses of empirical data for trilobites using the FBD model. We used two datasets in service of this: 56 taxa with 254 discrete morphological characters and temporal information in the form of

stratigraphic intervals; and a dataset the same as the first but with an additional 194 taxa with only temporal information, giving a total of 250 taxa. We assessed the impact on parameters inferred directly from FBD analyses, such as origin and divergence times, as well stratigraphic congruence and leaf stability. We found that including more taxa with only temporal information substantially increases precision of parameter estimates and produces trees that are more stratigraphically congruent and contain fewer rogue taxa.

Day 1, Session 1B, Kleiner Saal, 09:00 – 09:15
Recording allowed: No

A time-integrative biomineralization signal reveals templated silica precipitation as a driver of cellular preservation in Phanerozoic stromatolitic fossils

***Liam Olden, Jasmina Wiemann**
Johns Hopkins University, USA

Stromatolites record evidence of ancient microbial diversity, preserved via grain capture, biomineral templating or diagenetic mineralization. A proxy distinguishing templated from abiogenic mineral attraction in stromatolites is yet missing. Here, we develop such a time-integrative proxy and apply it to fossil stromatolites with subcellular preservation from a mid-Phanerozoic Australian Lagerstätte. Polarized light microscopy and elemental mapping of these stromatolites reveal vermiform morphologies with an internal diameter ranging from 8-30 µm, depending on the sectioning plane, and a long axis of <190 µm. Cellular sheaths are preserved through partial silicification, with a thickness of 5-12 µm. To assess the mode of mineralization, we compiled a training data set of n=65 modern and fossil prokaryotes and eukaryotes of known biomineralization status and diverse modes of diagenetic alteration. Combining Fourier-Transform Infrared and Raman spectra, we developed a predictive model distinguishing biomineralization and abiogenic mineralization through Fisher's Linear Discriminant Analysis and machine learning (RFMs, SVMs): Our model predicts mineralization with an accuracy of >90%. Projecting stromatolite spectra on this model reveals in vivo templated silica-biomineralization as the driver for subcellular preservation. Biomineralization enhances the physical resilience of select cellular structures against autolytic degradation, heterotrophic decay, and diagenetic stressors in deep time.

Day 1, Session 2A, Großer Saal, 12:15 – 12:30
Recording allowed: No

Body size evolution of Caimaninae (Crocodylia, Alligatoroidea) and the influence of climate

Ana Laura Paiva[1], Pedro Godoy[1,2], Emma M. Dunne[3], Alexander Farnsworth[4,5], Paul Valdes[4,5], Daniel Lunt[4], Wilfried Klein[1], Max Langer[1], Annie Hsiou[1]
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Caimaninae is a group of crocodyliforms that includes the six modern species of caimans, which occur predominantly in South and Central America and are mostly medium-sized crocodylians.

Nevertheless, the extant diversity of the group is incomparable to its fossil record, which shows a remarkable body size variation. In particular, the giants *Purussaurus* and *Mourasuchus*, from the Late Miocene of South America, are the most notable representatives. The relationship between body size and abiotic factors is poorly understood, particularly within the Caimaninae lineage. In this study, we explore evolutionary body size patterns within the group, investigating the potential influence of climatic factors, suggesting that larger caimanines tend to inhabit areas of higher temperatures. We estimated the body size of 33 caimanine specimens using a phylogenetically-informed method, combined with climatic variables from a General Circulation Model to reconstruct deep-time patterns. Our results indicate that giant Miocene caimanines were restricted to warmer climates, with less temperature variation. This suggests that the unique climatic conditions of the Miocene western Amazonian region may have facilitated the emergence of distinctive palaeoecosystems, favouring the evolution of these very large crocodylians.

Day 1, Session 2B, Kleiner Saal, 12:00 – 12:15
Recording allowed: Yes

Functional overlap shapes the adaptive landscape of cetacean feeding

Travis Park[1,2,3], Robert J. Brocklehurst[4], Stephanie E. Pierce[4], William M. G. Parker[1,5], Ellen J. Coombs[6], Tahlia I. Pollock[7], James P. Rule[1,2], Mudra Lad[1], Alistair Evans[1]
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The adaptive landscape is the dominant paradigm in evolutionary biology for visualising macroevolution. Regions of high fitness or performance (peaks) are separated by zones that are less optimal (valleys), with movement between peaks largely thought of as occurring due to changes in the direction of selection or a switch in functional demands. Another underexplored possibility is that some peaks share similar functional underpinnings that result in them being positioned in close proximity in the adaptive landscape, facilitating relatively easy movement between them. To test this idea, we used the case study of feeding strategies in cetaceans, as previous work has suggested that they form an evolutionary succession leading from raptorial to increasingly more specialized water-based feeding styles. We hypothesized that suction, suction-filter and ram-filter feeding would have peaks closer together than raptorial feeding. Constructing morphofunctional adaptive landscapes based on a broad sample of living and extinct cetaceans (n= 107) revealed this to be the case, providing quantitative evidence that these feeding strategies are closely linked in evolutionary terms. Surprisingly, most cetaceans do not lie along the Pareto front (optimal evolutionary path) between peaks, suggesting that other functional demands are influencing mandibular evolution, most likely the specialized cetacean auditory pathway.

Day 1, Session 1C, Konferenzräume 3&4, 10:00 – 10:15
Recording allowed: No

talks

Ancient biomolecules confirm the high-altitude origin of fossil woolly rhinoceroses and their cold-adaptations

Ryan Paterson[1], Xiaoming Wang[2], Mikael Fortelius[3], Alba Refoyo Martínez[1], Alberto Taurozzi[1], Gaudry Troché[1], Jack Tseng[4], Qiang Li[5], Fabrice Demeter[1,6], Jesper V. Olsen[1], Fernando Racimo[1], Enrico Cappellini[1]

[1]University of Copenhagen, Denmark; [2]Natural History Museum of Los Angeles County, USA; [3]University of Helsinki, Finland; [4]University of California, USA; [5]Institute of Vertebrate Paleontology and Paleoanthropology, CAS, China; [6]Muséum national d'Histoire naturelle, Paris, France

Discovery in the Himalayas of a Pliocene woolly rhinoceros (*Coelodonta thibetana*) with morphological adaptations to snow prompted an out-of-Tibet hypothesis for this species. Here we present 3.6-4.2 Ma old dental enamel protein sequences from a second find of the same species at a site in the Kunlun Pass Basin, at the even higher altitude of 4,700–4,900 m above sea level (asl), within the modern permafrost zone. This proteome has experienced extensive degradation but preserves sufficiently long sequences of the three primary enamel matrix proteins, to enable a confident phylogenetic analysis, confirming a close relationship between *Coelodonta antiquitatis* and *Coelodonta thibetana*, with an estimated divergence time in the latest Miocene to Early Pliocene, *c.* 4-6 million years ago. These divergence times support a Tibetan origin of the woolly rhino, suggesting the Woolly Rhino evolved its adaptations to extreme cold in the high elevations of the Tibetan Plateau in the Early Pliocene. Furthermore, an existing genome of the terminal species Coelodonta antiquitatis from the last glacial maximum may preserve additional evidence of adaptations to high altitude environments. These findings lend further credibility to the 'species factory' scenario of high-altitude origins of the woolly rhinoceros.

Day 1, Session 1A, Großer Saal, 09:00 – 09:15
Recording allowed: Yes

Of bites and dogs: bite simulations in the stem-Canini *Eucyon davisi* and insights on its palaeoecology

Emanuele Peri[1], Saverio Bartolini-Lucenti[1], Lorenzo Rook[1,2]
[1]Università degli Studi di Firenze, Italy; [2]Sapienza Università di Roma, Italy

Canidae are predators with an important ecological impact. Notwithstanding, several aspects of their palaeoecology remain poorly investigated. Furthermore, Canidae evolutionary history displays an intriguing variability in feeding-related adaptations, representing an attractive research topic. To explore this issue, we digitally simulated the bite of the Pliocene *Eucyon davisi* from China using finite elements analysis (FEA). The aim of this study is to improve our knowledge of the feeding ecology of this basal Canini through the comparison of its reaction stress and bite force with those of selected extant Canidae. The cranial models were acquired through CT-scanning, while the FEA simulations were built using a series of trusses to reconstruct the muscles. We simulated three bite styles: bilateral canine, unilateral P4, and M1 bites. The stress patterns and estimated bite forces observed in the three simulated load cases suggest, for *E. davisi*, a generalist ecology recalling the

living mesocarnivorous jackals. Likely, its dietary range possibly included vegetal material (fruits), small vertebrates, and (on occasion) larger prey (such as smaller ungulates).

Day 1, Session 1A, Großer Saal, 09:15 – 09:30
Recording allowed: No

Long-term patterns of the prey-predator interaction in the Late Cretaceous brachiopods of Ariyalur, India

***Arghya Poddar[1], Adrish Mahata[1], Shubhabrata Paul[1], Debahuti Mukherjee[2], Arkaprava Mukhopadhyay[1], Debarati Chattopadhyay[1]**
[1]Indian Institute of Technology, Kharagpur, India; [2]Geological Survey of India, Kolkata, India

Although brachiopods lost their status as the most important prey in the marine benthic community after the end-Permian mass extinction event, in small pockets throughout the Mesozoic world, they still formed a part of the food source for the predators. The present study evaluates the long-term patterns of the prey-predator interaction in brachiopods from the Late Cretaceous fossil record of Ariyalur, India. A total of 527 specimens, representing two terebratulid and six rhynconellid species, were collected from the Coniacian Anaipadi member of the Garudamangalam Formation, and 833 specimens, representing two terebratulid, two rhynconellid species and three isocranid species, were collected from the Maastrichtian Kallankurichchi Formation. Our preliminary data suggest that drilling intensity was marginally higher in the Maastrichtian compared to the Coniacian. However, drilling was mainly concentrated on the most abundant brachiopod taxa in the studied interval, which also displayed a preference for the size of the predated specimen. Although ornamentation provides an anti-predatory advantage, it did not influence prey selection in the Coniacian rhynchonellids as opposed to the predation in the unornamented terebratulids of Maastrichtian. A major contributing factor to this dichotomy can be attributed to the change in the substrate condition, influencing the faunal composition of this time.

Day 2, Session 6B, Kleiner Saal, 14:15 – 14:30
Recording allowed: Yes

'Phylogeochemistry': can trace elements inform belemnite evolutionary relationships?

Alexander Pohle, Kevin Stevens, René Hoffmann, Adrian Immenhauser
Ruhr University Bochum, Germany

Belemnites are commonly used as geochemical archives of Mesozoic climate conditions. Previous research has shown that proxies such as trace element concentrations (*e.g.* Ca, Mg, Sr, Fe, Mn) are biased by vital effects, which may vary between taxa. We used this premise to investigate the potential of element ratios as a phylogenetic character in this otherwise character-poor group of fossil cephalopods. We assembled a large literature dataset on belemnite element ratios containing taxonomic information at least on genus level and used Bayesian phylodynamic modelling to reconstruct ancestral states and evolutionary rates of element ratios. To assess the effect of tree topology, we further applied multidimensional scaling to the tree posterior. The results reveal that Mg/Ca and Sr/Ca ratios are taxon-specific but fluctuate considerably throughout the tree with

high evolutionary rates. The phylogenetic signal is therefore relatively weak, although potentially informative on smaller taxonomic scales. We highlight that geochemical data need to be interpreted with caution, as they are affected by evolutionary, developmental and environmental constraints, and may be diagenetically altered. A profound understanding of the phylogenetic patterns can therefore help to improve the interpretation of geochemical data. For this approach, we here coin the term 'phylogeochemistry'.

Day 1, Session 2C, Konferenzräume 3&4, 11:00 – 11:15
Recording allowed: Yes

The extended 'common cause': links between punctuated evolution and sedimentary processes

P. David Polly[1,2]
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The common-cause hypothesis says that factors regulating the sedimentary record also exert macroevolutionary controls on speciation, extinction, and biodiversity. I show through computational modelling that common cause factors can, in principle, also control microevolutionary processes of trait evolution. Using Bermuda and its endemic land snail *Poecilozonites*, I show that the glacial-interglacial sea level cycles that toggle local sedimentation between slow pedogenesis and rapid aeolian accumulation could also toggle evolution rates between long slow phases associated with large geographic ranges and short rapid phases associated with small, fragmented ranges and 'genetic surfing' events. Patterns produced by this spatially driven process are similar to the punctuated equilibria patterns that Gould inferred from the fossil record of Bermuda, but without speciation or true stasis. Rather, the dynamics of this modelled system mimic a two-rate Brownian motion process (even though the rate parameter is technically constant) in which the contrast in rate and duration of the phases makes the slower one appear static. The link between sedimentation and microevolution in this model is based on a sediment-starved island system, but the principles may apply to any system where physical processes jointly control the areal extents of sedimentary regimes and species distributions.

Day 2, Session 6C, Konferenzräume 3&4, 14:45 – 15:00
Recording allowed: Yes

Coding confidence in taxonomic identification as metadata for large databases and shareable resources

Omar Rafael Regalado Fernandez
Senckenberg Naturmuseum, Germany

Comparative anatomy and phylogenetics provide an invaluable framework to understand character evolution, establish homologies, quantify variability, and generate testable hypotheses. At the core of these analyses is assigning specimens an accurate taxonomy within a coherent, systematic framework that enables species delineation meaningfully. However, taxonomy is often undervalued in the current academic system, which is centred on publication as the main research output. When building large shareable resources, such as GBIF or the PBDB, much of the taxonomic framework is not encoded into the databases, namely the discussion on the accuracy and resolution of the

taxonomic identification. Within the type (name-bearing specimen), a selection of features is established as conditions to transfer the name from the type to another specimen. A named set is a mathematical structure where the name given to a set, X, is only transferred to another one, an image, I, only if there is a valid function of correspondence (f). The validity of this function is what intuitively informs about the confidence in the identification. Here we implement the formalization of named set theory on three examples (*Plateosaurus*, *Troodon* and *Edmontosaurus*) to create a coding system that enables sharing taxonomic certainty as metadata into large datasets.

Day 2, Session 5C, Konferenzräume 3&4, 11:45 – 12:00
Recording allowed: No

Selective preservation of coleoid soft tissues in Lebanese Lagerstätten Deposits.

***Alison Rowe**
Muséum national d'Histoire naturelle, Paris France

The Upper Cretaceous lithographic limestones of the Lebanese Lagerstätten (Sahel Aalma, Santonian, and Hjoula and Haqel, Cenomanian) are world-renowned for their exceptional preservation of fossil organisms. Though these three outcrops are part of the same Lagerstätten deposit, they reflect slight variance in faunal assemblage and/or depositional environment. Taphonomic studies are still quite rare at these sites and typically focus either on preservational differences between organisms or are comparative with other Lagerstätten types. Here we combine multiple imaging techniques to explore the preservation of a single coleoid species, *Dorateuthis syriaca*, that occurs at each of the outcrops in the Lagerstätten (range: ~10 Ma); specifically, whether each locality preserves the same tissues with the same composition and at the same high level of occurrence. Approximately 80 individuals of *D. syriaca* from these deposits have been analysed using a range of imaging techniques (*e.g.* optical microscopy; UV photography; Reflectance transformation imaging; X-ray fluorescence mapping) to identify soft tissues and their chemistry. Further statistical analysis quantifies and qualifies these data, showing potential preservational biases between the outcrops of the Lebanese Lagerstätten.

Day 1, Session 3A, Großer Saal, 14:30 – 14:45
Recording allowed: No

The oldest record of *Seebachia bronni*, type species of Seebachia (Bivalvia: Astartidae), from the late Tithonian (Jurassic) of Kutch, India, and its palaeobiogeographic and evolutionary implications

Ranita Saha[1,2], Shubhabrata Paul[2], Shiladri Das[3], Subhendu Bardhan[4]
[1]University of Florence, Italy; [2]Indian Institute of Technology, Kharagpur, India; [3]Indian Statistical Institute, Kolkata, India; [4]Independent

The present study reports the oldest occurrence of *Seebachia bronni* Krauss, 1850, the type species of the genus *Seebachia*, from the ferruginous oolitic bands of the upper Tithonian of Kutch, western India. The oldest species of *Seebachia* (*Seebachia*), *Seebachia* aff. *bronni* was previously reported from the middle–upper Oxfordian of the Morondava Basin in Madagascar. Transgression in the late Tithonian may have enabled the migration of *Seebachia* from Madagascar to western India. Although *Pruvostiella* (*Eoseebachia*), previously known as *Seebachia* (*Eoseebachia*), has been reported

from the same horizon of Kutch, analyses using quantitative morphological and morphometrical character reveal a significant difference between *Pruvostiella* (*Eoseebachia*) and *Seebachia*. Additionally, the range of *Seebachia aff. bronni* in the Oxfordian of Madagascar to *Seebachia bronni* sensu stricto in the Tithonian of India and the Early Cretaceous of South Africa may also reflect an evolutionary size increase following Cope's rule.

Day 1, Session 3B, Kleiner Saal, 15:00 – 15:15
Recording allowed: No

The out-of-place 'Lilliput effect': a case in Ostracoda (Crustacea) from the Pebas Mega-wetland (Miocene of Western Amazonia)

Andres Felipe Salazar-Rios[1,2], Martin Gross[1], Maria Belen Zamudio[1], Werner E. Piller[2]
[1]Universalmuseum Joanneum, Austria; [2]University of Graz, Austria

The Pebas Mega-wetland was a long-lived, mostly aquatic ecosystem that occupied vast areas of Western Amazonia during the Miocene (*c.* 23–10 Ma), that resulted in an extensive diversification and endemism of aquatic biota, including ostracods. For this research, we conducted micropalaeontological analyses on six outcrops in the vicinity of Iquitos (Peru) and one borehole in northwestern Brazil, covering the Middle Miocene (*c.* 16–13 Ma). One of the most common and widespread species is *Cyprideis caraionae* Purper and Pinto, 1985, which provided well-constrained knowledge about its ontogeny and evolutionary trends (*e.g.* size and ornamentation) through space and time. However, we found one layer with dwarf adult specimens of this species co-occurring with the 'normal sized' population. This finding corresponds to a pattern of the current meaning of the 'Lilliput Effect', although it is out-of-place, in the sense that: it occurs in a taxonomic group where dwarfism is considered rare; it takes place in a global 'background' time (rather than one of mass extinction, as typical); and it occurs in a period of greatest diversification of the aquatic biota in the Mega-wetland. We are now investigating the ecological and/or evolutionary causes that led to this unusual ostracod population.

Day 2, Session 4C, Konferenzräume 3&4, 09:15 – 09:30
Recording allowed: No

Exceptional preservation of the brain and radiation of the jawed vertebrates

***Alicia Sánchez Gimeno[1], Karim Benzerara[1], Mathieu Thoury[2], Pierre Gueriau[2], Gaël Clément[1], Alan Pradel[1]**
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The jawed vertebrates (gnathostomes) appeared during the Palaeozoic (-540 to -250 Ma) and dramatically diversified, notably thanks to evolutionary innovations of the braincase (including the brain), mandibular, hyoid and gill arches that are fundamental for feeding and interacting with the environment. However, evolutionary studies based on extant organisms do not allow a relevant comprehension of the evolutionary steps of the gnathostome central nervous system. Only two palaeoneuroanatomical studies on early chondrichthyans are based on fossilized brains and the majority consequently mainly use casts of the endocranial cavity, which were erroneously supposed to match the morphology of the brain it houses. Here we report a recent discovery of exceptionally preserved fossils from the Carboniferous of Uruguay. These include rare soft tissue preservation,

such as a new mineralized brain in a chondrichthyan and muscles associated with the skull of some actinopterygians. These remarkable preservations of species that lived during an important evolutionary radiation of crown gnathostomes will be studied using several imaging approaches that also will shed new light on the processes involved in the fossilization of the brain. This will provide new characters documenting the early stages of the morphological evolution of the vertebrate head skeleton and central nervous system.

Day 2, Session 5A, Großer Saal, 11:45 – 12:00
Recording allowed: No

Analyses of morphological variation in the early sauropodomorph dinosaur *Plateosaurus trossingensis* using 3D geometric morphometrics

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[1]Staatliches Museum für Naturkunde Stuttgart; [2]University of Hohenheim, Germany; [3]Royal Veterinary College, UK

Plateosaurus trossingensis is among the earliest described and best-known dinosaurs, represented by over 200 specimens exhibiting significant morphological variation. Previous efforts to resolve the taxonomy of these specimens have employed various methodologies yet failed to reach a consensus. Persistent questions include whether the observed morphological differences are indicative of developmental plasticity, sexual dimorphism, population variance, or taxonomic distinctions. Geometric morphometrics could provide more insight into these different options. In this study, we apply 3D geometric morphometrics to analyse 268 bones from 16 distinct appendicular skeletal elements across 6 localities in Germany and Switzerland, all attributed to *Plateosaurus trossingensis*. Our analyses indicate a substantial morphological spread among specimens from the type locality (Lower Beds in Trossingen, Germany) without distinct clustering, suggesting the presence of a single species at this stratigraphical unit. However, specimens from Bebenhausen, Wüstenrot, and Stuttgart-Erlenberg exhibit significant separation from this primary cluster across several skeletal elements, implying potential taxonomic divergence. Specimens from Halberstadt, Frick, Stuttgart-Degerloch, and the Upper Beds at Trossingen also show notable, though less pronounced, variation, which may reflect biologically plausible differences or taphonomic influence.

Day 1, Session 2B, Kleiner Saal, 12:15 – 12:30
Recording allowed: No

CT-based re-evaluation of the anatomy and phylogeny of the trematopid *Rotaryus gothae*

***Lena Schmitz[1,2], Mark J. MacDougall[1,3], Jörg Fröbisch[1,2]**
[1]Museum für Naturkunde Berlin, Germany; [2]Humboldt-Universität zu Berlin, Germany; [3]Cape Breton University, Canada

Trematopids are a monophyletic group of Permo-Carboniferous dissorophoid temnospondyls from North America and Europe. These anamniotes were well adapted for a terrestrial lifestyle, but most species are only known from a single specimen. The scarcity of well-preserved fossils, combined with complex anatomical variation among taxa, creates challenges in accurately resolving trematopid taxonomy and relationships. This study re-evaluates *Rotaryus gothae*, a trematopid

from the lower Permian Bromacker locality in central Germany, using computed tomography (CT) and 3D reconstruction techniques. This detailed examination of its cranial anatomy has enabled the identification of previously unrecognized and re-examination of formerly obscured features. Notable findings include the presence of three coronoids, a posteriorly extending dentary that partially divides the surangular, and novel information regarding the dentition on the dentary and palate (vomer, palatine, and ectopterygoid). This new data, resulting from the integration of advanced 3D imaging techniques and traditional anatomical investigations, has led to a better understanding of *Rotaryus* and its phylogenetic relationships. The findings highlight both the challenges posed by limited specimen availability and morphological variability. Our study underscores the necessity of re-evaluating early tetrapods with modern tools to address unresolved research questions and provide a foundation for future investigations.

Day 1, Session 2B, Kleiner Saal, 11:30 – 11:45
Recording allowed: Yes

3D imaging the head and tail of a complete Devonian jawless fish

Lisa Schnetz[1], Agnese Lanzetti[1,2], Andy S. Jones[1], Richard P. Dearden[1,3], Stephan Lautenschlager[1], Sam Giles[1,2], Zerina Johanson[2], Emma Randle[1], Ivan J. Sansom[1]
[1]University of Birmingham, UK; [2]Natural History Museum, London, UK; [3]Naturalis Biodiversity Center, the Netherlands

Stem gnathostomes play a pivotal role in examining the evolutionary origins of vertebrates. However, detailed three-dimensional (3D) data on their anatomy are mostly lacking despite being essential to infer feeding and locomotion ecologies. Here we present the first 3D whole-body morphology of a heterostracan, the cyathaspid *Anglaspis heintzi*, using X-ray and synchrotron microtomography. The oral apparatus is composed of three pairs of oral plates, one postoral plate, one pair of lateral oral plates and is bordered by one pair of lateral plates. A retrodeformed reconstruction reveals that the articulation of the postoral plate onto the ventral shield allowed for very limited movement, precluding a significant opening of the oral apparatus. The trunk is formed of a series of heavily ornamented trunk, dorsal ridge, ventral ridge and ventrolateral scales leading up to the four-lobed hypocercal tail fin. Our results show that the functional morphology precludes all previously proposed heterostracan feeding modes apart from suspension/deposit feeding. The hypocercal tail was likely an adaptation to allow for lift with forward motion in the absence of paired fins. Our results are consistent with previous evidence of suspension feeding in heterostracans and highlight the diversity of feeding and swimming ecologies in these early jawless gnathostomes.

Day 2, Session 6C, Konferenzräume 3&4, 14:15 – 14:30
Recording allowed: No

Was palaeolake Messel a death-trap? Insight from machine learning, modern bat drownings and decay experiments

Krister T. Smith[1,2], Renate Rabenstein[1], Joy O'Keefe[3,4]
[1]Senckenberg Research Institute, Germany; [2]Goethe University Frankfurt, Germany; [3]Indiana State University, USA; [4]University of Illinois Urbana-Champaign, USA

The Messel Pit is an Eocene maar lake that preserves an ecosystem from the last greenhouse phase of Earth's climate with exceptional fidelity. There are two main competing hypotheses to explain the occurrence of animal fossils at Messel: asphyxiation in toxic gases, and death following ingestion of contaminated surface water. Both hypotheses imply mortality much higher than the null hypothesis of accidental death. We tested these hypotheses amongst bats by recourse to a unique survey on bats that drowned in modern swimming pools and conducted experiments on fresh bat carcasses that simulate drowning. Overall, there are few good, surveyed, predictors of whether bats drown in swimming pools. In our experiments, carcasses with water-filled lungs tend to sink more quickly than those with air-filled lungs; all carcasses that initially sink "bloat and float" at shallow depths, but all floaters eventually disarticulate and sink within days to weeks. Our estimates of annual bat mortality at palaeolake Messel are of the same order of magnitude as mortality in swimming pools. Mass mortality horizons for vertebrates are very rare at Messel. In sum, our quantitative analyses provide no evidence that bat mortality at Messel rises above background levels.

Day 2, Session 4B, Kleiner Saal, 09:00 – 09:15
Recording allowed: No

Bivalves and brachiopods: direct competitors, ships in the night, or something in between?

Thomas J. Smith, Erin E. Saupe
University of Oxford, UK

Compelling examples of competitive displacement in ancient ecosystems are hard to find and harder to validate. However, a literal reading of the fossil record presents the decline of brachiopods and diversification of bivalves through the Phanerozoic as an intriguing candidate. Fuelling nearly half a century of intense debate, the validity of the brachiopod-bivalve transition as an example of competitive displacement remains uncertain. Here we explore bivalve and brachiopod diversity dynamics through time using spatially explicit methods, assuming that if bivalves outcompeted brachiopods, there should be an inverse relationship between the richness of the two in constrained geographic regions. We analyse a new dataset compiled from museum collections, the Paleobiology Database, and other online repositories using multivariate generalized linear mixed models in which time and geographic region of origin are specified as random effects. Preliminary results present a weak but significant negative relationship between bivalve and brachiopod richness through time, which suggests direct competition may have occurred between the two groups. However, this relationship breaks down when the number of references included within spatial subsamples is rarefied instead of the number of individual occurrences. Collectively, our results highlight the need for a multi-pronged approach in studies of diversity dynamics.

Day 1, Session 1C, Konferenzräume 3&4, 09:30 – 09:45
Recording allowed: No

From peak to decline: The story of Cenozoic neoselachian diversity

***Manuel Andreas Staggl[1,2], Eduardo Villalobos-Segura[1], Michael J. Benton[3], Jürgen Kriwet[1,2]**
[1]University of Vienna, Austria; [2]Vienna Doctoral School of Ecology and Evolution (VDSEE), Austria; [3]University of Bristol, UK

Following the post-K-Pg extinction and a subsequent recovery phase, neoselachian diversity (sharks, rays, and extinct immediate relatives) peaked in the Eocene. The subsequent, long-term decline persists until the present day, with only minor fluctuations. Faunal turnover displayed a different pattern and saw the first major changes since the Early Jurassic in the Miocene. We analysed neoselachian diversity patterns and evaluated the effects of environmental factors on Cenozoic neoselachians based on an extensive sampling standardized database. The results indicate that the availability of shallow marine habitats and atmospheric CO_2 concentration are among the main drivers of Cenozoic neoselachian diversification and faunal turnover. Analysed subsets of the whole neoselachian dataset, unifying orders of similar ecological preferences, differ in some respects from the results for the whole neoselachian clade, reflecting commonly assumed habitat and behavioural traits of these ecological subgroups. These results provide a comparative framework for assessing potential impacts of the ongoing climate crises on extant neoselachians. The continued survival and diversity of neoselachians is of paramount importance for ensuring the overall resilience and operational capacity of marine ecosystems.

Day 2, Session 4A, Großer Saal, 09:30 – 09:45
Recording allowed: No

Revealing patterns of homoplasy in discrete phylogenetic datasets with a new cross-comparable index

***Elizabeth M. Steell[1], Allison Hsiang[2], Daniel J. Field[1]**
[1]University of Cambridge, UK; [2]Stockholm University, Sweden

Investigating patterns of homoplasy can improve our understanding of macroevolutionary processes by revealing evolutionary constraints on morphology and highlighting convergent form-function relationships. Here we test the performance of several widely-used methods of measuring homoplasy, including the consistency (CI) and retention indexes (RI), using simulated and empirical discrete morphological datasets. In addition, we describe and test a new method with a novel randomization protocol, the relative homoplasy index (RHI). Our results suggest that RI consistently underestimates the extent of homoplasy. By contrast, RHI outperforms other methods in a range of situations and allows comparisons between different datasets. We show that relative levels of homoplasy remain constant with the addition of characters and decrease with the addition of taxa. We also show that levels of homoplasy can strongly influence the distribution of taxa in morphospace. Low homoplasy results in highly partitioned morphospace, while high homoplasy leads to clades overlapping in morphospace. Our results help illuminate the properties of homoplasy in morphological matrices, opening new potential avenues of research for homoplasy quantification in macroevolutionary studies.

Day 1, Session 1B, Kleiner Saal, 10:15 – 10:30
Recording allowed: Yes

Phanerozoic ocean biogeochemistry and marine biodiversity in space and time

Richard G. Stockey[1], Benjamin Mills[2], Erin E. Saupe[3], Pam Vervoort[4], Pedro Monarrez[5], Alison Cribb[1], Przemyslaw Gruszka[1], Alexandre Pohl[6], Fanny Montiero[7], Yixuan Xie[7], Gordon Inglis[1], Thomas Gernon[1], Dominik Hülse[8], Dan Lunt[7], Andy Ridgwell[9]
[1]University of Southampton, UK; [2]University of Leeds, UK; [3]University of Oxford, UK; [4]University of Birmingham, UK; [5]University of California, Los Angeles, USA; [6]Université de Bourgogne, France; [7]University of Bristol, UK; [8]MARUM, Universität Bremen, Germany; [9]University of California, Riverside, USA

The spatial and temporal distributions of dissolved oxygen and organic carbon through Earth's oceans have far-reaching implications for the evolution of marine ecosystems. In particular, spatially resolved oceanographic reconstructions enable us to directly link fossil occurrences to regional marine environmental conditions, facilitating a range of new approaches to mechanistically test environmental drivers of ancient extinction and biodiversification events. We present preliminary results for a new series of stage-by-stage simulations of 3D ocean biogeochemistry through the Phanerozoic. Our intermediate complexity Earth system modelling framework builds on global circulation and long-term carbon cycle modelling by coupling cGENIE to existing SCION and HADCM3L simulations. This enables us to present new reconstructions of 3D ocean biogeochemistry over the last ~540 million years, including dissolved oxygen in shelf environments, the volume of oxygen minimum zones, and seafloor redox. Our 3D reconstructions of Phanerozoic oceans provide a new platform for exploring the role of environmental change in the evolution of marine ecosystems through the Phanerozoic. We illustrate the potential of this approach to test mechanistic drivers of marine biodiversity dynamics in space and time by presenting preliminary results investigating the role of dissolved oxygen supply in the evolution of animal body size through the Phanerozoic.

Day 2, Session 4C, Konferenzräume 3&4, 09:45 – 10:00
Recording allowed: No

New insights into Wamradolops, an enigmatic metatherian from the Palaeogene of Peruvian Amazonia

Narla Stutz[1,2,4], Laurent Marivaux[2], François Pujos[3], Ana M. Ribeiro[4], Aldo Benites-Palomino[5], Rafael Varas-Malca[6], Rodolfo Salas-Gismondi[6,7], Pierre-Olivier Antoine[2]
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Metatheria (Mammalia) include living marsupials plus stem clades closer to them than to placental mammals. They have a Cenozoic evolutionary history in South America characterized by several phases of diversification and extinction. Today, their diversity is dramatically reduced compared to the past one. However, due to substantial gaps in the fossil record, especially for low latitudes of this landmass, much is still unknown. Several new Palaeogene localities in Peruvian Amazonia have yielded fossil metatherians, primarily documenting the order Polydolopimorphia. Among these, is *Wamradolops tsullodon*, of uncertain phylogenetic affinities, formerly described and only known at Santa Rosa (early Oligocene, Peruvian Amazonia). Our new fossil material provided the same

species, as well as a new related species, yet to be described. Both are abundant and widespread at the studied outcrops, enabling the observation of intraspecific morphological variation (*e.g.* size, presence/absence of cinguli, or stylar cusps). Preliminary phylogenetic analyses, including an unprecedented amount of polydolopimorphians, suggest that the order may be polyphyletic. *Wamradolops* is monophyletic and phylogenetically close to Prepidolopidae. This family, plus Argyrolagidae and Polydolopidae, are retrieved as belonging to the Australidelphia clade. Further analyses should help elucidating the Polydolopimorphia puzzle and the role the proto-Amazonian region played in the evolution of metatherians.

Day 2, Session 5C, Konferenzräume 3&4, 11:15 – 11:30
Recording allowed: No

Contrasting ecological selectivity patterns of the end-Permian and end-Triassic mass extinctions suggested from Bayesian analysis of marine invertebrates

Lewei Su[1,2], Zhen Guo[1], Zhong-Qiang Chen[1], Wolfgang Kiessling[2]
[1]China University of Geosciences, Wuhan, China; [2]Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

The end-Permian mass extinction (EPME) and the end-Triassic mass extinction (ETME) were both associated with rapid environmental changes resulting from the eruption of Large Igneous Province. Comparing extinction selectivity patterns may provide the most direct evidence of proximal extinction mechanisms during these two catastrophes. Here we quantify the diversification dynamics of different ecological groups of marine invertebrates from the Middle Permian to the Middle Jurassic in a Bayesian framework to directly compare ecological selectivity across the two mass extinctions. The results show that the EPME was strongly associated with physiology, with physiologically unbuffered animals being significantly more affected than the buffered forms. In contrast, we found no significant effect of physiology on extinction risk at ETME. Our multi-trait dependence models indicate an important effect of life position and motility on both PTME and TJME but in different directions; benthic and non-motile animals suffered higher extinction rates during EPME, while nektonic animals were preferentially affected during ETME. Given the similar scenarios, it is surprising to find different ecological selectivity patterns between these two crises, and more work is needed to decipher the underlying reasons.

Day 2, Session 6B, Kleiner Saal, 14:45 – 15:00
Recording allowed: No

Diet change and potential larval development in Late Devonian conodont.

Przemysław Świś[1,2], Paweł Bącal[3], Tomasz Szczygielski[3], Sergi López-Torres[2,4]
[1]University of Modena and Reggio Emilia, Italy; [2]University of Warsaw, Poland; [3]Institute of Paleobiology, Polish Academy of Science, Poland; [4]American Museum of Natural History, USA

Conodonts, an extinct group of marine chordates that lived between the Late Cambrian and the earliest Jurassic, occupy a unique place in Earth's geological annals. As the first vertebrates with mineralized tissues, they boast the richest fossil record among their contemporaries. Their remains have left an indelible mark on various scientific disciplines, including stratigraphy, palaeoclimatology, and evolutionary studies. Despite their huge impact on understanding Earth's history, surprisingly, their ecology is still poorly explored. One mystery is whether conodonts had a larval stage and

if their diet changed during ontogeny, a topic debated for over two decades. Here we used a combined novel approach using SEM photogrammetry, which is rarely applied to microfossils, and dental topographic analysis, a suite of quantitative methods well-tested in measuring 3D dental morphology in mammals. To test the hypothesis that conodonts underwent a shift in dental element topography, and therefore in diet as well, we examine the Late Devonian species *Tripodellus gracilis*, which was previously suspected to have a larval stage. Our results show morphological disparity between juveniles and adults, with two of the three dental topographic metrics being significantly different between different ontogenetic stages. This suggests that *Tripodellus* had morpho- and eco-larvae.

Day 2, Session 6A, Großer Saal, 15:00 – 15:15
Recording allowed: No

Exploring phenotypic evolution as a consequence of changes in the adaptive landscape across lineages and timescales

***Marion Thaureau, Kjetil L. Voje**
Natural History Museum of Oslo, Norway

The adaptive landscape has been suggested as a potential conceptual bridge between phenotypic evolution on generational to macroevolutionary timescales but remains largely untapped. We assessed the dynamics of the adaptive landscape across various timescales by analysing three evolutionary time series using multivariate models of evolution. First, we examined whether a human-induced decrease in river waterflow affected the optimal body mass of a salmon population over a few decades. Second, we explored whether changes in oxygen and carbon isotopes affected the optimal size of a species of coccolithophore across a hundred thousand years in the late Albian; and the optimal size in a planktic foraminifera lineage over a few million years during the Miocene. Results support a dynamical adaptive landscape in two of the datasets covering micro- and macroevolutionary timescales, meaning that the salmon population as well as the foraminifera lineage had to constantly readapt to environmental changes in the positions of adaptive peaks. Although the rate of adaptation and evolution varies among the three lineages, adaptive landscapes may be more dynamic than often assumed and advocated. Multivariate analyses of time series provide valuable insight into how changes in the adaptive landscape led to phenotypic variation across micro to macroevolutionary timescales.

Day 2, Session 5B, Kleiner Saal, 11:15 – 11:30
Recording allowed: Yes

Bird's stomach stones and other contents from "the dinosaur's great viscera" at Howe Quarry

Emanuel Tschopp[1,2,3], Carl Mehling[2], Ulrich Kotthoff[3,4], Stefanie Kaboth-Bahr[1]
[1]Freie Universität Berlin, Germany; [2]American Museum of Natural History, USA; [3]Universität Hamburg, Germany; [4]Leibniz Institute for the Analysis of Biodiversity Change, Hamburg, Germany

Purported sauropod gastroliths are known from numerous localities. In the Howe Quarry (Morrison Formation, Wyoming), sauropod gastroliths were found by Roland T. Bird in 1934. As Bird noted,

this mass of up to sixty-four gastroliths was "…intermingled with […] matted masses of carbonized plant fragments". The gastroliths "were smooth but not highly polished" and about the size of a small walnut. Six of these gastroliths, but no carbonized plant matter, remain in the AMNH collections. In the 1990s the Sauriermuseum Aathal (Switzerland; SMA) made a similar find at Howe Quarry, with a small gastrolith preserved on a layer of carbonized plant matter, which was associated with gastralia. Bird's notes and the SMA find strongly suggest that these are stomach contents. Given that gastralia have been reported from flagellicaudatan sauropods, but not from macronarians (the other sauropod clade present at Howe Quarry), an attribution of these stomach contents to Flagellicaudata is justifiable. An attempt to isolate pollen with glycerin showed that they were too degraded for proper identification. Instead, we will apply Fourier-Transformed Infrared spectroscopy to the carbonized plant matter to identify the plant remains. This would be the first direct evidence for the long-standing question regarding flagellicaudatan food preferences.

Day 1, Session 3C, Konferenzräume 3&4, 15:15 – 15:30
Recording allowed: No

Unusual early diagenetic preservation of an Oligocene whale bone as compared to other marine mammals from Hokkaido, Japan revealed by molecular taphonomy

Raman Umamaheswaran[1], Takuto Ando[2], Tatsuya Shinmura[3], Ken Sawada[1]
[1]Hokkaido University, Japan; [2]Akita University, Japan; [3]Ashoro Museum of Paleontology, Japan

We utilize biomarker analysis, light and fluorescence microscopy, and SEM-EDS to understand the molecular taphonomy of a whale bone from the Oligocene Morawan formation of Hokkaido, Japan, contrasted with two desmostylian bones (*Ashoroa laticosta* and *Behemotops katsuiei*) from the same locality. The trabecular matrix of all three specimens were clearly differentiated from mineral-filled cavities, and fluorescence microscopy further revealed organic preservation in the trabeculae. The cavities of the whale bone were filled with numerous circular and pennate microstructures. SEM-EDS revealed that these structures were siliceous while the surroundings were calcareous. Thus, we interpret them as diatom microfossils embedded within calcium infilling of the bone cavities. These structures were also present in *B. katsuiei* to a lesser degree and absent in *A. laticosta*. Biomarker analysis revealed the presence of several aromatic steroids (cholestenes) and intermediary steroid derivatives (anthra- and seco-cholestenes) in the whale that point to halting of diagenesis at an early stage, while the desmostylians showed a distribution characteristic of mid-late diagenesis with steranes and polyaromatic hydrocarbons. Diatom biomarkers were present in the matrices of the desmostylians but not of the whale. Hence, the whale bone is possibly autochthonous to the locality, with diatom colonization possibly occurring after transport.

Day 2, Session 4B, Kleiner Saal, 09:15 – 09:30
Recording allowed: No

Testing the fossil record of early animal evolution: regional versus global signals

***Lara J. Uttinger[1], Ben Slater[2]**
[1]University of Cambridge, UK; [2]Uppsala University, Sweden

The Cambrian Period (539–485 Ma) marks a critical phase in Earth's history, characterized by the rapid emergence of most modern metazoan phyla during the 'Cambrian Explosion'. Despite its significance, the precise details of how this evolutionary radiation unfolded remain unclear. One

question that remains unanswered, is how closely the regional, palaeocontinental records match with the overall global signal, and how and where they diverge. Using data extracted from the Paleobiology Database, regional patterns in the emergence of metazoan clades for each Cambrian palaeocontinent or terrane were compiled against a global Cambrian palaeogeographic model accessed using GPlates. Broad patterns in the radiation of body fossil groups and the order of fossil appearance for metazoan clades were found to be strikingly similar across most of the major Cambrian terranes (especially so when Lagerstätten effects were accounted for). This suggests that global fossil signals capture genuine underlying radiation, rather than being a composite artifact of multiple regional patterns. Moreover, it was found that the peaks in taxonomic species diversity do not necessarily correspond to larger excursions in the diversity of metazoan clades or fossiliferous lithologies, showing a limited influence of species diversity on those factors.

Day 2, Session 5B, Kleiner Saal, 11:30 – 11:45
Recording allowed: No

A surge of malformed chitinozoans accompanies the onset of the Ireviken Event

***Iris Vancoppenolle[1], Poul Emsbo[2], Patrick I. McLaughlin[3,4], Mikael Calner[5], Thijs R. A. Vandenbroucke[1]**
[1]Ghent University, Belgium; [2]United States Geological Survey, USA; [3]Illinois State Geological Survey, USA; [4]University of Illinois, USA; [5]Lund University, Sweden

The Silurian is marked by several large, positive carbon isotope excursions that follow and coincide with extinction events. Malformed microfossils have been reported at the onset of several of these events. Understanding these malformations offers insight into the underlying mechanisms of such events. Through bed-by-bed sampling, we generated high-resolution, quantitative data on chitinozoan malformation abundances from the Ireviken Event at the Lusklint 1 outcrop (Gotland, Sweden). Our findings reveal malformation abundances 3 to 30 times higher than the baseline levels, coinciding with measured enrichments of toxic metals. Given that these malformations are in vivo responses, the metals must have been present during deposition rather than entered the system through later diagenesis. As such, the malformations are considered to result from metal poisoning via the encroachment of metal-rich anoxic waters onto the continental shelf. Notably, chitinozoans, as early responders to the Ireviken Event's environmental changes, provide a continuous record throughout the event, as they did not face extinction.

Day 2, Session 6A, Großer Saal, 14:00 – 14:15
Recording allowed: No

The ichnological optimum: Evaluating spatial patterns in the Cambrian trace fossil record as a function of ecology, sedimentation, and outcrop.

***Yorick Veenma[1], Neil Davies[1], Anthony Shillito[2]**
[1]University of Cambridge, UK; [2]University of Saskatchewan, Canada

The ichnological record has greatly enhanced our understanding of evolutionary episodes, but trace fossil abundance and diversity can be influenced by local sedimentological controls, such that ecosystems coinciding with suitable sedimentary conditions can appear as an "ichnological optimum". We illustrate this concept using Cambrian successions from Norway and Wales and

with reference to the offshore transition zone (between storm and fairweather wave-base), which constituted the marine ichnological optimum during the Cambrian Explosion. We demonstrate that its high ichnodiversity can be attributed to: high ecological potential for diverse trace-making behaviours ('Original ichnodiversity'); episodic sedimentation without intervening wave-action, extending colonization windows during sedimentary stasis ('Registered ichnodiversity'); and its typical thin-bedded, heterolithic outcrop expression, conducive to trace fossil identification ('Observable ichnodiversity'). Holistic consideration of controls on original, registered, and observable ichnodiversity also refines the interpretation of Cambrian records from outside the ichnological optimum. Low-ichnodiversity shallow-marine successions, for instance, are shown to predominantly register short colonization windows, reflecting high sedimentation frequencies, pervasive wave-action, and longer colonization windows being under-represented at outcrop. The resulting short-stasis signature gave rise to the sparse fossil content and low ichnodiversity of shallow-marine sandstones, implying that Cambrian littoral ecosystems were more biodiverse than their known record suggests.

Day 1, Session 3B, Kleiner Saal, 14:30 – 14:45
Recording allowed: Yes

talks

Unravelling ancient sharks and rays: Phylogenetic insights into the Late Jurassic and Early Cretaceous neoselachians

Eduardo Villalobos Segura[1], Sebastian Stumpf[1], Manuel Amadori[1], Arnaud Begat[1,2], Patrick L. Jambura[1,2], Julia Türtscher[1,2], Jürgen Kriwet1[1,2]
[1]University of Vienna, Austria; [2]Vienna Doctoral School of Ecology and Evolution (VDSEE), Austria

Neoselachians are a remarkable group of aquatic vertebrates and probably the most successful group of cartilaginous fishes. Including all living sharks and rays, as well as the extinct clades that are phylogenetically closely related to them, the fossil record of this group dates back to the late Palaeozoic, making them one of the oldest lineages of vertebrates. Despite recent attempts to improve our knowledge of their diversity patterns in deep time, our understanding of their taxonomy and systematic relationships still is unclear for long periods of their evolutionary history. The Late Jurassic–Early Cretaceous interval (164-100 Ma) represents one of the most important transitional periods in life history, yet this interval has received little attention in the case of neoselachians. During this time, both clades, the sharks and rays were readily recognizable, apparently undergoing a phase of increasing diversification leading to their modern diversity and composition. Here we present the phylogenetic implications of a comprehensive morphological study of numerous holomorphic specimens from the Late Jurassic-Early Cretaceous. Parsimony and Bayesian approaches were used for the present revision. The results clarify the phylogenetic relationships of several groups of cartilaginous fishes whose relationships have been controversial for decades.

Day 1, Session 2C, Konferenzräume 3&4, 12:00 – 12:15
Recording allowed: No

Basement membrane assembly as a constraint on animal evolution

***Philip B. Vixseboxse[1], Sean McMahon[2], Alexander G. Liu[1]**
[1]University of Cambridge, UK; [2]University of Edinburgh, UK

Basement membranes are present in most animals (excluding sponges and placozoans) and serve functions in patterning organ development, providing structural integrity to tissues, and anchoring muscles in place. Assembly of a basement membrane is contingent on the expression of the enzyme peroxidasin, which induces cross-linking between collagen fibrils via the production of hypobromous acid *in situ*. The timing of peroxidasin evolution is contentious: some workers argue for an origin within stem Metazoa (with subsequent gene deletions within most sponges), whereas others favour a eumetazoan origin for peroxidasin-encoding genes. This uncertainty has profound implications for the predicted ancestral states and morphological complexity of stem-group animals. Using new genomic and transcriptomic data, we construct a peroxidasin molecular phylogeny, with comprehensive sampling of most animal phyla, to distinguish between the competing hypotheses for the evolution of the enzyme. We find that peroxidasin likely originated in the late Ediacaran, pre-dating the appearance of demonstrably eumetazoan fossils by perhaps only a few million years. The evolution of collagen cross-linking in the basement membrane, therefore, appears to have released a substantial constraint on the complexity of animal body plans, coincident with the late Ediacaran-Cambrian radiation of modern animal phyla.

Day 1, Session 2A, Großer Saal, 11:45 – 12:00
Recording allowed: No

Comparing the evolutionary trajectory of bird and bat wing shapes

***Benton Walters, Philip C. J. Donoghue, Emily J. Rayfield, William J. Deakin, Yuming Liu**
University of Bristol, UK

Animal wings are excellent test cases for studying the form-function relationship as they are constrained by the difficulty of becoming and staying airborne. Despite this, the two extant lineages of flying vertebrates, birds and bats, are highly successful and occupy a diverse range of flying niches. I focus on whether the vertebrate wing planforms are optimally designed for flight, as posited by adaptationism, and how the evolutionary paths of bird and bat wings differ. I use theoretical morphospace and performance surfaces to test the optimality of a sample encompassing 10% of the variation in bird and bat planforms. Multiple bird orders have evolved optimally shaped wings, but most extant birds possess suboptimal wing planforms. This suggests that functional optimization acts as a floor rather than a ceiling for many less specialized birds. The dense clustering of ancestral state planform shapes suggests that optimization occurred early in bird evolution. In contrast, bat wings appear to be optimized for the single set of functional constraints underpinning agility and manoeuvrability. Adding planforms reconstructed from fossil bats shows a potential rapid evolutionary trajectory from suboptimal forms in the most primitive complete fossil bat, Onychonycteris, to optimal wing shapes by the Middle Eocene.

Day 1, Session 1A, Großer Saal, 10:15 – 10:30
Recording allowed: No

talks

New fossil evidence from the Shibantan Lagerstätte of South China illuminates the Ediacaran–Cambrian transition

Xiaopeng Wang[1,2], Zhe Chen[1], Shuhai Xiao[3], Chuanming Zhou[1], Chengxi Wu[1], Yarong Liu[1], Ke Pang[1], Bin Wan[1], Alexander Liu[2], Qin Ouyang[1], Wei Wang[1], Xunlai Yuan[1]
[1]Nanjing Institute of Geology and Palaeontology, CAS, China; [2]University of Cambridge, UK; [3]Virginia Tech, USA

The fossil record for most crown group animal phyla first appears in the Cambrian and cannot be traced further back into the Ediacaran. The Ediacaran Period is characterized by the Ediacaran biota, whose unusual body plans are difficult to reconcile with modern animal groups. This has led to a substantial gap in our understanding of animal evolution between the Ediacaran and Cambrian periods. Here we present new fossils from the Ediacaran Shibantan Lagerstätte (~550–543 Ma) that provide critical insights into this evolutionary transition. The Shibantan Lagerstätte (Shibantan Member of the Dengying Formation, Hubei Province, China) is a rare example of a carbonate-hosted Ediacaran biota. Among the new discoveries are: the first crown-group sponge from the Ediacaran—a hexactinellid with an organic skeleton, addressing the problem of the 'missing sponges' in the Precambrian; diverse bilaterian trace fossils reflecting complex behaviours comparable to those seen in the Cambrian; and a new frond-like fossil that structurally resembles some modern benthic suspension feeders. These findings provide new evidence that bridges the evolutionary gap between the Ediacaran and Cambrian, offering fresh perspectives on early animal evolution.

Day 1, Session 3B, Kleiner Saal, 15:15 – 15:30
Recording allowed: Yes

Palaeozoic marine latitudinal diversity gradients were regulated by plate tectonics, climate change, and genus-specific traits

***Die Wen[1,2], Junxuan Fan[1], Lewis A. Jones[2], Philip D. Mannion[2]**
[1]Nanjing University, China; [2]University College London, UK

The latitudinal diversity gradient (LDG) is a fundamental prominent macroecological pattern of the biosphere that remains disputed regarding its origins and drivers. Here we analysed genus-level data of Palaeozoic marine invertebrates, using over half a million occurrence records from 18,234 genera. Using Principal component analysis, we applied a novel approach to identify variation in LDG shape. The dynamic nature of this variation was quantified by focusing on three LDG characteristics (peak diversity location, gradient steepness, unimodal/bimodal) and seven ecospace categories. Moreover, six ecological-driver hypotheses were tested by comparing LDG shape variations with time-series data of both abiotic (plate tectonics and climate change) and biotic (genus-specific traits) proxies. Our results suggest that secular variation in marine shelf distribution exerted a dominant influence on LDG peak location through time. In addition, variation in global average temperature exhibits the strongest correlation with LDG-peak geometry (unimodal/bimodal), suggesting the operation of genus-energy constraints. Broader latitudinal ranges of genera correlate with bimodal LDGs, whereas genus-specific traits, such as broader distributions and adaptability, also shape diversity patterns. This study highlights the complex interactions between climate, plate tectonics, and biological traits in driving long-term LDG variation, offering insights into the evolutionary biodiversity history on Earth.

Day 2, Session 5B, Kleiner Saal, 11:45 – 12:00
Recording allowed: No

Coupling of climate and biosphere dynamics in the Ediacaran Period

Thomas W. Wong Hearing[1], Mark Williams[1], Thomas H. P. Harvey[1], Alexandre Pohl[2], Alexander G. Liu[3], Lin Na[1,4], Benjamin H. Tindal[5], Thomas Vandyk[6,7]
[1]University of Leicester, Leicester, UK; [2]Université de Bourgogne, France; [3]University of Cambridge, UK; [4]Nanjing Institute of Geology and Palaeontology, CAS, China;[5]Natural England, UK; [6]The Open University, UK; [7]Birkbeck University of London, UK

Climate change has been linked with radiations, extinctions, and turnovers in biological diversity throughout the Phanerozoic. Three geographically, environmentally, and temporally segregated assemblages of early metazoans are recognized in the late Ediacaran biosphere: the Avalon (~575 to 560 Ma), White Sea (~557 to 553 Ma), and Nama (~550 to 538.8 Ma) assemblages, each characterized by the appearances of distinct morphogroups. Here we examine how turnovers between these assemblages relate to the mid-to-late Ediacaran geological record of climate change. Specifically, we re-evaluate the glacial sedimentary record with a particular focus on the ages of putative glaciogenic deposits. Our work reveals two icehouse intervals (~593 to 579 Ma and ~565 to ~550 Ma) alternating with two greenhouse intervals (~579 to 565 Ma and ~550 Ma into the Cambrian). Both icehouse intervals were characterized by ~10 to 15 Myr high to mid-latitude glaciations with waxing and waning ice sheets. Global turnovers between the Ediacaran macrofossil assemblages are broadly coincident with these changes between greenhouse and icehouse climate states. We therefore suggest that the earliest known metazoan biosphere was coupled with global climate in a similar way to the subsequent Phanerozoic Earth System and explore possible mechanisms for this coupling.

Day 2, Session 4C, Konferenzräume 3&4, 09:30 – 09:45
Recording allowed: No

Linking form, function and environment across the last 30,000 years of evolution in island lizard Podarcis pityusensis

***Stephanie Woodgate[1,2], Josep A. Alcover[3], Ana Pérez-Cembranos[4], Valentín Pérez-Mellado[4], Alistair R. Evans[5,6], Johannes Müller[1,2]**
[1]Museum für Naturkunde Berlin, Germany; [2] Humboldt-Universität zu Berlin, Germany; [3]Institut Mediterrani d'Estudis Avançats (IMEDEA), Spain; [4]Universidad de Salamanca, Spain; [5] University, Australia; [6]Museums Victoria, Australia

Finding empirical links between micro- and macro- evolution has been an area under intense investigation over the last 50 years. A unique candidate to form these linkages is the endemic Eivissa wall lizard, Podarcis pityusensis. This polymorphic lizard inhabits diverse habitats across the Pityusic islands today, with a high-resolution fossil record provided by the cave fossil site Es Pouàs. This dataset gives the opportunity to combine form and function analyses through time and across geography with ecological data, to investigate evolutionary selective pressures within a single lineage. 3D geometric morphometric analysis of fossil and modern P. pityusensis mandibles reveals significant changes in morphology over the last 30,000 years, with notable contraction in disparity since human arrival. While jaw morphology appears to be shaped by diet, Orientation Patch Count (OPC) reveals dental complexity is not; tooth shape in modern and fossil jaws is highly conserved. In-vivo measurements of bite force reveal that population dynamics are crucial in underpinning

evolutionary trajectories followed by this species, which may explain the strong impact of human arrival. Ultimately, we use this multifaceted approach to compare how various environmental selective pressures have driven evolution within this lineage, spanning scales of varying magnitude across time and space.

Day 2, Session 5B, Kleiner Saal, 12:00 – 12:15
Recording allowed: No

The timescale of eukaryote evolution estimated from Bayesian modelling of the fossil record

***Ruolin Wu[1], Leigh A. Riedman[2], Davide Pisani[1], Susannah M. Porter[2], Philip C. J. Donoghue[1], Daniele Silvestro[3,4,5,6]**
[1]University of Bristol, UK; [2]University of California at Santa Barbara, USA; [3]University of Gothenburg, Sweden; [4]University of Fribourg, Switzerland; [5]Gothenburg Global Biodiversity Centre, Sweden; [6]Swiss Institute of Bioinformatics, Switzerland

The origin of eukaryotes was one of the most formative and unlikely episodes in evolutionary history, underpinning the origin of complex life. The timing of their origin is extremely contentious, with both fossil- and molecular-based estimates each varying by almost a billion years. This occurs because of the challenge of interpreting the phylogenetic affinity of fossil unicellular eukaryotes and, consequently, the paucity of fossil calibrations for molecular clock analyses. Here we employ a new implementation of the Bayesian Brownian Bridge model to estimate the time of origin of eukaryotes from a new compilation of the early eukaryote fossil record. This approach analyses the age of a group of interest by using the first and last appearance data of species within the group. The resulting estimates not only shed light on the age of crown eukaryotes based on fossil data alone but also provide an objective basis for establishing probabilistic calibrations for molecular clock analysis. We consider the results of our analyses relative to previous interpretations of the fossil and biomarker records, as well as previous molecular clock analyses. We also consider the implications of our results for hypotheses on the relationship between eukaryogenesis and the evolution of the Earth system.

Day 1, Session 1B, Kleiner Saal, 09:45 – 10:00
Recording allowed: No

Abstracts of poster presentations

Conserved architectures in the feeding apparatus of early euconodonts underpins their functional morphology.

***Darío Abellán-Flor[1], María V. Paredes-Aliaga[1], Duncan Murdock[2], Philip C. J. Donoghue[3], Carlos Martínez Pérez[1,3]**

[1]University of Valencia, Spain; [2]Oxford University Museum of Natural History, UK; [3]University of Bristol, UK

Conodonts, extinct marine organisms known primarily from their tooth-like fossils, provide key insights into the evolution and function of the earliest vertebrate skeleton. However, the functional morphology and ecological roles of conodont elements remain under debate, especially for the earliest diverging taxa with relatively simple coniform element morphologies. This study examines the functional performance and apparatus architecture of the Middle Ordovician conodont Belodina compressa using high-resolution tomography. By analysing 11 clusters of elements from several individuals, we reconstruct the complete apparatus, identifying eight distinct morphological element-types consistent with the known architecture of the Panderodontida family. Additionally, using virtual cross-sections and beam theory, we assess the biomechanical performance of these elements in terms of bending and torsion resistance. Our results show that subtle variations in cross-sectional profiles significantly affect functional performance, with some elements optimized for bending resistance and others adapted to resist multidirectional forces. These findings suggest that the morphological specialization within the apparatus reflects functional adaptations. Aspects of the functional morphology of euconodont element architectures are highly conservative within not only panderodontids but across euconodonts more widely, demonstrating the underpinning of feeding ecology in conodonts in the earliest diverging groups.

Recording allowed: No

Orbital forcings govern shallow water trilobite evolution along the Early Ordovician northern Laurentian margin

Jonathan Adrain[1], Stephen Westrop[2]

[1]University of Iowa, USA; [2]University of Oklahoma, USA

The Ordovician northern Laurentian margin preserves one of the richest Lower Ordovician shallow water fossil records known from anywhere in the world. Combining new field-based taxonomic work with detailed stratigraphic context provides an unparalleled regional dataset of stratigraphic species distributions, permitting a new, highly resolved, species-level, biostratigraphic zonation. The stratigraphic distributions of species are strongly patterned: first appearance data (FADs) and last appearance data (LADs) tend to be strongly clustered so that a particular set of species occurs in essential stasis through a meter- or decimetre-scale stratigraphic interval then is abruptly replaced by an almost entirely new set of species. This phenomenon occurs without interruption throughout the Lower Ordovician rocks regionally. There are temporal variations in sampling intensity, but no data from anywhere in the interval suggest sustained, gradual, or stochastic species turnover. This pattern of lockstep Early Ordovician coordinated turnover through almost exactly 15 million years

contains 37 distinct trilobite assemblages. The average assemblage duration of 405,400 years is an almost exact match for the 405,000 year Milanković orbital eccentricity cycle, suggesting that shallow water marine evolution in the Early Palaeozoic may have been governed by the influence of astronomical forcing on climate.

Recording allowed: No

Measuring ornithischian tooth complexity using patch count rotated analysis

***Isaura Aguilar Pedrayes, David J. Button, Emily J. Rayfield, Michael J. Benton**
University of Bristol, UK

Ornithischians were a diverse clade of Mesozoic dinosaurs. Multiple ornithischian clades independently evolved varied, complex craniodental adaptations indicating specialized forms of herbivory. Previous studies suggest that an increase in tooth occlusal surface complexity was linked to increased bite efficiency in ornithischians, but this idea has yet to be tested. Orientation Patch Rotated (OPCR) methods have been used to identify diet-related non-homologous dental features in mammals and reptiles. Herbivores have significantly higher OPCR values than carnivores among both living and extinct mammals and, to some extent, reptiles, but these metrics have yet to be systematically compared across Ornithischia. Here we quantify and compare surface complexity between different groups of Jurassic and Cretaceous ornithischians. We found our sample of early ornithopods and thyreophorans have lower average toothrow complexity than later occurring species. Our preliminary work suggests that two ornithischian clades independently evolved higher average toothrow complexity regardless of tooth number evolutionary trends, which could be interpreted as a shift from omnivory to strict herbivory. We will measure surface complexity from representatives from ceratopsians and other ornithischian clades to allow us to trace evolutionary shifts in tooth surface complexity, quantify its relationship with bite performance, and explore patterns of dietary adaptation across Ornithischia.

Recording allowed: No

Foraminiferal response to transition from hothouse to icehouse

Sahil Ahmed, Madhura Ghosh, Ruby Barrett, Daniela N. Schmidt
University of Bristol, UK

The Eocene recorded the warmest long-term global average temperatures of the Cenozoic, the Early Eocene Climatic Optimum (EECO), followed by substantial cooling towards the Eocene-Oligocene transition. This climatic transition provides an opportunity to study the responses of planktic and benthic foraminifera to extreme heat and subsequent cooling. We analysed foraminifera from ODP sites 1209 (Pacific) and 690 (Southern Ocean) from 59-31 Ma and reconstructed planktic foraminiferal species composition, relative abundance, size, and mass accumulation rates. During the Eocene's warm periods, large symbiotic genera of planktic foraminifera, *Morozovella* and *Acarinina* dominated tropical mixed layers, while thermocline-dwelling *Subbotina* thrived in the Southern Ocean. Around 55 Ma, abundance of *Acarinina* doubled compared to *Morozovella*. In benthic systems, significant size reduction was observed in *Oridosalis umbonatus* with warming, particularly in low nutrient settings, with plasticity in diameter, volume, and surface area indicating

strategies for food optimization. As temperature decreased towards the Oligocene, large symbiotic genera declined in abundance while smaller thermocline dwelling *Subbotina* appeared in low latitude assemblages, resulting in reduced foraminifera accumulation and smaller sizes. During the Eocene, benthic specimens adopted adaptive strategies, highlighting their resilience, while planktic communities underwent a shift in their species composition in response to change.

Recording allowed: Yes

Enhancing palaeontological heritage through palaeoart. A case study from Italy

Isacco Alberti[1,2], Francesca Borchi[1,2], Silvia Danise[1,2], Luca Bellucci[3], Matteo Belvedere[1,2]
[1]Università di Firenze, Italy; [2]National Biodiversity Future Center, Italy; [3]Museo di Storia Naturale, Università di Firenze, Italy

Information panels on museum displays can be oversimplified, and it can be complex for the public to access in-depth information. Having this in mind, we designed an interactive web platform focused on the large mammal assemblage (*c.* 1.6 Ma) of the Farneta palaeontological site (Tuscany, Italy), the source of some of the most important finds of the Museum of Geology and Palaeontology of the University of Florence. The Farneta fauna is important because it represents a Faunal Unit of the Villafranchian European Land Mammal Age. The first goal of the web platform is to valorize the hidden collections not on display in the museum or housed in different local museums. The second is to engage with the public by offering 'behind the scenes' contents: information on the discovery and excavation of the fossil assemblage, artistic reconstructions of the fauna and the palaeoenvironment, and informative sheets with 3D models of each specimen (*e.g.* the species *Mammuthus meridionalis*, *Pseudodama farnetensis*, *Stephanorhinus etruscus*, *Panthera gombaszogensis toscana*). The platform can be reached with a QR code directly in the museum or through the museum website, to encourage the public for future visits and reach those who are unable to physically go to the museum.

Recording allowed: Yes

Was oxygen the touchpaper for the Cambrian Radiation?

***Ruaridh Alexander[1], Andrey Yu. Zhuravlev[2], Fred T. Bowyer[1], Laetitia Pichevin[1], Simon W. Poulton[3], Artem Kouchinsky[4], Rachel Wood[1]**
[1]University of Edinburgh, UK; [2]Borissiak Palaeontological Institute, Russian Academy of Sciences, Russia; [3]University of Leeds, UK; [4]Swedish Museum of Natural History, Sweden

Whether metazoan diversification during the Cambrian Radiation (*c.* 539515 million years ago) was driven by increased marine oxygenation remains highly debated. Global geochemical proxies have inferred global oceanic oxygenation events; however, the degree and extent of shallow oxygenation and its relationship to diversification remains uncertain. To resolve this, we interrogate an interval from *c.* 527–519 Ma by integrating the spatial and temporal distribution of shallow water, in situ reef metazoans, and the first large calcified motile bilaterians (trilobites) with high-resolution multi-proxy redox data through the highly biodiverse lower Cambrian Siberian Platform. We document primarily dysoxic water column conditions, suggesting that early Cambrian metazoans, including motile skeletal benthos, had low oxygen demands. We further document 1–3 Myr oxygenation

events coincident with positive global carbon isotope excursions that led to modestly elevated oxygen levels. These events correspond to regional increases in biodiversity, rates of origination, and habitat expansion, with the last event coincident with the rapid diversification of trilobites shortly after their first appearance. The oxygenation events postdate the first appearance of trilobites and archaeocyaths, however, and are thus decoupled from evolutionary innovation. This regional response to episodes of modestly elevated oxygen levels offers a potentially globally applicable model for biodiversification.

Recording allowed: No

An early origin of gigantism in anacondas (Serpentes: *Eunectes*) revealed by the fossil record

Andres Alfonso[1], Jorge Domingo Carrillo-Briceño[2], Rodolfo Sanchez[3], Marcelo R. Sanchez-Villagra[2], Jason J. Head[1,4]
[1]University of Cambridge, UK; [2]University of Zurich, Switzerland; [3]Museo de Paleontológico de Urumaco, Venezuela; [4]Museum of Zoology, University of Cambridge, UK

Extant snakes exhibit a wide range of body sizes, from 10 cm to over 8 m, with the largest sizes found in pythonids and the green anaconda, *Eunectes murinus*. The timing and ecological contexts for the origin of gigantism in these taxa are poorly understood due to an understudied fossil record for tropical snakes. Field research in the Urumaco and Soccoro formations of Venezuela has produced a fossil record of *Eunectes*, consisting of 18 specimens from 13 localities spanning the Middle to Late Miocene (~15-7 Ma). This provides a rich dataset to constrain body size histories for anacondas. We identified the fossil specimens based on vertebral morphologies, including a median tubercle at the base of the zygosphene and the curved shape of the interzygapophysial ridges in dorsal view. We reconstructed body size using linear regression models of vertebral measurements from precloacal vertebrae against total body length (TBL). Our results suggest that Miocene anacondas had TBLs ranging between four to five meters. This coincides with body size estimations from an ancestral state reconstruction performed over a time-calibrated phylogeny, revealing that *Eunectes* divergence might have occurred during the Early Miocene, quickly reaching a large body size similar to extant *E. murinus*.

Recording allowed: No

Diversity of microanatomical patterns in long bones of semi-aquatic mammals

***Apolline Alfsen[1], Christian de Muizon[2], Giovanni Bianucci[3], Olivier Lambert[4], Rodolfo Salas-Gismondi[5], Mario Urbina[5], Matthew R. McCurry[6], Antonia R. M. Kaffler[1], Alexandra Houssaye[2], Oliver Hampe[1], Eli Amson[7]**
[1]Museum für Naturkunde, Berlin, Germany; [2]Muséum national d'Histoire naturelle, Paris, France; [3]University of Pisa, Italy; [4]Institut royal des Sciences naturelles de Belgique, Belgium; [5]Museo de Historia Natural, Universidad Nacional Mayor de San Marcos, Peru; [6]Australian Museum Research Institute, Australia; [7]Staatliches Museum für Naturkunde, Stuttgart, Germany

For mammals, swimming implies substantial adaptations in bone external shape and internal structure. Semi-aquatic species have additional constraints to be able to navigate in two drastically

different environments. Despite clear differences in the use of forelimbs and hindlimbs for propulsion among semi-aquatic carnivorans, few studies have investigated how these differences impact their microanatomy, and none have quantified the variation in a comparative framework. Here we explore how diverse the microanatomy of humerus and femur is among these mammals, which combine specialized swimming and terrestrial locomotion. Densely sampling mustelids and pinnipeds through µCT-scanning, we quantified the profile of bone cross-sectional parameters along the bone length. Pinnipeds revealed a greater diversity of profiles, showing a clear differentiation between forelimb- and hindlimb-propelled swimmers and some examples of extremely spongious bones, similar to extant cetaceans. Finally, using a subsample of virtual slices, we contrasted the microanatomical phenotypes of early semi-aquatic cetaceans with those of carnivorans. *Peregocetus pacificus* and *Rodhocetus balochistanensis* have a microanatomical profile reminiscent of otariids and, in some ways, of otters. This study highlights the relevance of microanatomical profiling along the bone length to better characterize the diversity of adaptations to a semi-aquatic lifestyle and improve inferences in the fossil record.

Recording allowed: Yes

A new austrolimulid from the Triassic of Poland presents insight into xiphosurid evolution after the End-Permian extinction

***Jonatan Audycki[1], Russell D. C. Bicknell[2], Grzegorz Niedźwiedzki[3,4], Kenneth De Baets[1]**
[1]University of Warsaw, Poland; [2]American Museum of Natural History, USA; [3]Uppsala University, Sweden; [4]Polish Geological Institute-National Research Institute, Warsaw, Poland

Xiphosurans, commonly known as horseshoe crabs, are predominantly marine chelicerates famous for their apparent morphological stasis and limited diversity. However, some fossil representatives of this group have radically diverged in form from the classic horseshoe crab morphology, challenging this traditional view of horseshoe crab evolution. This is especially true for the austrolimulids – a group of horseshoe crabs known almost exclusively from the Triassic, which developed extremely elongated genal spines and have sometimes been linked to brackish and freshwater environments. Here we report new horseshoe crab specimens from the lower part of the Middle Buntsandstein deposits in the Holy Cross Mountains (southeastern Poland) that most likely constitute a new genus within the Austrolimulidae. Dated to the latest Induan/earliest Olenekian, the new taxon seems to represent a transition between a less-derived anatomy of geologically older austrolimulids and the extreme morphology of *Austrolimulus fletcheri* from the Middle Triassic of Australia. This find expands the palaeogeographical range of morphologically 'extreme' austrolimulids and supports their possible connection with brackish habitats, making it a favorable starting point for further studies on their evolution and ecology. Additionally, based on analysis of associated fossils, we provide further support for the latest Induan-earliest Olenekian marine influence in the Polish Basin.

This research was financially supported by the Polish National Science Centre grant 2022/47/O/NZ8/02934.

Recording allowed: No

Primate origins: a review of dietary hypotheses and what the fossil record tells us

***Matteo Battini[1], Mark A. Purnell[1], Sarah E. Gabbott[1], Stephen L. Brusatte[2], Thomas Williamson[3]**
[1]University of Leicester, UK; [2]University of Edinburgh, UK; [3]New Mexico Museum of Natural History and Science, USA

Primate origins are of particular interest to us because of our shared evolutionary history. However, as research has focused on the hominin branches of the tree, comparatively little is known about the origin of the primate crown group. It is widely thought that a dietary shift early in primate evolution was the driver behind the acquisition of the crown group's defining traits, but the direction of this shift is still debated. Two different hypotheses have been proposed. According to one, an insect-rich diet led to the acquisition of these traits; the alternative proposes that a shift to fruit eating played a major role. Interestingly, both hypotheses claim the support of the fossil record. To test this, we ran a meta-analysis of 127 dietary interpretations of fossil primates collated from the literature. Interpretations were classified into dietary and evidence-type categories; we tested statistical associations between diets and taxa and whether interpretations changed through the Palaeocene. Only one family shows evidence of a shift in diet. Overall, we found a lack of consistency in interpretations; a more robust analysis of diets in fossil primates is required before the merits of alternative scenarios for primate origins can be evaluated.

Recording allowed: Yes

The Giant of Lilliput: exceptionally large burrows in the aftermath of the end-Permian extinction

Andrea Baucon[1], Marco Mottes[2], Davide Conedera[3], Girolamo Lo Russo[4], Carlos Neto de Carvalho[5,6], Nereo Preto[3], Danilo Giordano[2], Anna Breda[3]
[1]University of Genova, Italy; [2]Istituto Istruzione Superiore U. Follador, Italy; [3]Università degli Studi di Padova, Italy; [4]Museo di Storia Naturale di Piacenza, Italy; [5]Naturtejo UNESCO Global Geopark, Portugal; [6]Universidade de Lisboa, Portugal

The Lilliput Effect, characterized by a reduction in organism size following mass extinctions, is a prominent feature of post-crisis ecological landscapes. This phenomenon is distinctly observed in the Werfen Formation of the Dolomites following the end-Permian extinction. The Formation is acknowledged for its extensive archive of size changes, highlighting a significant decrease in both body and trace fossil sizes. However, our research in the Mazzin Member of the Werfen Formation near Falcade (northeast Italy) has uncovered remarkably large fossil burrows that are ~10 times bigger than the largest burrow previously recorded in this unit. The studied structures are unbranched horizontal burrows with elliptical chambers and globular swellings. These burrows, exceeding 15 cm in diameter and 1 m in length, were produced less than one million years after the Permian-Triassic boundary. The presence of scratch marks suggest that they were produced by an arthropod. While not refuting the Lilliput Effect, the findings propose the coexistence of small and large burrowers, suggesting natural selection may have favored a bimodal size distribution. The results challenge the traditional understanding of post-extinction recovery dynamics and highlight the need for further investigation into the factors influencing size variability during mass extinction recoveries.

Recording allowed: No

Large bodied mammals explore more jaw ecomorphologies than small bodied mammals.

Gemma Louise Benevento[1], John T. Clarke[2,3], Matt Friedman[4], Susanne A. Fritz[1,2,3], Roger B. J. Benson[5]

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Mammals underwent taxonomic and morphological adaptive radiation across the Cretaceous-Palaeogene (K–Pg) boundary. Morphological adaptations to the jaw, relating to disparate feeding ecologies, have been shown to increase in disparity during the Cenozoic. Mammal body mass also increases across the K–Pg boundary and is intrinsically linked to many aspects of a mammal's ecological niche, including their feeding ecology and, therefore, jaw morphology. Here we test whether increases in jaw phenotypic disparity among early Cenozoic mammals is linked to their evolutionary expansion into larger body sizes that permitted the exploration of new feeding roles. Using jaw continuous character traits for Jurassic-Eocene and Recent (including Pleistocene) mammals, we analysed jaw ecomorphological disparity across small and large-bodied mammals using principle component analysis. Additionally, using a recently published metatree of synapsids pruned to include mammaliaformes from this study, we analysed rates of jaw morphological diversification and compared these rates to body mass evolution. We found that large mammals have higher jaw ecomorphological disparity than small mammals throughout the early Cenozoic and in the Recent. Moreover, extant and Pleistocene large mammals show higher disparity than Eocene large mammals, and there are some jaw morphologies that are unique to large mammals relative to small mammals.

Recording allowed: No

Palaeogeography as a predictor of extinction risk over the Phanerozoic

Lila Blake[1,2], Cooper Malanoski[2], Erin E. Saupe[2]

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The fossil record documents substantial variation in extinction rates over the Phanerozoic. Previous works have identified species-specific traits such as geographic range size and body size as good correlates of extinction for taxa across both background and mass extinction intervals. Here we explore how differing palaeogeographic boundary conditions can explain the substantial variation in marine extinction rates observed throughout the Phanerozoic. We present an integrated approach combining taxon occurrence data with palaeogeographic reconstruction models to examine the role of palaeogeography in modulating extinction risk in marine invertebrates over the past 495 million years. We find that palaeogeography can explain the observed variations in extinction selectivity over the Phanerozoic. The relationship between palaeogeography and extinction risk is strongest during periods where temperature change induces thermal range shifts. Differences in palaeogeography alone are unlikely to explain the observed differences in extinction intensity. Instead, the effect of palaeogeography on a taxon's risk of extinction is likely mediated by additional factors, such as taxon dispersal ability. Our results have implications for understanding species'

extinction risk today and in the future; taxa living along predominantly E-W oriented coastlines are predicted to be at significantly increased risk of extinction today due to anthropogenic emissions.

Recording allowed: No

Enhanced zebrafish mandible segmentation: Integrating Dice-Hausdorff metrics for precision in morphometric and biomechanical analysis

***Felix Bowers, Richard Lane, Wahab Kawafi, Emily J. Rayfield, Chrissy L. Hammond**
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Segmentation, the isolation of features in computed tomography (CT) datasets based on greyscale values (Hounsfield units) serves as a foundational step in anatomical study of fossil and extant organisms, leading to downstream morphometric and biomechanical analyses. Segmentation is often labour-intensive with outcomes that vary based on the operator. To address these challenges, automated methods leveraging deep learning architectures, such as U-Nets and Convolutional Neural Networks, are gaining popularity in both biomedical image processing and palaeontological studies. In this work, we present a refined segmentation approach designed for the zebrafish mandible. One of the most employed validation metrics in segmentation is the Dice score, which evaluates the proportional overlap between models. However, while effective for volume-based comparison, it falls short in assessing surface shape continuity, which is critical for downstream analyses such as Finite Element Analysis (FEA). To overcome this limitation, we implemented a deep learning model with U-Net architecture, enhanced by a novel validation function that integrates the Dice score with a weighted Hausdorff distance. This combined metric ensures both volumetric precision and surface shape accuracy, providing a more robust framework for segmentation, and significantly improving its applicability for further biomechanical and morphological investigations.

Recording allowed: No

Molecular dating of the evolutionary history of plastid endosymbioses

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Plastids, such as chloroplasts, are DNA-containing organelles acquired through endosymbiosis. Despite their critical role in eukaryotic evolution, biodiversity, and primary production, the evolutionary history of plastids, particularly those derived from red algae, remains poorly understood. This study investigates the timing and origins of plastid endosymbiosis events using an eight-plastome marker alignment across 103 taxa, including Cyanobacteria, Archaeplastida, Cryptophyta, Haptophyta, and the SAR supergroup, covering all known endosymbiotic events. Multiple topological hypotheses for plastid trees were constructed using maximum likelihood methods, incorporating prior knowledge of species tree topology. Divergence times were inferred with MCMCTree, calibrated with 17 phylogenetically informative fossil node constraints. The results support a single secondary red algal endosymbiosis, followed by multiple serial events. They suggest a Stramenopila ancestor as the recipient and a stem-Rhodophyta or stem-Rhodophytina as the donor for the secondary event. Additionally, the study aligns with previous work on green plastid origins but recovers older estimates. Regarding the timescale, all endosymbiotic events are

inferred to have occurred during the Meso- and Neoproterozoic, with red algae-derived plastids generally predating those derived from green algae.

Recording allowed: No

Survival is the ability to swim in strange waters: A study of the biogeography of Late Cretaceous ammonites

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The Earth is currently undergoing what is widely regarded as the sixth mass extinction event of the Phanerozoic, driven largely by anthropogenic climate change. This is forecast to impact biodiversity and the stability of global ecosystems. Understanding and mitigating the effects of this crisis requires a better understanding of past extinction dynamics. A key tool in examining these is biogeography, in particular the concept of biogeographic range. This is a strong predictor of extinction risk with fossil taxa exhibiting a higher range being buffered from extinction relative to less widespread groups. We explored these dynamics using the extensive fossil record of ammonoid cephalopod molluscs (ammonites) from the Late Cretaceous. Using methods including latitudinal range, convex hull and minimum spanning tree we examined how the ranges of ammonites changed from the Albian to Maastrichtian, and explored at substage level the effect of the Cenomanian-Turonian (CT) boundary event. We also investigated the sensitivity of these metrics to sampling bias. We highlight temporal and spatial variations in ammonite biogeographic range, how this is driven by climate perturbations such as Oceanic Anoxic Event 2, and the value of studying biogeographic range through time to explore the impacts of climate change.

Recording allowed: No

A Taphonomic classification of fish teeth and ganoid scales from the Rhaetian bonebed of Southwestern Germany

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Rhaetian bonebeds across Europe have been widely studied, focusing on their faunal composition and complex depositional history. However, currently, the literature lacks discussions about the taphonomy and preservation of osteichthyan and chondrichthyan fossils contained in bonebeds. In this study, we propose a qualitative classification for fossil fish teeth and ganoid scales. Specimens were handpicked from two locations along the NW-slopes of the Swabian Alb, southwestern Germany. Morphogroups were created to examine the mechanical weathering of different shapes. A quantitative analysis was made before the classification was tested qualitatively by investigating the erosional pattern of each morphogroup individually. Afterwards, the analysed samples were compared to those of other European localities that preserve Rhaetian bonebeds. Our results show differences in mechanical weathering through the different morphogroups and between the localities. Ganoid scales are more resistant to abrasion than teeth. This pattern can be explained through the conditions of biomineralization, hydrodynamical behaviour and environment. Teeth seem to be an indicator of the energy level of the environment, while ganoid scales reflect the

transport distance of fossils. Our study shows that microfossil fish teeth and ganoid scales may be used for a taphonomic interpretation of aquatic depositions that contain fish remains in high detail.

Recording allowed: No

Quantifying skeletal pneumaticity: more than just air-filled bones

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Postcranial skeletal pneumaticity (PSP; *i.e.* epithelial-lined, air-filled cavities within bones) is a distinctive trait of avian structure and biology that first evolved among the non-flying archosaurian ancestors of birds. Studies have quantified pneumaticity in both extant and fossil archosaurs by calculating the area or volume fraction in bone occupied by air. This 'Air Space Proportion' (ASP) measure has historically relied on a key assumption: that the soft tissue mass within pneumatic bones is negligible, an assumption that has rarely been explicitly acknowledged or tested. We present the first comparisons between estimated ASP, which assumes that the internal cavities of pneumatic bones are entirely air-filled, and true air space proportion (ASPt), which relies on fresh specimens instead of dried skeletal preparations and accounts for intraosseous soft tissues within pneumatic cavities. Using birds as model archosaurs exhibiting PSP, we find that estimates of ASPt are significantly lower than estimates of ASP in bird humeri. Preliminary investigations of femora, cervical and thoracic vertebrae exhibited similar trends, though to a lesser extent. Our findings raise an important consideration that should be acknowledged in investigations of skeletal pneumaticity and bulk skeletal density in extinct archosaurs, as well as in volume-based estimates of archosaur body mass.

Recording allowed: No

The evolution of Tessellated Calcified Cartilage (TCC) in chondrichthyans.

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Chondrichthyans have evolved a unique suite of cartilaginous tissues that replace the structural function of bone, with tessellated calcified cartilage (TCC) as a key tissue. TCC forms small blocks that create a thin layer(s) over the uncalcified core of the skeleton, providing an optimum of stiffness, flexibility, and lightness. Despite its significance, our understanding of calcified cartilage in chondrichthyans lags behind that of bone in osteichthyans. This knowledge gap limits insights into cartilage calcification, its relationship to bone ossification, and the broader evolution of hard tissues in vertebrates. High-resolution µCT scanning has been used to visualize TCC in 3D, but only in a few extant taxa thus far. In this study, we use synchrotron microtomography to study the 3D structure of TCC in both living and extinct chondrichthyans for the first time, providing a more comprehensive understanding of its variation and evolution. Our initial findings suggest the evolution of calcified

cartilage in stem-chondrichthyans was non-linear, with diverse hard tissues present in the acanthodians. The TCC in stem-holocephalans appear to be more similar to that of stem and crown-elasmobranchs, characterized by polygonal blocks, while modern holocephalans display a more granular and irregular structure.

Recording allowed: No

Digitizing the colonial Tendaguru collection

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The collection history for colonial vertebrate palaeontological collections was often considered important as it provided additional scientific documentation, and the history was viewed from the perspective of colonizers. In recent years however, increasing awareness of colonial heritage have encouraged other ways of looking at collections. Justified demands are being made to open up collections, specifically to increase transparency and accessibility. Colonial scientific objects are scientific and cultural, and new perspectives lead to different demands regarding these objects. To increase transparency and availability of object data, we are developing a comprehensive digitization strategy for the dinosaur fossils that, in addition to 3D digitization, includes metadata assessment, documentation, and data accessibility. This strategy is oriented on the FAIR principles and importantly, contextualizes the data in terms of colonial background and making it available virtually. Using non-destructive digitization approaches helps preserve unique documentation of colonial field practices and expertise of local people that the Tendaguru expedition harvested from. Finally, when active preservation and documentation of historical field practices becomes part of collection management strategies, we can preserve colonial collection specimens as life documents of palaeontological excavations under colonial conditions, increasing awareness of fellow scientists for the perspectives one can have on a fossil.

Recording allowed: No

Diversification and disparity in a major Palaeozoic clade of Brachiopoda: the rise and fall of the Plectambonitoidea

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The Plectambonitoidea Jones, 1928 is an abundant and diverse Palaeozoic clade of the phylum Brachiopoda. The shells were generally small and pursued a recumbent mode of life resting on a convex ventral valve or possibly on a concave dorsal valve. A phylogeny is presented for the *c.* 125 genera comprising the superfamily, based on 50 characters. The changing disparity through time has been evaluated from the morphological matrix based on the sum of variances and the diversity trajectory of the clade mapped using corrected range data from the Paleobiology Database. The group expanded its reach during the Tremadocian, accelerating in numbers during the Floian and Dapingian, and peaking in the Darriwilian. Originations occurred during a window within the Tremadocian-Floian ages. The group suffered a major extinction at the end of the Ordovician and

in the late Silurian, continuing as a dead clade walking until the Early Carboniferous; extinctions were most marked during the Katian-Aeronian ages. On the other hand the expansion of disparity predated the hikes in diversity, accelerating during the early part of the Tremadocian. In common with other major groups, experimentation and innovation amongst new body plans exploded prior to bursts of diversity at lower taxonomic levels.

Recording allowed: No

A vertebrate Chibanian Konservat-Lagertätten from the oceanic volcanic island of Tenerife (Canary Islands)

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Fossil Lagerstätten sites are valued by the palaeontological community as important windows into ancient ecosystems. One type of such sites is the so-called Konservat-Lagerstätten, which are defined by their fossil quality, as they preserve fossils with connected or articulated skeletal components. In the case of fossil vertebrates, one of the criteria to be considered in this category is the presence of complete, or mostly complete (>75%) skeletons. We present the discovery of two fossil specimens of the endemic giant *Gallotia* lizards from the island of Tenerife (Canary Islands) found in a sedimentary formation (eolianite) belonging to the Chibanian. They appear together and their skeletons are articulated and preserve most of their anatomical elements (head, neck, dorsum, tail, ribs and partially limbs). The three-dimensional preservation indicates that death occurred by rapid burial when the lizards were inactive or dormant. This exceptional finding provides data on the social behaviour of the basal lacertid genus *Gallotia*. Furthermore, it is possible that this catastrophic death may be related to the volcanic disturbances occurred in Tenerife between 0.6 and 0.7 Ma associated with the great landslides, and/or the eruptions of the Cañadas edifice.

Recording allowed: No

Detecting the effect of past biotic interactions and climate changes on phenotypic evolution

***Nils Chabrol[1], Gilles Escarguel[1], Hélène Morlon[2], Julien Clavel[1]**
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Detecting the impact of biotic interactions at the macroevolutionary timescale is one of the big challenges of macroevolution, as many hypotheses have been formulated verbally on the consequence of those interactions on trait evolution. There is also more and more evidence, from macroecological studies, that those interactions are stronger in hot climates compared to cold climates. A widely used set of methods to test such hypotheses on long timescales are Phylogenetic Comparative Methods (PCM), which allows to discriminate between different models of trait evolution based on both the phylogeny and morphological trait measurements of a given clade. We developed new PCM models of trait evolutions that infer the effect of competition on the

phenotypic evolution, and the impact of long-term climate change on the strength of this effect. These models can be applied to both neontological and fossil data, can take the biogeographic history of the studied clade and can infer different regimes of competition depending on the ecological class of the species. We assessed the power of those new models to detect the effect of competition on trait evolution through simulations and tested several hypotheses on the effect of competition on the phenotypic evolution of extant and fossil clades.

Recording allowed: No

From bline worms to world serpents, the evolution of Squamata bite force

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A diverse array of species and ecologies make Squamata an ideal clade for studying the relationship among performance, morphology, and ecology. As a result, many studies have examined how bite force correlates with ecologies and cranial morphology in Squamata. However, these studies mostly utilized in vivo bite force and were thus limited in terms of the number of taxa and traits that could be included. To address this gap, we used lower jaw measurements to calculate a bite force proxy based on the second moment of area for >400 species (both extant and extinct) spanning all major clades. We employed phylogenetic comparative methods to test the relationship between bite force and jaw dimensions, diet, habitat, venomous adaptations, and teeth implantation. We found a significant positive relationship between bite force and jaw dimensions. We also found that carnivorous species and venomous species have significantly lower bite force compared to species of other diets and non-venomous species. Interestingly, several clades exhibit significant variation in bite force that could not be explained by any of the ecological factors examined. These results suggest that, although there are some relationships between bite force and ecologies, the ecomorphology of Squamates is nuanced and requires further investigation.

Recording allowed: Yes

A revision of Exogyrinae subfamily from the Campanian-Maastrichtian of the Ariyalur Sub-Basin, India: Insights into taxonomy and palaeobiogeography

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Indian Institute of Technology, Kharagpur, India

Oysters are commonly found in marine Jurassic-Cretaceous deposits worldwide, prompting extensive taxonomic studies that have led to inconsistencies in their identification. Here we re-evaluated the Exogyrinae subfamily using a comprehensive dataset from the Campanian-Maastrichtian strata in the Ariyalur sub-basin, India. Six species across four genera are identified: *Exogyra tamulica* and *Exogyra ponderosa* from the older Sillakudi Formation; *Rhynchostreon cauveryensis* sp. nov., *Aetostreon* sp. indet., *Ceratostreon flabellatum*, and *Ceratostreon pliciferum* from the younger Kallankurichchi Formation. We describe a new species, *Rhynchostreon cauveryensis* sp. nov., and reported the first occurrences of *Aetostreon*, *Exogyra ponderosa*, and *Ceratostreon flabellatum* from this region. We also provide morphologic revision of previously reported *Ceratostreon pliciferum* and

Exogyra tamulica. However, we found *Exogyra tamulica* in the Sillakudi Formation, whereas it had been previously reported from the Kallankurichchi Formation. Both qualitative and quantitative methods were employed to compare their detailed morphology. The palaeobiogeographic distributions of the studied taxa were also investigated to trace their potential migration routes. This integrated approach aids in understanding the evolutionary history of the Exogyrinae subfamily, especially in the context of India's northward journey as an isolated landmass towards the tropics, which likely shaped the diversity and distribution of these oysters.

Recording allowed: Yes

Shallow ocean deoxygenation drove trilobite turnover during the late Cambrian SPICE event

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The spread of marine anoxia is believed to have played a key role in the development of the SPICE (Steptoean positive carbon isotope excursion) event and the end-Marjuman extinction in the late Cambrian (~497.5 Ma), but their cause-and-effect relationship is poorly constrained. Here we present an integrated analysis of carbonate $\delta^{13}C$, cerium anomalies (Ce/Ce*) and genus-level diversity data of trilobites from the North China Platform. Our results show tightly coupled changes between the SPICE, an increase in Ce/Ce*, and a trilobite turnover event, which we interpret as indicating enhanced productivity and organic remineralization, leading to the development of low-oxygen conditions in shallow water settings. This study therefore establishes a direct link between local ecological stress and trilobite turnover during the global SPICE event. Furthermore, the presence of low-oxygen rather than fully anoxic conditions during the peak of the SPICE event could explain the nature of the end-Marjuman crisis, which was characterized by the replacement of shallow water fauna by deeper-water counterparts that were potentially more tolerant of hypoxia.

Recording allowed: Yes

Is the fleshy fruit an overlooked key innovation that underpins the species richness of flowering plants?

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Angiosperms (flowering plants), with over 300,000 species, represent one of the most spectacular and enigmatic evolutionary radiations on Earth. A potential explanation for this evolutionary success may be found in the unique functional traits (*i.e.* 'key-innovations') of angiosperms, which allowed them to explore new ecological opportunities for diversification and trait evolution. A key but understudied innovation is the evolution of fleshy fruits, a feature whereby angiosperms entice animals to swallow and distribute their seeds. This innovation is thought to have been particularly crucial for solving a dispersal problem introduced by angiosperms in rainforests, where shady conditions should create a selection pressure for larger and more energy-rich seeds able to grow taller before becoming fully self-reliant. These larger seeds are then hard to disperse via abiotic

mechanisms, increasing the need for traits, such as fleshy fruits, which deliver a biotic dispersal mechanism. Here, I quantify speciation, extinction, and net diversification rates on an 80,000 species phylogeny of plants using a novel diversification inference method, and examine the impact of fleshy fruit upon these rates.

Recording allowed: No

The Pelsa/Vazzoler Fossil-Lagerstätte: a window into the Middle Triassic biodiversity of the palaeotropics

***Davide Conedera[1], Andrea Tintori[2], Stefano Dominici[3], Evelyn Kustatscher[4], Hans Hagdorn[5], Matteo Montagna[6], Roberto Gatto[1], Stefano Monari[1]**
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The Dolomites (northeast Italy) are one of the most extensively studied mountain ranges in the world, especially for their Triassic carbonate platforms and coeval basinal sequences. The newly discovered Pelsa/Vazzoler Fossil-Lagerstätte (Agordo Dolomites, Belluno) yielded a remarkably diverse fossil assemblage of late Ladinian age, deposited in a small intraplatform basin. It includes thousands of well-preserved silicified invertebrates belonging to more than 100 molluscs species and dozens of echinoderm, brachiopod, cnidarian, and porifera taxa. Studies on molluscs suggest that a significant radiation of modern benthic groups occurred as early as the late Ladinian. Furthermore, 250 fish specimens were found which belong to at least 10 species, including actinopterygians like *Habroichthys* and *Marcopoloichthys*, the flying fish *Thoracopterus wushaensis*, previously described from China, but also sarcopterygians and chondrichthyans. This makes the Pelsa/Vazzoler Fossil-Lagerstätte the most diverse vertebrate fossil deposit in the Dolomites. Abundant conifer, fern and cycad remains, together with rare insects, help to reconstruct the surrounding terrestrial environment. Finally, ammonoids, conodonts and radiolarians provide a biostratigraphic framework and insights into extraplatform basin faunas beyond the carbonate platform. Altogether, the Pelsa/Vazzoler Fossil-Lagerstätte promises to provide further new insights into the biodiversity of the western Tethys tropical ecosystem during the late Ladinian.

Recording allowed: Yes

Body size selectivity on origination and extinction across the Ediacaran Period

***Matthew Craffey[1], Simon A. F. Darroch[2], Kate Lyons[1]**
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The Ediacaran Period (645-538 Ma) marks the appearance of macroscopic animals. This is a critical transition as increases in body size (a key ecological trait) may have allowed for the evolution of new kinds of organisms and ecological communities. Thus, examining how body size changed across the Ediacaran may help us to better understand how animal ecosystems initially developed. We measured lengths (*e.g.* longest axis) and widths for 97 Ediacaran genera from museum specimens and the literature. We calculated mean log biovolume using measured lengths and widths and

simple geometric models for each taxonomic group that best corresponded to their reconstructed morphology (ex. ellipsoid, cylinder). We compared body size distributions between each Ediacaran interval (the Avalon, White Sea, and Nama) using Kolmogorov-Smirnov tests. We also determined the selectivity of body size and taxonomic grouping on origination and extinction using log odds regressions. We find that body size distributions shifted dramatically from the Avalon to White Sea but not the White Sea to Nama, despite intense extinction. We find that body size helped reshape the Nama's taxonomic composition through: increased extinction at the White Sea-Nama transition among smaller taxa; and increased origination among small-bodied taxa belonging to more derived groups.

Recording allowed: Yes

Biological landscapes at the dawn of conifers

James Craig, Neil S. Davies, William J. McMahon
University of Cambridge, UK

Pennsylvanian and Early Permian strata from Euramerica record a floral shift from lycopsid-dominated tropical 'coal swamps' to conifer-dominated dryland environments. In oxidized red-bed facies of the latter environments, vegetation superficially appears less abundant, meaning that the environments and biogeomorphic impact of the earliest conifers are poorly understood. In this talk, we describe plant fossils, vegetation-induced sedimentary structures (VISS) and trace fossils from the Prince Edward Island Group of Canada, which records a semi-arid fluvial system. Standing trees from in-channel and floodplain deposits are interpreted as walchian conifers that expand the sparse late Palaeozoic records of *in situ* coniferopsids. Petrified fallen tree fossils up to 28 metres in length are found in association with charcoal deposits. The plant fossil record is complemented by VISS – sedimentary structures formed by *in situ* plant-sediment/hydrodynamic interactions – which provide evidence of plants mediating sedimentation and erosion. Diverse VISS from the PEI Group show early conifers were equally important biogeomorphic agents to the coal forests that preceded them. Ichnodiversity increases upwards through the stratigraphy, whereas plant fossil abundance decreases; these trends may reflect continuing aridification through the Early Permian, as fauna adapted to new dryland niches and vegetation became sparser.

Recording allowed: No

Do ecosystem engineers facilitate recovery after mass extinctions?

Alison Cribb
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The end-Permian mass extinction was the most devastating biotic crisis in the marine biosphere, resulting in a subsequent recovery period that was prolonged several millions of years into the Early Triassic. However, it is unlikely that global recovery patterns were spatially homogenous. Rather, ecological succession in the Early Triassic was likely influenced by biotic interactions operating on the community scale. For example, ecosystem engineers – organisms whose behaviours change resource availability and thereby the structure of their communities – such as bioturbators and reef-builders have long been implicated in the recovery of Triassic marine ecosystems. During

times of modern and ancient climate change, ecosystem engineers are hypothesized to ameliorate environmental stress, acting as buffers against ecological collapse and promoting biotic recovery. Here, three questions are addressed: First, how did the diversity and distribution of ecosystem engineers change across the Permian-Triassic boundary? Second, is the ecological recovery of ecosystems different between communities that are and are not influenced by ecosystem engineers? And third, do taxonomic turnover rates significantly differ between these two different pools of communities? By quantitatively addressing these questions, we can better understand the extent to which key ecosystem engineers bolster community resilience and facilitate ecosystem recovery.

Recording allowed: No

Early Palaeozoic radiolarian diversifications and evolutionary faunas

Taniel Danelian, Claude Monnet
Université de Lille, France

A factor analysis of an exhaustive sample-based dataset of middle Cambrian to Silurian radiolarian occurrences allowed the detection of several evolutionary faunas composed of specific radiolarian families, which record simultaneous increases and decreases in species richness over geological time. The late Cambrian – Tremadocian fauna is dominated by echidninid and protoentactinid archeospicularians, in addition to palaeospiculids. These three families are still present during the Floian–Dapingian, while aspiculids and proventocitids also diversify during this interval. The fauna that emerges during the Darriwilian will last until the end of the Ordovician; it is dominated by the spumellarian families Inaniguttidae and Haplotaeniatidae, and to a lesser extent, by the entactinarian families Haplentactiniidae and Entactiniidae. The emergence in this fauna of the deep-dwelling albaillellarian family Ceratoiciskidae, but also of the peculiar archaeospicularian family Secuicollactidae, is also noteworthy. Our analysis confirms the evolutionary affinity of the Early Ordovician fauna with the one present in the late Cambrian. It highlights the dramatic faunal change occurring during the Dapingian–Darriwilian transition, which took place during profound climatic and oceanographic changes during this interval. Our results highlight the contrast between the Late Ordovician and Silurian radiolarian evolutionary history and dynamics.

Recording allowed: No

The importance of fossils re-evaluation in museum collections: Devonian ichthyofauna of Belarus and Lithuania as a case study

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In the Baltic States and Belarus, the Lower and Middle Devonian strata are distinguished by a rich fossil record of invertebrates, including scolecodonts, brachiopods, ostracods, trilobites, bivalves, crinoids, gastropods and tentaculites. Conversely, the diversity of conodonts, fish and other vertebrate fauna has been relatively limited. This study presents a re-evaluation of the ichthyofaunal assemblage from the collections of Drs J. Valiukevičius and J. Šečkus, stored at the Nature Research Centre in Vilnius, Lithuania, after over 30 years. Additionally, we incorporated

fish material from Dr D.P. Plax's collection to enhance the palaeobiological correlation of the region. The analysed material includes fossils from Chondrichthyes, Osteichthyes, Thelodonti and Placodermi, representing the Lochkovian, Emsian and Eifelian Stages across 27 boreholes in Belarus and Lithuania. The analysed fish remains—comprising isolated scales, teeth, jaw fragments, dermal plate sections, tubercles, otoliths and incomplete fin spine elements—were re-evaluated and formalized into 38 species. This updated ichthyofaunal data has shed new light, adding information about the diversity of species discovered in recent decades. Consequently, it has significantly improved and detailed biostratigraphic correlations within the region as well as broadened the palaeogeographic distribution of these taxa during the Eifelian and Givetian Stages of Laurasia.

Recording allowed: No

Museum 'dark data' illuminates the biogeographic and evolutionary history of echinoids

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The age of digitally accessible palaeontological datasets has transformed palaeontology, enabling previously impossible macroevolutionary insights. However, a substantial reservoir of generally inaccessible 'dark data' resides within museum collections, which may alter our understanding of ancient faunal groups and their ecological and evolutionary history. We demonstrate how the addition of data held exclusively in museums impacts our macroevolutionary understanding of an entire taxonomic group, using a dataset of Palaeozoic echinoids containing virtually all museum occurrences of the clade. We find that museum 'dark data' shows clear differences in composition compared to data available from the published literature and significantly impacts biogeographic patterns, increasing the geographic range size of taxa by an average of 35%. Global model results assessing drivers of diversity are also significantly affected by the addition of museum only data. Conversely, museum "dark data" has a more limited impact on establishing the temporal ranges of taxa or on estimates of overall diversity, and are impacted by similar socio-geographic biases as the published record. These findings show that unpublished museum data are vital to obtaining a complete understanding of macroevolutionary patterns in deep-time, illustrating the importance of the collection, curation, digitization, and continued care of 'dark data' in palaeobiology.

Recording allowed: No

Tomographic analysis of the skull anatomy of *Ortacanthus meridionalis* (Xenacanthiform) from the Upper Carboniferous of Puertollano (Spain)

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The current diversity of chondrichthyans is only a small sample of their diversity during the Palaeozoic. Amongst them, Xenacanthids, an extinct group of freshwater sharks, provide key insights into the complexity of late Palaeozoic freshwater ecosystems. However, their fossil record is often limited due to the cartilaginous nature of their skeletons. In this study, we use computed tomography to examine a newly discovered, well-preserved skull of the xenacanthiform shark

Orthacanthus meridionalis, from the Upper Carboniferous of Puertollano (Ciudad Real, Spain). Its exceptional preservation has allowed a detailed identification of cranial structures, including the chondrocranium, orbits, ocular processes, palatoquadrates and Meckel's cartilages. Tomographic analysis also revealed 238 teeth, many *in situ*. Dentition analysis showed that *O. meridionalis* exhibited monognathic heterodonty, with symphyseal teeth likely anchored directly to the neurocranium. Tooth replacement rates, estimated at 26 days per row based on size progression, provide new insights into the palaeobiology of this enigmatic shark. These findings enhance our understanding of xenacanthid anatomy and ecology, offering a rare glimpse into Palaeozoic freshwater environments.

Recording allowed: No

Preliminary results on the biomechanics of feeding behavior in the amphicyonid *Magericyon anceps*

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Bear-dogs (Amphicyonidae) were diverse and successful carnivorans during the Cenozoic with supposedly diverse feeding behaviours, including hypercarnivory and durophagy. *Magericyon anceps*, from the middle Miocene of Spain, has been characterized as a hypercarnivorous species employing active ambush hunting, strong bites, and powerful pulling-back movements. Here we tested this biomechanical hypothesis using finite element analysis of 3D models of its lower jaw and compared the results with those of modern carnivorans with diverging hunting strategies. Our results show low von Mises stress in mediolaterally and anteroposteriorly directed loads (as lions and hyaenas), but high stress on dorsoventrally directed loads on the canine (as wolves), and an estimated bite force lower than those of modern similar-sized lions and hyenas. These results support the hypothesis that *Magericyon anceps* was capable of powerful stretching movements of the neck associated with defleshing, but unlike biting and hold a struggling prey or employing canine-shear behavior as lions and some sabretooth felids do. Although isotope analyses have shown *Magericyon anceps* to prey on relatively large mammals such as *Austroportax*, mandible biomechanics do not support a killing strategy like lions or smilodontines, but as barbourofelids, this species may have required additional forelimb help to restrain the prey.

Recording allowed: Yes

Open Palaeontology – a community-driven diamond open-access journal with preregistration

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We present a new diamond open access journal, *Open Palaeontology* (*OPal*). *OPal*'s scope covers all aspects of palaeontology, with a flexible publishing model, a range of publication types, preprinting, and transparent peer review. The founding principles of *OPal* directly address concerns that the

current academic publishing landscape is systemically unfit for purpose, resulting from systemic inaccessibility, opacity, and lack of accountability. But all is not lost: there is a wealth of established and emerging good practice across the academic publishing landscape, and *OPal* will draw on these across its publishing model. *OPal*'s ethos is rooted in accessibility, transparency, and accountability in academic research, incorporating diamond open access to mitigate financial inaccessibility, interactive and transparent peer review procedures, and research preregistration integrated with article publication. We also propose a flexible approach to publishing research at various stages of intellectual development and in different formats. We hope that *OPal* will help transform our understanding of how palaeontological research can be rigorously assessed and published. We seek people interested in working on the *OPal* management boards and as handling editors. We particularly encourage early-career researchers, those working in non-academic positions, and people working outside Europe and North America to get in touch!

Recording allowed: No

Precociality in a sauropod hatchling from the Jurassic Morrison Formation

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Sauropods were a highly diverse group of herbivorous dinosaurs, some of which represented the largest terrestrial vertebrates in Earth's history. Osteohistology, the study of bone microstructure, is a reliable analytical tool to provide insights into their growth and life cycles. Here we describe the histology of a femur assigned to Flagellicaudata (GPIH 6156; Geologisch-Paläontologisches Institut Hamburg), which measures only 27,9 cm in length. Innovative non-destructive µCT analysis allowed detailed examination of the bone's internal structure. This analysis placed the specimen in the early histological ontogenetic stage (HOS) 3, representing a hatchling with a body mass of 119 kg, less than 1% of its adult size. Contrary to the early juvenile bone tissue identified in the midshaft (type A-B), the fourth trochanter shows extensive remodelling, indicating significant muscular strain and activity. The results suggest rapid development, precocial behavior, and early independence in diplodocid sauropod juveniles. The classification of GPIH 6156 as HOS-3 makes it one of the youngest sauropods ever reported. Although precociality is widely assumed to be a plesiomorphic trait in dinosaurs, direct evidence remains rare. Hence, the histological analysis of this juvenile provides crucial insights into early sauropod ontogeny and palaeobiology.

Recording allowed: Yes

Phylogeny of gogiid blastozoans: insights into the Cambrian diversification of echinoderms

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The phylum Echinodermata has been known in the fossil record since the Cambrian Series 2. Among its earliest representatives, eocrinoid blastozoans are the oldest bearing free-

feeding appendages (brachioles). Most Cambrian eocrinoids are grouped within the order Gogiida Broadhead, 1982. They exhibit a wide range of morphological disparity and a large palaeobiogeographic distribution. Historically, gogiids have been extensively described in Laurentia (modern North America), and they have been attributed to many species, all assigned to the same genus: *Gogia*. Over the years, gogiids have also been discovered in other palaeogeographic areas (high-latitude Gondwana, South China), and often attributed to new monospecific genera. In the last twenty years, ontogenetic series of several gogiids were documented, based on abundant and well-preserved material from China and the Czech Republic. Such ontogenetic series question the possibility that some of the numerous gogiids from North America may correspond to different ontogenetic stages of a more limited number of taxa. Hence, this study aims to: review the species of the genus Gogia and their possible ontogenetic relationships; explore affinities between gogiids from various palaeogeographic areas; and complete the first phylogenetic analysis of this order.

Recording allowed: Yes

LegaSea: AI and citizen science help contextualize fossils and artefacts from the Dutch North Sea

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The North Sea Basin is a treasure trove for palaeontologists and archaeologists alike. Over the past 150 years, hundreds of thousands of late-Quaternary (130 ka – present) vertebrate fossils and artefacts were collected from fishing nets and sand-nourished beaches by fossil enthusiasts. Because these fossils are found *ex-situ* it is challenging to identify faunal assemblages and link them to the original depositional environment. In the LegaSea project we aim to identify and characterize late-Quaternary vertebrate communities from the rich beach finds through a novel AI-assisted citizen science approach. A large dataset of standardised images from museum and private collections (>40.000 images) and images from the citizen science platform Oervondstchecker.nl (>75.000 images) is used to train AI models for automated fossil identifications. Results for the standardized dataset (top-3 accuracy: ~95%) are promising and the models are further developed for a publicly available fossil-ID app. Furthermore, combining taxonomy, taphonomy and associated metadata enables the grouping of these fossils in faunal assemblages which are dated and linked to the independently dated stratigraphy from which the fossils originate. The contextualized fossils and artefacts will help us better understand changes in biodiversity during the late Quaternary of NW Europe resulting from climate change and human activity.

Recording allowed: Yes

Disparity and function of forewing coloration in an extinct planthopper lineage

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Mimarachnidae is an extinct group of planthoppers from the Cretaceous of Eurasia. Although most representatives of Mimarachnidae exhibit cryptic features, the forewing coloration in some

genera is notable for its complex eyespots, offering valuable insights into the diversification of these patterns during the Cretaceous. The number and position of eyespots vary between genera, but the sequence of concentric colour bands is conserved, suggesting a shared developmental pathway, akin to what is found in butterflies. We describe two new species with alternative predator-evasion strategies of the genera *Xiaochibangus* and *Dachibangus*. The former displays two rows of large eyespots forming a highly salient and recognizable pattern, interpreted as an aposematic signal. The other presents a large, isolated eyespot near the wing apex, which may have functioned as a 'false head' aimed to deflect the attack of an approaching predator away from vital organs. The species of *Xiaochibangus* display a noteworthy variety of unique colour pattern modifications, increasing salience. Additionally, the eyespots of both genera are highlighted by a light-colored ring, although their position within the eyespot differs, implying convergence. By contrast, the eyespots of *Multistria* are reduced, possibly due to alternative selective pressures favouring crypsis.

Recording allowed: Yes

A new marine fish-bearing site of the Seefeld Member (Norian, Upper Triassic) in Tyrol, Austria

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The bituminous dolomitic limestone of the Seefeld Member is well-known for its exquisitely preserved marine fish fauna. Nevertheless, marine vertebrates from these sites remain rare in publicly accessible scientific collections. Here we present newly articulated specimens recovered from two field campaigns in Obsteig (Tyrol). The new assemblage reflects the characteristic faunal composition of a shallow marine environment, including large specimens of the genera *Saurichthys* and *Paralepidotus*. Although the diversity is comparable to assemblages from other known localities (*e.g.* Wiestal, Salzburg), the taphonomic arrangement suggests a different taphonomic history of the Obsteig assemblage compared to the famous mass-mortality layers of Wiestal. The absence of distinct event horizons in Obsteig, in contrast to the high mass mortality rates and dense accumulation of articulated fish fossils in Wiestal, points to a more stable environmental setting on the tidally influenced platform. Nevertheless, the dark, organic-rich deposits devoid of benthic organisms and large trace fossils suggest anoxic conditions at the seafloor, which favoured the preservation of articulated specimens. This new material provides valuable insights into this ancient subtropical ecosystem from the Upper Triassic in Austria.

Recording allowed: No

Hydrodynamic simulation and functional analysis of archaeocyaths

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As an extinct group of hypercalcified sponges, archaeocyaths represent the earliest metazoan reef builders of Phanerozoic. While previous studies have provided thorough descriptions of archaeocyath morphology, the biomechanical significance of their skeletal structure remains ripe

for further exploration. Over the past decade, computational fluid dynamics (CFD) has increasingly been employed to reconstruct the function and ecology of fossils through simulations. Most earlier numerical experiments conducted on extinct organisms relied on the Reynolds-averaged Navier Stokes (RANS) equations; however, large eddy simulations (LES) have seldom been discussed in fossils. In this study, three-dimensional models of archaeocyaths are generated using SolidWorks. Flow simulations based on both RANS and LES models address a lingering question: does the skeletal structure of regular archaeocyaths optimize flow physics within their body cavities? Our CFD analyses reproduce sea floor hydrodynamics where archaeocyaths thrived. Findings indicate that skeletal features induce internal recirculation patterns at low flow velocities, offering advantages for selective filter feeding and sexual reproduction, which may affect their geographical distribution. In essence, the computational results confirm that archaeocyathan models passively entrain flow, a mechanism upon which modern sponges rely for suspension feeding. The observed flow direction through the models aligns with predictions of the spongiomorph-affinity interpretation of archaeocyaths.

Recording allowed: Yes

Lower jaw functional morphology suggests the largest freshwater turtle, *Stupendemys geographica*, was herbivorous

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Two new complete lower jaws and a partial skull from the Miocene of Colombia offer new opportunities to explore the palaeobiology of the largest freshwater turtle, the *Stupendemys geographica*, which could reach 2.8 m in carapace length. The mandibles display an upturned symphyseal hook and an almost flat but relatively broad triturating surface with a midline ridge that lacks rugosities. The coronoid process and adductor fossa are greatly developed, suggesting powerful external adductors. Here we report the first attempt to understand the feeding behaviour of this giant using functional morphology. We used photogrammetry to digitize one mandible and modelled the adductor muscles to simulate maximum gape and biting scenarios using finite element analysis. We obtained a maximum bite force of 6,700 N for the largest *Stupendemys*, comparable to those of similar-sized crocodiles. This is, however, lower than expected for carnivorous and durophagous turtles but matches the inferred force for herbivorous species of this size. The maximum gape was estimated at 42°, which is at the lower end of the range of maximum gapes known in turtles, usually occupied by herbivorous taxa. Therefore, our biomechanical analyses indicate that the largest freshwater turtle was mostly herbivorous, like its extant podocnemidid relatives.

Recording allowed: Yes

Palaeoecological implications of the locomotor ecomorphology of *Stephanorhinus hundsheimensis* from Barranc de la Boella (Tarragona, NE Iberia)

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The archaeological site of Barranc de la Boella (Tarragona, northeast Iberia), dated between 1.07 and 0.87 Ma, represents one of the earliest occurrences of hominins in Europe, alongside a rich assemblage of associated fauna. While species indicative of permanent water bodies are evident, the precise nature of the surrounding palaeoenvironment remains under debate. Our study focused on unpublished rhinoceros specimens from this site. Biometric and anatomical analysis suggests that these individuals belong to the species *Stephanorhinus hundsheimensis* although they are unusually small. To gain further insight into the palaeoenvironment, we applied 3D geometric morphometrics to the humerus and femur of these rhinos. Preliminary results reveal ecomorphological similarities to the extant Javan rhinoceros (*Rhinoceros sondaicus*), which thrives in areas characterized by secondary forests and open scrubland near rivers. As previously proposed, and according to the Mediterranean meadows, these findings suggest that the landscape of Barranc de la Boella was likely a mosaic of woodlands and open areas rather than a dense forest. This reinterpretation of the habitat provides new insights into the niche parameters of *S. hundsheimensis* and the ecosystem that early hominins inhabited, and enhances our understanding of the environmental conditions that have influenced their survival and dispersal in Europe.

Recording allowed: No

The role of hind limbs in pterosaur flight apparatus

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Pterosaurs were a diverse group of extinct flying vertebrates that played a key role in Mesozoic ecosystems. Palaeoecological investigations have focused on the forelimb, while the contribution of the hind limbs has been ignored. This study assessed the contribution of hind limbs by focusing on three models: a narrow wing model (NWM), excluding the hind limbs; standard (SWM) and extended (EWM) reconstructions incorporating those into the wings and extended posteriorly. Surface area of wing panels and aspect ratio was calculated for 42 specimens distributed among 32 species spanning the known diversity of pterosaurs. Cross-comparison of the three models shows increases in wing area ranging from 1.8-2.1 times greater for the S.W.M and 2.1-2.5 times greater, compared to the N.W.M (2.8-16.8 m^2). Aspect ratios decrease from 8.6-23.9 for the NWM to 4.8-10.5 for the SWM and 3.9-8.4 for the EWM. Taxa with long hind limbs (*e.g.* Azhdarchoidea) show much greater variation between models than taxa with medium/short hind limbs (*e.g.* Rhamphorhynchinae). Collectively, these results demonstrate that wing reconstructions are highly sensitive to hind limb inclusion/exclusion and posture. This is important for future studies of pterosaur wing shape and function.

Recording allowed: Yes

The first terrestrial microvertebrate assemblage from the Middle Triassic of Arizona

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The Moenkopi Formation (Anisian, Middle Triassic) yields the oldest Mesozoic terrestrial vertebrates in North America. These assemblages are best known from a diverse ichnological record and fragmentary remains commonly found in the youngest members of the unit, the Holbrook Member of Arizona its lateral equivalent in New Mexico. The Moenkopi fossil record indicates a widespread and low-diversity fauna of chondrichthyans, actinopterygians, sarcopterygians, temnospondyl amphibians, dicynodonts and archosauromorphs. Here we expand this list based on a new site from the Holbrook Member exposed at 'Radar Mesa' in northern Arizona. Our initial survey of the microvertebrate assemblage sampled taxa known from other contemporary localities (*e.g. Anisodontosaurus*, *Tanystropheus cf.*, *Arizonasaurus*). We also report new tooth, scale and jaw morphotypes that expand the range of previously known actinopterygians, hybodontiforms, amphibians, archosauromorphs. Noteworthy is the first instance of *cf. Saurichthys*, a putative procolophonid parareptile, a diverse range of archosauromorph tooth morphotypes (including leaf-shaped serrated crowns) and the absence of groups that are common in younger assemblages in the same stratigraphic section, such as xenacanthids, aetosaurs and phytosaurs. Although our study nearly doubles the number of taxa reported from the Moenkopi Formation, it confirms the lower diversity of Anisian low-latitude ecosystems compared to those of younger stages.

Recording allowed: No

The cranial microanatomy and the relation to the Anuran clade Pipoidea

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Anurans are vertebrates known for their ability to live in diverse environments, a trait that reflects their extensive evolutionary history. We determined whether the microanatomical structures of cranial bones display not only an ecological signal but also a clade-specific range of values within the Pipoidea clade, characterized by its unique structure and lifestyle. Micro-CT scans of the skulls of eight extant and extinct Pipoidea were compared with four phylogenetically distant aquatic species. The scans focused on the frontoparietal and maxilla bones, from which the overall compactness, cross-sectional area, and thickness were extracted and analysed. Statistical analysis, which tested means among the taxa, revealed clear differences in the microanatomical values. The results showed significant differences between the different groups when observing the thickness and cross-sectional area. However, the compactness presented no statistically significant difference between the extant and extinct Pipoidea specimens. These findings suggest the potential for a significant clade-specific signal, as well as an environmental signal, in skull bone compactness, which could be considered in future phylogenetic analyses. However, further examination with more taxa is needed to confirm these findings and to gain a deeper understanding of the microanatomical features of anurans and their evolutionary implications.

Recording allowed: Yes

Unravelling cranial kinesis configuration in *Gallotia* (Lacertidae, Gallotiinae) using musculoskeletal and finite element models

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The vertebrate skull faces a crucial challenge: balancing the need to protect the brain and associated critical regions while enabling effective food processing. In this study, we combine a musculoskeletal model using multibody dynamic analysis (MDA) with finite element analysis (FEA) for the giant Canary lizard *Gallotia stehlini* skull to evaluate how different kinetic and suture configurations balance the two conflicting roles of protecting important organs and chewing food. A model of the skull was generated using micro-computed tomography, whereas adductor muscles were reconstructed to create a musculoskeletal model. This model allowed an optimization of the bite force to infer the muscle forces used as input in the FEA model. The musculoskeletal model was tested under three independent configurations: akinesis, streptostyly and amphikinesis. Finite element models incorporated cranial sutures using contact elements and heterogeneous material properties derived from nano-indentation experiments. Our results show that streptostyly minimizes stress in the basal, parietal, and occipital areas, protecting critical regions and reducing stress on the mandible. We conclude that streptostyly, as shown to occur in *Gallotia stehlini*, can be applied to the study of extinct giant species of the genus *Gallotia*.

Recording allowed: No

Preservation of fossil spatangoid echinoids (*Micraster*) within barite ($BaSO_4$) concretions from the Late Cretaceous of Biban area (Algeria)

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Concretions, often termed 'time capsules', serve as geological 'black boxes', preserving critical insights into Earth's ancient history. The barite concretions from the Biban area are predominantly oblate or ellipsoidal and are encased within a Maastrichtian sequence of marls. Our study employs petrography, SEM-EDS, major and trace element analysis (including REEs) and sulphur isotope analysis to characterize and unravel the genesis of these structures. These concretions typically exhibit a core enveloped by a centimetre-thick cortex of radially fibrous barite crystals. The cores of these concretions are composed of microcrystalline barite and frequently contain well-preserved fossil echinoids (*Micraster*) or fragments of compacted echinoid tests alongside poorly cemented zones filled with clay, organic matter, foraminiferal tests and siliceous sponge spicules. Our findings indicate that the concretions originated during early diagenesis in organic-rich, fine-grained sediments at shallow burial depths, forming as a result of microbial degradation of organic material during periods of sedimentary hiatus.

Recording allowed: No

A new species of *Dinodontosaurus* from the Manda Beds of Tanzania, and evidence for a likely Late Triassic age for the alleged oldest dinosaurs

***Hady George[1], Juan Escobar[2], Edmund Moody[1], Charles Saanane[3], Michael Day[4], Nigel Larkin[5]**
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Fossils from the Manda Beds of Tanzania have greatly informed on the diversity and evolution of Triassic tetrapods, including what has been argued to be the oldest dinosaurs. Here we describe dicynodont craniomandibular material from the Manda Beds that we refer to as a novel species of the otherwise South American *Dinodontosaurus*. This taxon can be distinguished from other *Dinodontosaurus* species by a combination of anatomical characters, including a bulbous palatal ridge that is not present in any other dicynodont taxon. The unique bulbous ridge likely facilitated a greater capacity for crushing and grinding vegetation relative to contemporary taxa, shedding light into resource partitioning in Triassic environments consisting of numerous dicynodont species. Moreover, the presence of *Dinodontosaurus* in the Manda Beds, as well as other therapsid and archosauromorph taxa, indicates this unit is equivalent to South American units that have been shown to be the latest Middle Triassic to Late Triassic through radioisotopic dating. Considering recent research debunking the equivalency of the Manda Beds with South African units, the most fossiliferous subunit of the Manda Beds, and its possible oldest dinosaurs, can be reinterpreted to be Ladinian to Carnian in age as opposed to the Anisian age historically assigned to it.

Recording allowed: No

Comprehensive restudy of the endocranial anatomy of *Olivierosuchus parringtoni* (Synapsida, Therocephalia) and its implications for pre-mammalian evolution

***Alessandro Gigliotti[1], Luisa C. Pusch[1], Christian F. Kammerer[2,3], Julien Benoit[3], Jörg Fröbisch[1,3]**
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Therocephalians constitute a major lineage of non-mammalian therapsids that crossed the Permo-Triassic boundary. Recent studies rendered them paraphyletic with a filial relationship to Cynodontia, the clade including mammals. Hence, studying the significantly under-studied therocephalians is essential for understanding mammalian evolution. Here we provide a redescription of the cranial anatomy of the holotype of the akidnognathid therocephalian *Olivierosuchus parringtoni* (BP/1/3849) from the Early Triassic *Lystrosaurus declivis* Assemblage Zone of the Karoo Basin in South Africa. By using computed tomography, we gathered new insights into its endocranial morphology, including soft tissue structures (*i.e.* the brain and inner ear endocasts). Comparing highly variable cranial characteristics with closely related taxa leads to a broader understanding of character variability within Therapsida, also concerning evolutionary events like the end-Permian mass extinction. We found that the inner ear morphology is highly variable among non-mammalian therapsids, with *Olivierosuchus* representing an intermediate stage in the evolution towards the mammalian condition. The morphology of the brain endocast undermines the concept of neurological

conservatism as is present in most (non-probainognathian) therapsids. The synapsid encephalization quotient was calculated and surveyed among selected late Permian to Early Triassic therapsids, showing no link between brain sizes and survival in the end-Permian mass extinction event.

Recording allowed: Yes

Middle Cambrian echinoderms bearing weird structures: putative oldest trace of parasitism on deuterostomes

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Biotic interactions are rarely described in the fossil record, yet they are considered as one of the main drivers of evolution. During the Cambrian period, Lagerstätten and phosphatized disarticulated fossil fragments have provided only a handful of cases that preserve biotic interactions. Here we show echinoderm plates from the middle Cambrian of Australia bearing unusual outgrowths that resemble parasitic activity. Only 5 to 10% of echinoderm plates from the Australian locality present one or more outgrowths. Moreover, a combination of scanning electron microscopy (SEM) and 3D CT-scanning methods have provided microstructural evidence that these outgrowths result from parasitic interactions. Finally, the size of plates bearing these distinctive outgrowths is, on average, also significantly smaller than regular plates. These combined arguments support that a parasitic interaction generated these outgrowths, which are structures rarely observed through the entire Phanerozoic record of echinoderms. The echinoderm was the host, and an unidentified epibiont was the parasite. These results add approximately 45 million years to the currently oldest known trace of parasitism on deuterostomes.

Recording allowed: No

A cryptic record of Cambrian protists

***Thomas Green[1], Mark Williams[1], Brian Pedder[2], Pascal Olschewski[3], Thomas H. P. Harvey[1]**

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Cambrian palynomorphs include conventional acritarchs (vesicular bodies generally attributed to phytoplankton) but also spine-shaped forms comparable to animal body parts. However, confident identification of spiny palynomorphs is hindered by their simple morphologies and patchy occurrence. Here we examine new specimens of the spinose cone-shaped 'acritarch' *Corollasphaeridium* from the lower Cambrian (Series 2, Stage 4) Forteau Formation of Canada, the upper Cambrian (Furongian Series) Nolichucky Formation of the USA and the upper Cambrian (Furongian Series) Deadwood Formation of Canada and the USA, and reassess its biological affinities. The Furongian *Corollasphaeridium wilcoxianum* exhibits a trumpet-shaped cone with 5-10 apical spines, a flaring and infolded aperture rim, and an ornamentation of branched ridges. Earlier Cambrian species differ in ornamentation but share the distinctive aperture rim. The morphology

and size distribution of *Corollasphaeridium* are difficult to reconcile with either an acritarch or animal identity and instead support comparisons with the loricae of testate amoebae and tintinnid ciliates. Therefore, we interpret *Corollasphaeridium* as a loricate protist, albeit without clear synapomorphies with any extant group. The palaeoenvironmental and palaeogeographical distribution of *Corollasphaeridium* indicates localization in nearshore habitats in the palaeotropics. Our results place loricate protists in Cambrian marine communities and emphasize the hidden diversity among 'acritarchs'.

Recording allowed: No

Evaluating the mechanistic importance of ocean deoxygenation in regional biodiversity dynamics during the Permian–Triassic mass extinction

***Przemyslaw Gruszka[1], Dominik Hülse[2], Richard G. Stockey[1]**
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Ocean deoxygenation threatens modern marine ecosystems in a warming world. Past episodes of widespread ocean anoxia during hyperthermal events have likely been drivers of marine extinctions. Dissolved oxygen concentrations in modern oceans and 3D models of ancient oceans vary spatially; therefore, the ecophysiological impact of deoxygenation is expected to be regionally variable, but the direct control of expanding oxygen minimum zones (OMZs) on regional biodiversity remains underexplored. We aim to evaluate the hypothesis that expanding OMZs were key drivers of marine extinctions during ancient hyperthermal events and examine how marine ecosystems were affected at varying degrees of spatial resolution. Focusing on the Permian-Triassic mass extinction (PTME), we present new methodological approaches integrating 3D Earth system model simulations of marine redox conditions with marine animal biodiversity reconstructions in areas of different hypoxic stress regimes. Our analyses of spatio-temporal changes in diversity trends in different physiological stress regimes provide new quantitative constraints on the role of warming-driven ocean deoxygenation on marine biodiversity, evaluating the impact of expanding OMZs on ecosystems' distribution and regional diversity dynamics. By integrating oceanographic and ecophysiological models with regional biodiversity reconstructions at different ocean depths, we enhance our mechanistic understanding of the environmental drivers behind the PTME.

Recording allowed: Yes

A facilitated grouped access route for major-to-trace elemental mapping and speciation of flat fossils at the PUMA beamline of the SOLEIL synchrotron, France

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Synchrotron-based X-ray fluorescence major-to-trace elemental mapping and chemical speciation of elements of interest using X-ray absorption spectroscopy are increasingly used for the anatomical and/or taphonomic study of flat fossils. The standard route for obtaining beamtime at the synchrotron can, however, prove complicated for 'novice' users and poorly adapted to the timing of some palaeontological research: access is allocated based on highly technical calls for proposals that are open twice per year and typically require 6–12 months from submission to experiment.

As an alternative, we used the 'block allocation group (BAG)' route to implement facilitated access at the PUMA beamline (SOLEIL synchrotron, France). This grouped proposal framework aims to provide access for studies relying on only one or too few fossils to justify individual beamtime, as well as easier and more efficient access for new groups, while also benefiting the 'synchrotron palaeontology' community by enhancing synergy among existing 'expert' user groups. In this contribution, we will present the workflow of this BAG and detail the technical capabilities and constraints of the instruments available at the PUMA beamline, particularly regarding sample size and preparation, illustrated by recently collected data. We will also address possible future directions.

Recording allowed: Yes

Exploration of the dynamic evolutionary rates of early animals

***Zhiqing Guo[1], Thomas Smith[2], James Clark[3], Davide Pisani[1], Philip C. J. Donoghue[1]**
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The timing and rate of diversification of animal body plans remains the subject of contentious debate, with views polarized between an early and late Neoproterozoic origin of animals. To explore the implications of these timescales on rates of evolutionary innovation, we used a Bayesian morphological clock model to estimate the evolutionary rate dynamics based on three competing timescales and a dataset of 2,232 phenotypic characters reflecting all aspects of animal anatomy. Our results show that accelerated evolutionary rates are not associated with the deep internal branches of animal phylogeny, such as the eumetazoan and bilaterian stem-lineages but, rather, within more derived branches in the phylogeny of ecdysozoans and deuterostomes. Furthermore, with timescales based on all but the most literal interpretation of the fossil record, the rate accelerations occur within the Ediacaran rather than the later Cambrian Period, in which animal fossil diversity increases dramatically as part of the Cambrian Explosion hypothesis. Partitioning of characters according to the nervous system, feeding, locomotion, fossilization, and development, reveals very different pattern of evolutionary rate variation. Together, these results suggest that the fundamental diversification of animals was not associated with the coordinated evolution of key innovations.

Recording allowed: No

Morphological diversity as a potent tool to measure biodiversity in deep time

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Measuring biodiversity has become an important task as its loss represents a major threat to our society. Biodiversity losses as documented by the fossil record have therefore become of central interest, and diverging lines of argumentation – underlining the exceptionality of the current biodiversity loss or denying it – draw support from fossil data. A major challenge is the way in which modern-day biodiversity is measured. Counting species or weighing biomass in the modern fauna heavily outweighs fossil numbers, making direct comparisons challenging. Morphological diversity offers an alternative, applying quantitative measures of a continuous type, significantly dampening artefacts caused by decision-making. Strong polarization introduced by absence-

presence decisions or challenges such as species polymorphism do not bias morphological diversity analyses. Also, sample-size corrections are possible. I will present examples of different animal groups in which diversity loss is challenging to show with other quantitative methods or of fossils, which are often ignored as they are challenging within a taxonomic framework but are ecologically important. Among the latter are larval forms of beetles, flies, and their closer relatives, but the method can also be successfully applied to large animals such as representatives of Dinosauria.

Recording allowed: Yes

The environmental and ecological drivers of Mesozoic dinosaur diversification

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Dinosaurs first appear in the Late Triassic fossil record (~233 Ma) as relatively minor components of terrestrial ecosystems. They went on to rapidly diversify in the Early Jurassic (~201.3 Ma), becoming the dominant terrestrial vertebrates until the extinction of all non-avian species at the Cretaceous/Palaeogene boundary, 66 Ma. The mechanisms driving this radiation are still debated, with evidence for both abiotic factors, such as climatic shifts and tectonic activity (supporting the Court Jester model), and biotic factors, including reduced competition from previously dominant pseudosuchian groups (the Red Queen hypothesis). Here we analyse the Mesozoic dinosaur fossil record to estimate genus-level diversification and preservation rates under a Bayesian framework. We assess the impact of biotic and abiotic factors on diversification, showing that climatic change, eustatic sea-level change, tectonic fragmentation, and the decline of terrestrial pseudosuchians were all significant drivers of dinosaur diversification. We further subdivide our dataset at a regional scale to account for spatial sampling heterogeneity and show that the influence of these drivers on diversification varies both regionally and among the three major dinosaur clades: Sauropodomorpha, Theropoda, and Ornithischia. Our findings suggest that Mesozoic dinosaur diversification was shaped by a complex interplay of ecological and environmental factors.

Recording allowed: Yes

Global palaeobiogeographic patterns across Mesozoic extinction events

***Zsofia Horvath-Kostka[1], Ádám T. Kocsis[2], Jozsef Palfy[1,3]**
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Extinction events during the Phanerozoic Eon are subject to intensive research as their understanding provides context for and helps forecast the natural processes of current anthropogenic global change. Both the beginning and the end of the Mesozoic Era were marked by extinction events, whereas during the mid-Mesozoic, one major and several minor extinction events occurred. We used the Paleobiology Database to examine how marine bioregionalization was affected across extinctions and other events of major environmental change. We investigated the benthic groups separately and also analysed all marine groups together, both at the species and the genus level. We applied biogeographic bipartite network analysis focusing on biogeographic connectedness (BC). The value of BC is related to the degree of endemism and cosmopolitanism which, in turn, are affected by environmental events superposed on the control of palaeogeography.

High cosmopolitanism characterizes Induan, Rhaetian, Toarcian, Valanginian and Danian, whereas high endemism is documented for Norian, Sinemurian, Bajocian, Aptian, Albian and Campanian stages. Minor events are documented by benthic groups and species of all marine groups in Carnian, Bathonian-Callovian and Early Cretaceous (Valanginian-Hauterivian). BC serves as a valuable metric to reveal palaeobiogeographic patterns related to the impact of environmental change on the Mesozoic marine biota.

Recording allowed: Yes

Investigating the anatomy and evolution of the basipterygoid processes across Dinosauria

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Basipterygoid processes are paired, stalk-like projections of the basisphenoid (an element of the braincase) that articulate with the pterygoids (elements of the bony palate), forming a component of the cranial kinetic system. Among extant Dinosauria (birds), cranial kinesis is most extensively developed in neognaths (where the presence of basipterygoid processes is variable) and is reduced in palaeognaths (where basipterygoid processes are always present). The increased cranial kinetic capacity of neognaths has been hypothesized to partially underpin the stark imbalance in species diversity between neognaths (~ 10,000 extant species) and palaeognaths (~ 59 extant species). Across Dinosauria the presence and morphology of the basipterygoid processes is highly variable, yet this variation remains incompletely characterized due to a scarcity of comparative discussion in the literature. Here we used computed tomography (CT) to systematically examine the basipterygoid processes of a broad taxonomic selection of birds and non-avian dinosaurs. We identify an abrupt shift in the predominant orientation of basipterygoid processes between birds (laterally directed) and non-avian dinosaurs (ventrally directed), with potential implications for the cranial kinetic capacity of their skulls. We also characterize ontogenetic changes in the basipterygoid morphology of birds, suggesting ontogenetic variation in cranial kinesis through skull development.

Recording allowed: No

Palaeo-seasonality through serial stable isotope analysis of Pleistocene to Recent *Etheria elliptica* shells from the middle Atbara River region, eastern Sudan

***Aisha Huseen[1,2], Ulrich Struck[1], Robert Bussert[3], Ali Eisawi[2,4], Faysal Bibi[1]**
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Precipitation seasonality is a determining factor of African savanna habitats, but whether such strong seasonality existed in the geological past is questionable. Growth layers in bivalve shells can provide valuable data for reconstructing palaeoenvironmental conditions, including rainfall, water temperature, and river productivity. This study analyses eight fossil and three modern *Etheria elliptica* shells from the middle Atbara River in eastern Sudan for stable oxygen and carbon isotopes. The fossil *E. elliptica* derive from sediments dated ~224 to 17 ka. The $\delta^{18}O$ results of the

fossil and modern shells are similar, but the fossils are more enriched (5.9 to -2.4 ‰ and 1.5 to -6.4 ‰, respectively). These values might indicate a drier climate during the Late Pleistocene. The $\delta^{13}C$ signatures range from -4.5 to -14.1 ‰ and -9.6 to -16.9 ‰ for fossil and modern shells, respectively. A lack of correlation between $\delta^{18}O$ and $\delta^{13}C$ indicates different factors influenced on the $\delta^{13}C$ values, such as metabolic activity and dissolved inorganic carbon sources. The middle Atbara's hydrology is modified by dams, which may affect the modern $\delta^{18}O$ and $\delta^{13}C$ values. Overall, the results suggest that a strongly seasonal precipitation regime has existed in eastern Sudan since at least ~200 ka.

Recording allowed: Yes

Visualizing rhombiferan echinoderm respiratory structures in 3D

***Lucy Jackson[1,2], Imran A. Rahman[1], Ross P. Anderson[3], Frances S. Dunn[3]**
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Modern echinoderms (*e.g.* starfish, sea urchins) are a morphologically and ecologically diverse animal phylum, but the fossil record illuminates a wide array of extinct echinoderm body plans that do not closely resemble modern forms. Rhombiferans are one class of extinct echinoderms which are characterized by rhomb-shaped arrangements of respiratory pores on their theca. Our understanding of how these respiratory structures extend into the theca is incomplete, making the function and evolution of respiratory structures across rhombiferans difficult to decipher. We used X-ray micro-CT to visualize, for the first time in three dimensions, the respiratory structures of a hemicosmitoid rhombiferan. The results reveal previously undescribed internal canal systems, inferred to be an internal respiratory distribution network derived from the somatocoel, similar to that possessed by crinoids. These results expand our understanding of the morphology and function of respiratory structures in extinct echinoderms. Ultimately, they may help uncover homology among respiratory structures across the disparate extinct clades, with potential implications for reconstructing their phylogenetic relationships and evolutionary history.

Recording allowed: No

A greater diversity of bone-eating worms in the Late Cretaceous Chalk Group of the United Kingdom constrained by nannofossil biostratigraphy

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The bone-eating worm *Osedax* is today a member of the highly adapted invertebrate assemblages associated with whale carcasses on the ocean floor. In the fossil record, this worm creates the trace fossil *Osspecus*, containing one ichnospecies. *Osspecus* has been found in fossil whales and in fossil marine reptiles, with the earliest occurrence in the Albian. In studies of present-day whale bones with living species of *Osedax*, it has been found that there is a rough one-to-one correlation between species of *Osedax* and boring morphology. This proxy for species diversity can be used in the fossil record to expand on the diversity of extinct species through describing boring geometries. We examined plesiosaur, ichthyosaur, and mosasaur fossils from the Upper Cretaceous Chalk Group of

the United Kingdom for *Osspecus*, found five new boring geometries in six marine reptile specimens, and re-classified previous findings, thus naming seven new ichnospecies and additional examples of the one previously described ichnospecies. Using nannofossil dating from the surrounding chalk sediment, we constrained the dates of these boring occurrences and found that many of them occur in the early Late Cretaceous, with a high species diversity at this time, indicating a likely earlier origin for *Osedax*.

Recording allowed: Yes

Can palynological data be used as an archive of vegetation phylogenetic diversity?

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Phylogenetic diversity (PD) represents the amount of evolutionary history contained in an assemblage of taxa. It can, therefore, provide a more detailed assessment of biodiversity gains and losses through time and space and their underlying causes and consequences relative to simple counts of the number of species present in a sample, and as such, is used both as a conservation metric and as a tool to understand community assembly. To date, however, PD has been underexplored by palaeoecologists, and it is not currently known how well variations in vegetation PD across broad spatial scales are captured by palynological assemblage data. Here, I compare estimates of angiosperm PD from vegetation data and surface palynological samples from across North and South America. The results indicate a relatively low concordance between vegetation and palynological PD, suggesting that palynological data cannot be used as a straightforward PD archive. Other data sources (*e.g.* aDNA data for late Quaternary datasets, macrofossil data in deeper time settings) need to be considered for reconstructing vegetation PD through time.

Recording allowed: No

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rmacrostrat: an R package for accessing and retrieving data from the Macrostrat geological database

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The geological record is a vast archive of information that provides the only empirical data about the evolution of the Earth. In recent years, concentrated efforts have been made to compile macrostratigraphic data into the online centralized database Macrostrat (https://macrostrat.org). Macrostrat is a global stratigraphic database containing information regarding surface and subsurface rock units and their respective ages, lithologies, geographic extents, and various other associated metadata. However, these raw data are currently only directly accessible through the Macrostrat application programming interface (API), which is a barrier to potential users that are less familiar with such services. This data accessibility hurdle currently prevents full capitalization of the value offered by Macrostrat, particularly its potential to improve understanding of the geological and biological evolution of the Earth. Here we introduce rmacrostrat, an R package which interfaces with the Macrostrat database, to access and retrieve a variety of geological, palaeontological, and

economic data directly into the R programming environment. We provide details about how the package can be installed, its implementation, and potential use cases. For the latter, we showcase how rmacrostrat can be used to visualize regional stratigraphic columns, produce regional geologic outcrop maps, and investigate temporal trends in macrostratigraphic units.

Recording allowed: Yes

Bayesian network analysis reveals the assembly drivers and emergent stability of Pleistocene large mammal communities

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Vilnius University, Lithuania

The nature of community assembly is one of the oldest questions in ecology. The observed fossil community structure is a result of a number of environmental, biogeographic, ecological, and taphonomic factors. Using Bayesian network inference methods, we determined the degrees of association between 12 large mammal families and their local environment, global temperature, locality age and large-scale geographical extent. With the exception of Hominidae, we do not find significant associations between external variables (latitude, age, mean surface temperature) and the families analysed here, demonstrating that the majority of families showed remarkable resilience to the extreme climatic variability of the Pleistocene. The associations between the mammal families themselves seem to be structured by the degree of generalism in carnivores and omnivores and by similar environmental preferences in herbivores. We are currently conducting research on biotic interactions at the taxonomic levels of genera and species. To our knowledge, this is the first Bayesian network inference study of motile land animal palaeocommunities. The results of this study may be useful for further research into the influence of biotic and environmental factors on palaeocommunities.

Recording allowed: Yes

Between form and function: morphological convergence and divergence in long bones of Carnivoramorpha with a reassessment of locomotor habits of fossil taxa

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Carnivoramorpha is a >60-million-year-old group displaying a large diversity in phenotypes, body sizes, and habitats, exhibiting diverse types of locomotion, which also evolved independently in several carnivoran lineages. However, the drivers of this diversification and the role of convergence in locomotor evolution remain unclear. In this study, we tested for morphological convergence in external traits of the humerus and femur of different fossil taxa and their extant relatives to better understand how the exceptional diversification of this mammalian group was driven. The locomotor habits of extinct taxa were newly assessed by comparing the morphologies of fossil and extant species considering previously reported locomotor habits. To compare morphology, we used long bone measurements from 105 species. We included stem representatives of Carnivoramorpha and taxa from the crown group Carnivora. Our preliminary results indicate that the morphological

variation of the carnivoran humerus is less pronounced than that of the femur. The most evident distinction in both bones is between aquatic and non-aquatic species. While some extant species similar in locomotor habit to their fossil relatives also share morphological features, many stem carnivoramorphans appear as outliers, showing fewer similarities. That suggests that phylogeny plays an important role and needs to be considered.

Recording allowed: No

Evidence of Covarion rate variation in empirical morphological datasets

***Basanta Khakurel, Sebastian Höhna**
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Accounting for varying evolutionary rates for morphological characters across branches in phylogeny is fundamental in relaxing assumptions of rate homogeneity. Traditional models for palaeontological datasets often assume that all characters evolve according to the same Markov process, which applies uniformly across the entire tree. While models incorporating among-character rate variation through discretized probability distributions offer flexibility, they still fail to address rate variation across lineages. The covarion model, originally developed for molecular data, provides a promising framework for addressing this issue in morphological phylogenetics. In this study, we applied the covarion model in RevBayes to a diverse range of morphological datasets, detecting covarion-like rate variation in nearly half of the datasets analysed. Our method allows for characters to evolve within various rate categories and switch between them during the evolutionary process implying different selective pressures for different characters. By accounting for rate variation across lineages, the covarion model enhances phylogenetic tree inference and offers valuable insights into the complexities of morphological evolution. Its integration into tip-dating analyses could further refine divergence time estimates, making it especially useful for studies combining fossil data with extant taxa.

Recording allowed: No

Reinvestigating the appendicular skeletal morphology of *Confuciusornis* using high-resolution µCT scanning

***Grace Kinney-Broderick[1], Guillermo Navalón[1], Daniel J. Field [1,2]**
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Of the exceptionally preserved Mesozoic avialans from China, *Confuciusornis sanctus* is one of the most commonly represented taxa with over one thousand specimens unearthed to date. Most existing anatomical research on *Confuciusornis* has been limited to two-dimensional investigations of slab-prepared fossils. Here we aim to document the skeletal morphology of *C. sanctus* using high resolution X-ray computed tomography (CT) data from two specimens to reevaluate its morphology in light of improvements in our understanding of Mesozoic avialan morphology gained in the 25 years since its most recent monographic treatment. The ability to visualize these elements using high-resolution three-dimensional data reveals previously unappreciated morphological details of the pectoral girdle, forelimbs, pelvic girdle, and hindlimbs. In the pectoral girdle we discuss novel muscle attachment sites and their potential implications for flight capabilities. CT data reveal

distinctly individualized elements of the pubic symphysis which may clarify an important stage in the evolutionary history of avian reproduction. Our redescription using high resolution CT data will facilitate new research into the flight capabilities, and biology of Confuciusornis, a pivotal taxon in early avian evolution.

Recording allowed: No

Revealing Silurian secrets: Chelicerate arthropods from the Kalana Lagerstätte, Estonia

***Kelly Kittus, Oive Tinn**
University of Tartu, Estonia

The Kalana Lagerstätte in Central Estonia offers a unique glimpse into the shallow-water environment of the early Silurian (Llandovery, Aeronian, Raikküla Regional Stage) within the Baltic Palaeobasin. What sets Kalana apart is the exceptional preservation and detail of organisms rarely found in the fossil record. The biota is dominated by exquisitely preserved algae, including various uncalcified dasyclad species such as *Palaeocymopolia silurica*. Additionally, the site has yielded fossils of the agnathan vertebrate *Kalanaspis delectabilis* and beautifully preserved crinoids. These Silurian algal forests provided a habitat not only for well-known crinoids and fishes but also for a diverse array of arthropods. Among these are the oldest chelicerate fossils in Estonia, including specimens like the juvenile *Eurypterus tetragonophthalmus*, the large *?Erettopterus osiliensis*, the tiny *Bunodes lunula*, and numerous yet unidentified specimens. These chelicerates offer valuable insights into early Silurian marginal-marine ecosystems, helping to illuminate their distribution, palaeoecology, and the broader marine community of that era. By examining the chelicerate fossils from Kalana, we aim to identify these species and enhance our understanding of this specific ecosystem. This will allow us to reconstruct the palaeobiology of these ancient creatures and clarify their role within the Silurian marine environment.

Recording allowed: Yes

Trimming troubling trilobites: an investigation into the many species of Redlichia

***Joël R. Koelewijn[1], James D. Holmes[2]**
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Trilobites from the genus *Redlichia* Cossman, 1902 are found in many early Cambrian rocks from modern-day Australia, China, Iran, Korea, Morocco, Pakistan, and Spain. Over the past hundred years, many *Redlichia* species have been described from fragmentary or distorted specimens, and it is likely that the genus has been substantially 'oversplit'. This is especially unfortunate given that *Redlichia* is often considered an informal index taxon of unnamed Cambrian Series 2 (Stage 4), and could potentially be used in defining this problematic interval. Therefore, a review of species within the genus is required. Here we present a preliminary geometric morphometric analysis of Australian *Redlichia* (based on cranidia), including new material from the late Stage 4 (Ordian) Wirrealpa Limestone in the Flinders Ranges, South Australia. Results suggest substantial overlap in morphology between previously described species, suggesting that either: *Redlichia* species cannot be reliably identified by cranidia alone; and/or the genus is oversplit, and species need to be

synonymized. We propose future work for addressing these issues that will guide taxonomic revision of this genus, and greatly assist in local and regional correlation.

Recording allowed: Yes

Quantitative investigation of extinction patterns in sloths (Xenarthra, Folivora) during the Cenozoic

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University of São Paulo, Brazil

Sloths represent a remarkable mammalian clade, especially when its extinct diversity, which severely declined throughout its evolutionary history, is considered. Multiple extinction events led to a decrease in species richness and ecomorphological diversity, as well as more restricted spatial distribution, with the Pleistocene-Holocene megafaunal extinction being the most iconic. To better understand the drivers of such decline, we characterized extinction patterns in Folivora across its entire evolutionary history using quantitative and phylogenetic approaches. Two time-calibrated phylogenies were used to address temporal and phylogenetic uncertainties. The D-statistics method was used to detect phylogenetically-clustered extinctions across the trees, using different time bins. Extinctions were treated as binary traits, and D-values between 0 and 1 were obtained for each time bin, with values near 0 indicate phylogenetically-clustered extinction, while values near 1 suggest a random distribution. Results showed phylogenetically-clustered extinctions in the early Miocene (D values between 0.05 and 0.03) and, in one of the trees, also during the Pleistocene (D = 0.14). Several factors may be associated with these extinctions, including biotic factors like body size, locomotion habits, and diet, as well as abiotic factors like climatic variations and habitat changes caused by Andean uplifting during the Miocene.

Recording allowed: Yes

Middle Devonian brachiopods from Panxi of eastern Yunnan, China and their biostratigraphic and palaeoecological implications

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The Middle Devonian is particularly notable for shallow marine benthic invertebrates, especially brachiopods, which flourished in association with stable tectonic and ongoing transgression. Research on Middle Devonian brachiopods in South China has a long-standing history, with the Panxi section in eastern Yunnan serving as a reference section for Middle Devonian stratigraphy. It is located in the transitional zone between the coastal and shallow marine facies, characterized by fossiliferous bioclastic limestone and dolomitic limestone, occasionally interbedded with terrestrial clastics. More than 500 individual brachiopods specimens were collected and systematically identified in this study. Among all species, the Stringocephalidae is notable for its dominance in terms of both diversity and fossil abundance in this section. This assemblage extends from the Nanpanjiang Formation to the Yidade Formation, where it can be identified as the *Stringocephalus* Abundance assemblage. In the uppermost part of the Qujing Formation, carbonate deposits and

benthic faunas are interrupted by massive input of clastic deposits. Specifically, the disappearance of *Stringocephalus* fauna coincides with the Taghanic biocrisis that occurred in the middle–late Givetian. This biocrisis, associated with transgressive events, had a profound impact on the evolution of marine faunas, resulting in significant changes in brachiopod diversity and succession.

Recording allowed: Yes

Ontogenetic dietary partitioning in a Triassic sauropterygian: implications from a new juvenile specimen of *Brevicaudosaurus jiyangshanensis* (Reptilia: Diapsida)

***Qiling Liu[1,2], Long Cheng[2], Thomas L. Stubbs[3], Zichen Fang[2], Li Tian[4], Chunbo Yan[2], Michael J. Benton[1]**

[1]University of Bristol, UK; [2]Wuhan Centre, China Geological Survey, China; [3]The Open University, UK; [4]China University of Geosciences (Wuhan), China

During the first 10 million years of the Triassic, sauropterygians diversified rapidly into many marine predatory niches. Adults of the early Middle Triassic eosauropterygian *Brevicaudosaurus jiyangshanensis* show fang-shaped premaxillary teeth that resemble those of some nothosaurids and are adapted for feeding on large prey. We report here a juvenile example of the species, about one-third the length of the adult. The new juvenile shares apomorphies of the adult, like the posteriorly constricted parietal table, broadened humeral mid-diaphysis and short tail. But its juvenility is confirmed by unfused neural arches and developing epiphyses of the humerus. Through principal coordinate analysis (PCO), we investigated the dental functional morphology of adult and juvenile *Brevicaudosaurus*. The result shows a significant difference: the small, smooth conical premaxillary teeth of the juvenile differ from the ornamented fangs of the adult and suggest it fed on small, fast-moving, soft prey. The differences in the teeth between juveniles and adults suggest that this is an example of ontogenetic dietary niche partitioning, a common strategy to avoid intraspecific competition.

Recording allowed: Yes

First unequivocal burrow infill with skeletal remains from the Cisuralian of Germany

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Recent studies highlighted an unexpected abundance and diversity of fossil burrows during the Permian. Nevertheless, fossil burrows containing skeletal remains, which are the most informative regarding taphonomy and behaviour, are relatively rare. We present an exceptional specimen from new excavations at the Bromacker locality (Tambach Formation, Germany) in the frame of the Bromacker project, funded by the German Federal Ministry of Education and Research. It has a large dome-like shape (80 cm long and 15 cm thick) and consists of four fine-grained sandstone layers with normal grading, abundant and overlapping scratch traces on its bottom and longer, deeper and wider-spaced scratch traces on its sides. This structure is interpreted as the

infill of a burrow chamber, that cuts a laminated mudstone with *Ichniotherium sphaerodactylum* tracks. The infill layers contain about 100 bones in different degrees of articulation, in a semi-circular arrangement and belonging to at least one individual assignable to Diadectes. Further studies will be necessary to determine whether the bones were originally in place, transported or scavenged. This opens a new window into the importance of burrows for taphonomic and ecologic interpretations of the Bromacker locality in the context of rapid evolutionary change and global warming during the Cisuralian.

Recording allowed: No

The role of deep-sea ecosystems in the diversification of sharks

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The deep ocean is undoubtedly the largest ecosystem on Earth. However, in contrast to the rich and ecologically complex shallow-water communities, deep-sea species assemblages are less diversified. Such heterogeneity in species richness could be explained by three macroevolutionary mechanisms: speciation, extinction, and dispersal rates. Yet, low sampling in extant and extinct lineages dramatically hindered our understanding of how these processes operate in the deep sea. In this context, fossils are the most direct evidence of life in the past, and overlooking extinct lineages will inevitably lead to spurious inferences. Using an unprecedented fossil occurrence database based on the abundant shark fossil record, the most recent time-calibrated sharks' phylogeny, and cutting-edge methods of trait evolution and diversification estimates, we outline the major macroevolutionary mechanisms giving rise to the diversity and disparity of the most speciose order of deep-sea sharks (Squaliformes). We demonstrate that deep-sea clades originated in shallow water during the Early Cretaceous and subsequently colonized the deep sea independently during the Late Cretaceous. Furthermore, we show that key innovations and environmental change likely promoted these shifts. By combining neontological and palaeontological evidence, we describe how macroevolutionary processes likely shaped the evolutionary history of an iconic clade of marine vertebrates.

Recording allowed: Yes

Time frame and taphonomy of a bonebed from the Lance Formation (Late Cretaceous)

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Working with and deciphering the origins of disarticulate bone beds always proves to be a challenge for palaeontologists. Taking taphonomy and the half-time of bones into consideration, the interpretation of bone beds becomes even more difficult. With this project, an attempt is made to analyse the time averaging of the genesis of a bone bed collected in 2019 by a team of Senckenberg Museum palaeontologists from the late Cretaceous Lance Formation, Niobrara County, Wyoming. We suggest that the taphonomy observed in the bone bed indicates a possible faunal or environmental change inside a fluvial river system. The bone bed consists of three layers (sandstone, transitional, and mudstone), with a very diverse taxonomic profile: disarticulated teeth, postcranial material, as well as bone fragments belonging to taxa from Dinosauria, Crocodyliformes, Testudines, and

Osteichthyes in various degrees of preservation. The taphonomic analysis of this bone bed is twofold: first, an assessment of the stages of bone modification, abrasion, and breakage of the bonebed, followed by a comparison with bonebeds of similar environments and age to assess post-concentration events. Given that most of the records for the Lance Formation are fluvial bone beds, understanding their half-time will improve our calibrations for future environmental reconstructions.

Recording allowed: Yes

First morphological description of the inner ear bony labyrinth of *Panthera spelaea* (Felidae, Carnivora)

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While the external skull features of the Pleistocene cave lion (*Panthera spelaea*) are well studied, intracranial features are scarcely known. Hence, we present the first detailed morphological description of the inner ear bony labyrinth (BL), which houses the organ of balance and hearing. The present specimen originated from a cave near Vence, France. Based on µCT scans, virtual 3D-reconstructions and linear measurements of the BL were performed. Our findings are compared with published data of extant Pantherinae, especially *Panthera leo* and *P. tigris*. The morphology of the BL of *P. spelaea* resembles those of extant *Panthera* species. The number of cochlear turns (3.25) and the shape of the canaliculus cochleae match juvenile Pantherinae. The shape of all semicircular canals is most similar to that of *P. tigris*. Cochlear length and inner ear height (IEH) are closer to *P. tigris*, while the size of the semicircular canals and the ratio of IEH to skull basal length is more similar to *P. leo*. Whereas the size of the skull and BL measurements implicate an adult specimen, the shapes of certain BL features suggest a juvenile one, which should be further investigated with an increased sample size, including earlier postnatal stages.

Recording allowed: Yes

A new procolophonid with complex dentition from the Late Triassic of southwest England.

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Fissure fill deposits from the Late Triassic to Early Jurassic of England and Wales preserve a diverse small tetrapod fauna including procolophonids, an important group of Permian and Triassic parareptiles that radiated across Pangaea following the end-Permian extinction event. Procolophonids are currently known from two fissure fill sites: isolated remains from Ruthin Quarry (Wales) and material of *Hwiccewyrm trispiculum* from Cromhall Quarry (southwest England). The age of the Cromhall fissure deposits has been debated but recent radiometric dating suggests a Carnian age for some fossil assemblages. Here we present material from several Cromhall fissure assemblages, interpreted as stratigraphically older than that which yielded *Hwiccewyrm*. We describe a new species of leptopleuronine procolophonid based on partial remains with unique tooth morphology. *Threordatoth chasmatos* gen. et sp. nov. is characterized by maxillae with

a reduced number of complex tricuspid teeth and dentaries with labiolingually compressed monocuspid teeth which in some cases have a peculiar edentulous tip. These distinct tooth morphologies occlude closely, perhaps facilitated by a flexible dentary symphysis. This unique combination of characters may suggest a high degree of oral food processing of a mode unlike other procolophonids, occurring among the broader leptopleuronine adaptation towards diets of high-fibre herbivory/omnivory and insectivory.

Recording allowed: No

Exploring the independent origin of leaves: a theoretical morphology approach

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Leaves are essential for land plant survival, adaptation and diversification, displaying a staggering array of shapes and sizes. Despite structural and functional similarities, leaves have independently evolved from leafless ancestors several times – a pattern mimicked at lower taxonomic levels, where the coupling of diversification and phenotypic plasticity have resulted in extensive morphological convergence, further complicating the morphological study of leaf evolution. Here we use elliptic Fourier analysis and >8,000 individual leaf outlines sampling the huge leaf disparity of seed plants to build a theoretical morphospace for leaves. We showcase the utility of this tool by projecting empirical leaf outlines and phylogenies of bryophytes, lycophytes and ferns into this space to estimate and compare ancestral leaf shapes and the disparity they have led to. We find that species from all groups consistently crowd the same region of the morphospace (although ferns and especially seed plants occupy a much larger volume) and that their ancestors had a relatively simple morphology, with lycophytes and bryophytes showing a more slender ancestral leaf. This theoretical morphospace can be easily augmented with new samples or integrated with other attempts to use theoretical morphology in a unified framework to explore functional and developmental aspects of leaf evolution.

Recording allowed: No

Evolutionary escalation in a Cambrian biota from the Grand Canyon

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Exceptional preservation deposits (*i.e.* Fossil-Lagerstätten) open a direct window on non-biomineralized faunas recording the Cambrian radiation of animal phyla. However, middle Cambrian Lagerstätten are typically segregated from the well-aerated, resource-rich environments that sustain the highest levels of ecological competition and open-ended adaptive innovation. We describe exceptionally preserved and articulated organic mesofossils from the *c.* 507-502 Ma Bright Angel Formation of the Grand Canyon, revealing a previously cryptic middle Cambrian biota in one of the world's best-known geoheritage sites. The Bright Angel biota opens a direct window onto a shallow shelf Cambrian environment characterized by high oxygen and nutrient levels, with exceptionally high levels of bioturbation that point to elevated levels of animal activity. Its

components include suspension-feeding and predatory crustaceans, substrate-scraping molluscs, and priapulids with complex filament-bearing teeth, which denote an unrecognized degree of functional sophistication among Cambrian scalidophorans and suggest convergence on modern microphagous forms. Together with co-occurring trace and biomineralized counterparts, these organic fossils reveal a surprisingly escalated ecology, disclosing a unique range of modern feeding strategies in the aftermath of the Cambrian explosion and showing that Burgess Shale-type deposits do not capture the functional and phylogenetic 'state of the art' of their contemporary biosphere.

Recording allowed: Yes

A new notosuchian crocodyliform phylogeny resolves the sebecid problem

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Notosuchia encompasses a taxonomically and morphologically diverse clade of crocodyliforms that were abundant in the Cretaceous of Gondwana. The systematics of the clade have frequently been debated; in particular, an ongoing dispute concerns the phylogenetic placement of the group Sebecidae. Whereas many studies find a monophyletic Sebecosuchia comprising Baurusuchidae + Sebecidae, sebecids have alternatively been recovered as the sister to Peirosauridae and closely related taxa. To re-evaluate the systematics of the group, we compiled the largest and most comprehensive notosuchian dataset to date, encompassing 545 morphological characters scored for 115 species. 112 novel characters were constructed focusing on previously undersampled regions of the skeleton (postcrania and the endocranium). Continuous characters were utilized for the first time in the context of Notosuchia, and taxon sampling was increased, in part via inclusion of seven notosuchians previously unevaluated in a phylogenetic context. Under multiple scenarios, including utilization of different character combinations and weighting schemes, we recover a monophyletic Sebecosuchia. The inclusion of highly fragmentary remains confirms the presence of a diverse, deeply nested clade of sebecids and closely affiliated taxa outside of South America, providing insights into the evolutionary and biogeographic history of this group.

Recording allowed: Yes

Ecosystem recovery following the Permo-Triassic mass extinction

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The Permo-Triassic mass extinction (PTME ~252 Ma) was the most catastrophic biotic event of the Phanerozoic, and recovery was protracted due to environmental instability through the Early Triassic. Although the PTME itself is well studied, there is debate surrounding the nature and timing of marine ecosystem recovery in the aftermath of the extinction. It is argued whether ecological recovery occurred in a stepwise bottom-up manner, with full recovery occurring contemporaneously with the recovery of taxonomic diversity by the Anisian stage of the Middle Triassic (some 5-8 million years after the PTME), or whether Early Triassic communities recovered rapidly albeit

with markedly different structure to pre-extinction ecosystems. We used Lagerstätten data to track ecological recovery via snapshots of marine communities through the Triassic by modelling community structure and function. We show that marine communities recovered quickly in the aftermath of the PTME, but Middle Triassic communities show a significant increase in diversity and vertical structure compared to Early Triassic communities. This suggests that alpha diversity as well as marine community structure and function recovered fully by the Middle Triassic, in line with global taxonomic diversity, but this recovery did not occur via a step-by-step rebuilding of marine ecosystems through the Early Triassic.

Recording allowed: Yes

Unveiling the diversity of Brazilian fossils in higher education through a new educational game

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In Brazil, palaeontology should be included in basic education, according to the National Curriculum Parameters (PCNs), and in higher education as a mandatory subject in undergraduate biological sciences courses. However, traditional teaching methods and a lack of resources have made palaeontology less engaging in educational settings, resulting in fragmented content and hinders students' scientific reasoning. To address this issue, this work proposes an educational game as an alternative tool for teaching palaeontology, an area that needs more innovative approaches. The game aims to explore Brazil's fossil diversity, its localities, and where palaeontological collections are stored. It consists of a board (90x60 cm), tokens for players, and cards featuring artistic reconstructions of fossil groups created with the 'Aseprite' program, alongside a glossary of palaeontological terms. The board is divided into spaces that guide the players' moves, allowing them to gain or lose fossils and cards. The winner is the player with the most points (fossils and cards) at the end. Designed for groups of four to five players, each session lasts around 60 minutes and uses low-cost materials. The game will be implemented with undergraduate students at the University of São Paulo, and its impact on the learning process will be evaluated.

Recording allowed: Yes

Patches of Meganeura wings sewed into a new reconstruction

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Carboniferous insects provide essential information regarding the early diversification of insects and the origin of winged flight. *Meganeura monyi*, described by Brongniart in 1884 based on material from the Commentry locality (France) and related to damsel- and dragonflies (Odonata), is emblematic of these early insect faunas, owing to its exceptionally large size. It is also a key taxon to understand how Odonata became a successful aerial predator. To date, *Meganeura monyi* is represented by seven specimens. Although it has been redescribed multiple times, no comprehensive study including complete sketches and photographs of all specimens has been conducted since Brongniart's major account (1893). This is largely due to the combination of large

size, uneven preservation, and material incompleteness. Moreover, most live reconstructions are largely inspired from dragonfly wing morphology, an approach inadequate for a stem-Odonata. We endeavoured to redescribe the species based on all available specimens using modern documentation techniques, such as reflectance transformation imaging (RTI) and surface scanning. Furthermore, to obtain a realistic reconstruction of the entire fore- and hindwing structure, we resorted to a morphometric approach, using other large-sized Palaeozoic stem-Odonata for comparison. This work allows, for the first time, a robust estimate of the wingspan of the species.

Recording allowed: No

A newly discovered trilobite mass extinction during the Early Ordovician (end-Stairsian; Tremadocian) of North America

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Two trilobite mass extinctions are recorded in the Early Ordovician of Laurentia. While the older extinction at the Skullrockian–Stairsian boundary has been reported in the literature for many years, the younger event at the end of the Stairsian went unnoticed until recently. New taxonomic and biostratigraphic data revealed the existence of the younger mass extinction at the transition between the Stairsian and Tulean regional stages. This younger extinction features a complete turnover of trilobite genera and noticeable changes at higher taxonomical levels. The Stairsian–Tulean contact is well exposed at the southern House Range of the Ibex area, western Utah. Here, the top of the Stairsian (*Pseudohystricurus obesus* Zone) is characterized by a diverse trilobite fauna (24 species; 14 genera) dominated by dimeropygids and hillyardinids. At the base of the Tulean, the diverse Stairsian fauna is abruptly replaced by a low-diversity assemblage dominated by a single abundant asaphid species and a rare new species of bathyurid. The expression of the extinction is abrupt, and no major lithological changes are associated with it. Further investigation is needed to reveal the causes of the extinction.

Recording allowed: No

Halfway to a sixth mass extinction in the oceans?

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The disappearance of 24 marine species from 1500 to 2024 has been confirmed; however, the implications of these losses for the current biodiversity crisis are uncertain. A direct and comprehensible comparison to past marine extinctions is complicated since past-present data differ substantially regarding the taxonomic level and the temporal resolution at which they are recorded. We use probabilistic models to statistically extract short-term extinction rates from the fossil record so that past and present observations are comparable. We introduce the EKG500 metric; quantifying extinct species (E) per thousand (K) extant genera (G) over 500 years. We contrast modern marine

extinctions at the species level with computer-simulated species extinctions over the past 500 Ma. Results show that the EKG500 in the marine realm for the 1500–2000 period is 0.9, based on 18 extinctions and 20,000 extant marine genera with fossilization potential. This rate does not yet conclusively indicate a sixth mass extinction in the oceans. However, if the extinction of 17 doubtful marine species is confirmed, or if 10% of critically endangered marine species become extinct by 2050, the EKG500 would rise to ≥3.0, strongly suggesting a mass extinction event in the oceans.

Recording allowed: Yes

Squamate faunae from the Denver Formation of Colorado, USA, highlight ecosystem disruption and high levels of extinction at the end-Cretaceous mass extinction

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Recent fieldwork in the Denver Basin (Colorado, USA) has unearthed faunal and floral assemblages that have improved our understanding of the Cretaceous-Palaeogene (K-Pg) mass extinction (KPgE). These discoveries have allowed us to refine our understanding of diversity changes and extinction severity among vertebrates and plants. The basin includes two squamate rich microvertebrate localities: DMNH Loc.3648, ~3m (30-50 ka) below the KPgE and DMNH Loc.2560, ~9 m (~128 ka) above the KPgE. Microvertebrates are preserved in a sequence of medium- to fine-grained sandstone channels interpreted as meandering rivers and include mammals, crocodilians, testudines, amphibians, chondrichthyans, actinopterygians, dinosaurs and squamates. Over 20 squamate taxa were recovered from DMNH Loc.3648, totalling >100 individual remains, while DMNH Loc.2560 produced 43 squamate remains of *Odaxosaurus piger*, *Palaeoscincosaurus* sp., and a third taxon (Morphotype A). These two faunae document 85-90% diversity loss across the K–Pg. The Denver Basin records not only extinction but also survival of squamates – both taxa present at DMNH Loc.2560 are also present in DMNH Loc.3648. While the latest Cretaceous squamate fauna represents the full diversity of squamate clades (borioteiioids, anguids, platynotans, ophidians, scincomorphs, iguanomorphs) and various feeding adaptations (herbivorous, insectivorous, faunivorous), the recovery fauna consists only of insectivorous or omnivorous species.

Recording allowed: No

New postcranial material of the gorgonopsian *Aelurognathus tigriceps* from the Daptocephalus Assemblage Zone (Karoo Basin, South Africa) with novel insights into the pelvic girdle, hind limbs, and tail

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Gorgonopsians are a group of therapsids known from the Middle to Late Permian period, and represent a transitional point in the evolution of mammalian locomotion. The vast majority of prior descriptive work on gorgonopsians has focused on cranial material, leading to a dearth of information on the postcrania of the clade. While some recent work has begun to focus on some postcranial elements, such as the pectoral girdle and forelimbs, few published specimens

exhibit thorough descriptions of the pelvic girdle, hind limbs, and the tail. Here we present a new specimen of *Aelurognathus tigriceps* housed at the Iziko South African Museum (Cape Town, South Africa). The cranial material preserved, the anterior two-thirds of the skull, allows for species identification, however the area of interest for the specimen is the well-preserved postcranial skeleton, including the near-complete series of dorsal vertebrae and ribs, complete pelvic girdle, hind limbs, feet, and a nearly complete tail. The tail, in particular, is of interest as it is longer than any other known and published gorgonopsian. The new material presented here provides an opportunity to establish diagnostic postcranial phylogenetic characters.

Recording allowed: No

Exploring developmental and functional constraints on pointed tooth shape in tetrapods

Tahlia Pollock[1,2], William J. Deakin[1], Pablo Milla Carmona[1], Charlie Caldicott[1], Emily J. Rayfield[1], Philip C. J. Donoghue[1], Alistair Evans[2]
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Conical teeth occur in almost all tetrapod groups (amphibians, reptiles, and mammals). This simple tooth form exhibits broad morphological diversity, from stout human canines to slender, curved snake fangs or the straight, two-metre-long narwhal tusk. What drives this diversity? The Power Cascade developmental model offers insights into growth and form, while functional constraints suggest that morphology is closely tied to performance—balancing puncture ability and breakage resistance. Here we explore limits on evolution and resolve the relative contributions of developmental and functional constraints on tooth form. To do this we used the Power Cascade model to generate a sample of theoretical pointed tooth forms that span the variation seen in tetrapods. Then via 3D geometric morphometrics, we integrated theoretical and empirical morphologies from about 150 tetrapod species into a combined morphospace. Not all areas of the morphospace determined by the developmental model are explored by empirical forms, for example, areas associated with straight laterally compressed forms. Next, we will use performance testing and the Pareto rank-ratio approach to examine functional optimization within the Power Cascade. We hypothesize that this discrepancy between the diversity of forms possible via a developmental model and those realized in Nature will be functionally constrained.

Recording allowed: No

Isolated radiodont mouths: case study of two unique oral cones from the Early Ordovician Fezouata Shale (Morocco).

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Radiodonts became emblematic of the Fezouata Shale (Early Ordovician, Morocco), with the giant Aegirocassis. Based on frontal appendages, three species have been described, with three other unpublished morphotypes. Other anatomical parts can also be preserved, such as the oral cone (the monthpart). We describe two almost complete but isolated radiodont oral cones from the Fezouata Biota. Both are tetraradial, and the main difference is that the first cone has 28 plates and is one of the smallest ever found (3.1 mm in diameter), while the second has 24 plates in tetraradial

arrangement and bears prominent nodes on just two of the larger plates. Based on morphological characters, multivariate statistics have been used to predict the most probable radiodont family and feeding strategy for these oral cones. Results suggest the first oral cone was a hurdiid sediment sifter, and the second one is closer to hurdiid, but the feeding strategy is unclear. This method shows that the family of newly discovered oral cones can be predicted. For the feeding strategy uncertainty, this is likely the result of the lack of data concerning suspension-feeding radiodonts that are rare in the rock record but are abundant in the Fezouata Shale.

Recording allowed: No

Species-specific body size response of bivalves to the Permian-Triassic climate crisis

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A predictive ecological response to both the present and past climate crises is that benthic marine species will/have become temporarily smaller. The problem with studying major climate events is that very few species, or even genera, survive these events. Here we utilized a rare bivalve record that spans the Permian-Triassic climate crisis from the Dolomites, Italy. At the species level, there is almost a complete turnover, and the newly evolved species are typically significantly smaller, but not unusually small. This means that the observed body-size decline is driven by the preferential evolution of smaller species. Subsequently, there are two pulses of body size recovery determined by different mechanisms. The first phase (late Griesbachian) is driven by the size increase of pre-existing species, whereas the second phase (early Spathian) is due to the appearance of larger species. These results, combined with the observation that late Permian species show a size reduction prior to their extinction, suggest that both evolutionary and ecophenotypic controls as a mechanism to explain size reductions during climate crises.

Recording allowed: No

Molecular dating of the teleost whole genome duplication (3R) is compatible with the expectations of delayed rediploidization

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Vertebrate evolution has been punctuated by three whole genome duplication (WGD) events that have been implicated causally in phenotypic evolution, from the origin of phenotypic novelties to explosive diversification. Arguably, the most dramatic of these is the 3R WGD event associated with the origin of teleost fishes. However, tests of a causal relationship between WGD and teleost diversification have proven difficult due to the challenge of establishing the timing of these phenomena. Here we show, based on molecular clock dating, that the 3R event occurred in the early–middle Permian (286.18 to 267.20 Ma), 52.02 to 12.84 million years before the divergence of crown-teleosts in the latest Permian–earliest Late Triassic (254.36 to 234.16 Ma) and long before the major pulses of teleost diversification in Ostariophysi and Percomorpha (56.37 to 100.17 million years and at least 139.24 to 183.29 million years later, respectively). The extent of this

temporal gap between putative cause and effect precludes 3R as a deterministic driver of teleost diversification. However, these age constraints remain compatible with the expectations of a prolonged rediploidization process following WGD, which, through the effects of chromosome rearrangement and gene loss, remains a viable mechanism to explain the evolution of teleost novelties and diversification.

Recording allowed: No

An invasive air sac system was present in the common ancestor of the dinosaurs

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Crucial to the evolutionary success of birds is their uniquely efficient respiratory system comprising air sacs that drive unidirectional airflow and pneumatize the postcranial skeleton. Osteological correlates of this system are recognized in fossils, allowing inference of avian-like respiration in derived theropods, sauropods and pterosaurs, providing major palaeoecological insights. However, the absence of these correlates in basal dinosaurs suggests multiple independent invasions of the skeleton by air sacs. Bone in contact with air sacs possesses a highly distinctive texture named pneumosteum. However, to date, destructive sampling requirements have limited the number of specimens that can be investigated histologically for pneumosteum. Propagation phase contrast synchrotron micro-computed tomography provides a non-destructive tool to observe histology in 3D. We used this approach to investigate a basal dinosaur cervical vertebra from the Early Jurassic of South Wales. The vertebra possesses a series of large interconnected internal cavities lined by pneumosteum, indicating that the cavities were filled by extensions of air sacs. This provides the first unambiguous evidence that an avian-like respiratory system was already present in the dinosaur common ancestor. The acquisition of this highly efficient physiological system may have been a key innovation that allowed dinosaurs to dominate Mesozoic terrestrial ecosystems.

Recording allowed: No

Non-integumentary melanosome geometry suggests a highly conserved role for melanin in Amphibia and Reptilia

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Melanosomes are melanin-rich organelles that occur in the integument, eyes and internal tissues of extant vertebrates. Questions remain regarding melanosome evolution and whether a link exists between melanosome geometry and chemistry. We tested this using an enzymatic digestion process to extract melanosomes from 143 tissues of four reptile and two amphibian taxa. Combining new and previous data yields an expanded dataset of 13 taxa and 10 tissue types. Scanning electron microscopy and statistical analyses confirm tissue-specific melanosome geometry in Reptilia and Amphibia. Intriguingly, melanosomes in reptiles are smaller and more elongate in most tissues, except the heart, ventral skin and gonads. New X-ray fluorescence data reveals unexpected trends in the relationship between melanosome geometry and chemistry. The melanosomes of reptile

and amphibian gonads are rich in calcium and potassium but have different geometries. In contrast, melanosomes in the dorsal skin have similar geometries but different chemistry, whereby skin melanosomes in amphibians are richer in sulphur and zinc. These data confirm that during the evolution of amphibians and reptiles melanosome geometry was decoupled from chemistry. Further analyses will provide deeper insight into the controls underlying these trends and thus on the evolution of melanosomes at a pivotal stage of vertebrate evolution.

Recording allowed: No

A regurgitalite from the early Permian Bromacker locality (Thuringia, Germany)

***Arnaud Rebillard[1,2], Lorenzo Marchetti[1], Mark J. MacDougall[1], Christopher Hamann[1], Jean-Sébastien Steyer[3], Jörg Fröbisch[1,2]**

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Bromalites (fossilized digestive remains) can be preserved inside (*e.g.* gastrolite, cololite) or outside (*e.g.* coprolite, regurgitalite) a body fossil and provide unique information regarding the behavioural ecology and physiology of extinct animals, such as direct evidence of predator-prey interactions. We present a new specimen of regurgitalite (fossilized regurgitated stomach content) from the lower Permian continental Bromacker locality (Tambach Formation, Thuringia, Germany), using CT-based 3D-imaging, chemical and taphonomical analyses. The specimen exhibits a compact cluster of about 40 bones, an unusual taphonomic disposition suggesting that it represents a regurgitalite. The bones in this cluster are disarticulated, partially aligned along their long axes, and include mostly long bones and a maxilla, likely assignable to the small captorhinomorph *Thuringothyris mahlendorffae*. The regurgitalite further contains two additional long bones representing two other distinct taxa, likely an anamniote and another small reptile. Size and composition of this regurgitalite suggest that it was produced by a terrestrial apex predator, such as the sphenacodontid *Dimetrodon teutonis* or the varanopid *Tambacarnifex unguifalcatus*, known from Bromacker. This study constitutes the first investigation of an early Permian terrestrial regurgitalite and provides novel insights into the behavioural ecology and trophic network at the Bromacker locality and late Palaeozoic ecosystems in general.

Recording allowed: No

The neglected diversity of Mesozoic echinoderm larvae (Ophiuroidea, Echinoidea, Holothuroidea)

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Echinoderm larvae are common and ecologically important members of the marine plankton in all oceans today. It has been recognized that all modern echinoderm representatives, with the exception of Crinoidea, have feeding (planktotrophic) larvae, whereas benthic, free-living feeding larvae are missing. Lecithotrophic (non-feeding) larvae with benthic or planktonic habits have been reported in all modern echinoderms. All of these types of echinoderm larvae have unique

morphologies and, with the exception of the bipinnaria larvae of Asteroidea, a calcitic skeleton. In contrast to modern representatives, the fossil record of echinoderm larvae is essentially non-existent and biased due to missing studies and a lack of awareness of such small and fragile fossils. However, modified laboratory techniques and detailed study of sieve residues below 0.1 mm have the promise to provide microscopic larval skeletons. Our study reports a few hundreds of ophiopluteus, echinopluteus and auricularia skeletons from Early Jurassic strata of Germany (Lower Saxony, Saxony-Anhalt), Austria (Salzburg) and France (Ardennes), as well as Late Triassic sediments of Italy (Dolomites). Most of the specimens found belong to ophiuroids and holothuroids, only a few correspond well to echinoid larval skeletons. All plutei and auricularia skeletons found have unique characteristics, revealing evolutionary changes between Mesozoic and Cenozoic forms. Our new findings provide a window into the poorly known fossil record of echinoderm larvae, showing a hidden diversity of such fragile microfossils and the possibility of direct geological recording.

Recording allowed: No

The structural diversity of the phloem in seed plants

***Teagan Reinert, Alexander J. Hetherington**
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The phloem transports sugars throughout a plant and is vital to the survival of the organism. Change in the phloem during evolution may have helped angiosperms rise to dominance, but this needs to be tested. To investigate the structural diversity of the phloem cell in angiosperms and gymnosperms, Non-metric Multidimensional Scaling (NMDS) plots were created using data from the literature. Phloem cell traits like sieve cell radius, sieve cell length, pore radius, pore number, and plate thickness of 45 extant species and the Permian gymnosperm fossil *Agathoxylon* were used in the analysis. The results show that extant angiosperms and gymnosperms have clearly defined regions in the NMDS, indicating that the structure of the phloem in the two groups is clearly distinct. However, despite being a gymnosperm fossil, the phloem of *Agathoxylon* sits firmly in the angiosperm space; this suggests that the phloem of *Agathoxylon* is more similar to angiosperm phloem. The examination of this morphospace can help elucidate how phloem cells have evolved through time in the gymnosperm and angiosperm groups.

Recording allowed: No

Amber Worlds: an anthropological approach to amber extraction, trade, and science

Alessandro Rippa, Leni Charbonneau, Yayi Zheng, Laur Kiik
University of Oslo, Norway

How are amber's scientific and commercial values intertwined? What is the role of private collectors in the study of amber specimens, and how do they affect scientific practices and outputs? What are the key ethical issues in the study of amber from conflict areas? These are some of the key questions that we explore in the ERC-funded project "Amber Worlds: A Geological Anthropology for the Anthropocene (AMBER)." The AMBER project is based at the University of Oslo and is carried out by several Social Anthropologists interested in studying how amber travels across the world as both a commercial and palaeontological object. To address our key questions, we are doing ethnographic

research with palaeontologists and geologists, as well as local communities in sites of amber mining and trade such as Burma (Myanmar), China, Lebanon, Poland and Mexico. This poster showcases our early findings and seeks to exchange views and experiences with the broader palaeontological community at the Palaeontological Association Annual Meeting. Please join us for a conversation.

Recording allowed: Yes

Late Jurassic fossils in the Solnhofen Museum (Bavaria, Germany)

Valentina Rosina
Museum Solnhofen (Bürgermeister-Müller-Museum), Germany

The Solnhofen Museum (Bürgermeister-Müller-Museum) showcases extensive collections of exceptionally preserved fossils from the Upper Jurassic limestones of southern Germany. These thin-bedded to laminated limestones were likely deposited in depressions within a sponge-algal-coral reef environment of the Solnhofen Archipelago at the northern edge of the Tethys Ocean. This flat marine landscape extended about 100 km from Langenaltheim-Solnhofen in the west to Kelheim-Regensburg in the east. The museum collections feature numerous specimens of marine protists, algae, invertebrates, vertebrates, and terrestrial plants from sites like Painten 1/2, Kelheim, Zandt, Hienheim, Pfalzpaint, Daiting, Eichstätt, Mühlheim, and Solnhofen (Upper Kimmeridgian to Lower Tithonian). Among invertebrates, crustaceans, cnidarians, echinoderms, insects and ichnofossils are particularly diverse. Vertebrates include a variety of cartilaginous and bony fish, including sarcopterygians, and reptiles like crocodiles and pterosaurs, especially from the Brunn site (owned by the Bavarian State Collection for Paleontology and Geology in Munich). The collection includes holotypes and original fossils from various publications. The exhibition showcases three original *Archaeopteryx* specimens. The museum engages in research, offers student internships in collaboration with palaeontological institutions, and conducts its own excavations in nearby quarries. The museum's support association organizes educational events and excursions to significant palaeontological sites and museums.

Recording allowed: No

A new late Pleistocene fossil *Crocodylus* from Sudan reveals potential cryptic diversity in modern African crocodiles

Khalafallah Salih[1,2], Johannes Müller[1], Ali Eisawi[2], Robert Bussert[3], Brian Kraatz[4], Sumiko Tsukamoto[5], Faysal Bibi[1]
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The fossil record of African *Crocodylus* is common in late Cenozoic deposits, especially from Miocene to Plio-Pleistocean deposits; however, there is lack of knowledge about species diversity within the genus especially after early Pleistocene. Here we report on a complete skull of a new fossil *Crocodylus* from the late Pleistocene of the Middle Atbara River, East Sudan. Cranial morphology overall resembles the Plio-Pleistocene members of *Crocodylus* (*C. thorbjarnarsoni* and *C. anthropophagus*) in having upturned squamosals, although not as prominently developed

as in these species. However, the skull differs in several morphological traits from the previously described *Crocodylus*, as well as from extant *C. niloticus/suchus* in having a prominent sagittal boss on the dorsal surface of the rostrum and the absence of the supraoccipital exposure on the dorsal skull table. Phylogenetic analysis suggests the Sudanese *Crocodylus* represents a separate species and is more closely related to the fossil palaeo-African species than to the extant forms.

Recording allowed: No

Kalligrammatid lacewings from the Cretaceous of Spain

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Lacewings (Neuroptera) represent a small insect order with about 6,000 extant species described. Neuropterans peaked in diversity and disparity during the Mesozoic, as perhaps best exemplified by the extinct family Kalligrammatidae, also informally known as 'Jurassic butterflies'. Kalligrammatids are generally recognizable by elongated fluid-feeding mouthparts, large wingspans of up to 16 cm, and eye spots and scales on their wings. A re-examination of the neuropteran material from the Early Cretaceous (Barremian) site of Las Hoyas (Cuenca, Spain), recovered after decades of excavations, revealed a significant collection of kalligrammatid specimens that had hitherto remained unstudied. From that material, we have found and assessed a total of 25 specimens, mostly corresponding to isolated wings, although a few specimens preserve both wing pairs in anatomical connection. Two new taxa belonging to different subfamilies have been identified. One of these is based on 23 specimens – an unusually high abundance through which assessing variability regarded as intraspecific in the group. The exceptional preservation of some specimens has allowed a detailed assessment of wing colouration patterns, eye spots, and some preserved scales. These findings are a noteworthy addition to the known palaeoentomological diversity from Las Hoyas, contributing to the knowledge of Cretaceous wetland ecosystems.

Recording allowed: No

Too many species? Ecophenotypism in the (phytoplankton) fossil record

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Over 4,000 species of acritarchs (organic-walled microfossils) have been described throughout the Palaeozoic. Detailed revisions of several acritarch genera, based on biometrical analyses of larger populations, reveal significant morphological variability, with clear overlaps among previously defined taxa. A comparison with studies on modern dinoflagellate cysts reveals interesting similarities: some dinoflagellate species develop variable cyst morphologies depending on environmental factors. A prominent example is the dinoflagellate cyst *Lingulodinium machaerophorum* (Deflandre and Cookson, 1955) Wall, 1967, which is known to exhibit different process lengths that can be related to low and high salinity/temperature ratios. The variable morphologies, particularly the process lengths, observed among Palaeozoic acritarchs, could potentially reflect ecophenotypic responses to changing environmental conditions. We hypothesize

that many fossil acritarch 'species' are actually the cysts produced by only a few phytoplanktonic organisms (or even a single biological species) exhibiting high morphological variability. Given that ecophenotypism is generally under-investigated in the fossil record, we suggest that the uncritical use of many databases (by palaeontologists who do not specialize in the taxonomy of the studied groups) may lead to erroneous interpretations.

Recording allowed: No

Can polymorphism-aware phylogenetic models improve inference with discrete morphological data?

***Walker Sexton, Sebastian Höhna**
Ludwig-Maximilians-Universität München, Germany

Morphological data is an important source of phylogenetic information since fossils generally cannot provide DNA and are critical for generating time-calibrated phylogenies; however, very few methods have been developed to address the rampant issues in morphological phylogenetic inference. Some such issues include the prevalence of polymorphic characters, which occur when a taxon has multiple character states for a single given character, and the lack of differentiation between polymorphic and ambiguous characters. Coding polymorphic characters as ambiguous leads to underestimation of the actual number of character changes, while replacing polymorphic characters by a single character state can both over and underestimate the number of character changes. Polymorphism-aware phylogenetic models (PoMos) have been applied to genetic data, integrating populational evolutionary forces with deep-time phylogenetic models and estimating allele frequency change over time. Thus, PoMos can incorporate and model appropriately polymorphic characters at tips of the phylogeny. We implement PoMos in RevBayes with varying numbers of states to infer phylogeny and evaluate the efficacy of these models with polymorphic morphological datasets. With this project, we explore the potential advantages and disadvantages of applying polymorphism-aware models to discrete morphological data.

Recording allowed: Yes

Responses and resilience of shelf-dwelling benthic foraminifera through the K–Pg boundary crisis

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Given the importance of low-trophic-level biomineralizers in maintaining ecosystem processes, examining responses of these clades to major deep-time environmental perturbations – for example the K-Pg boundary crisis ~66 Ma – is imperative for understanding ecosystem resilience mechanisms. We conducted the first study of continental-shelf benthic foraminiferal morphological responses across the K-Pg boundary, aided by the limited K-Pg species loss (~15%) of this clade. Lenticulinid specimens from boundary-spanning deposits at Brazos River, Texas, were imaged using automated microscopy and µCT-scanning. We measured parameters associated with environmental stress (diameter, chamber number, surface area: volume etc), and used multivariate analyses to quantify overall variation through time. A high end-Cretaceous morphological disparity was

reduced approximately 4.5-fold within ~10 thousand years following the Chicxulub impact. Initial Palaeocene diameters were restricted around Cretaceous modal values, with significant decreases in mean chamber number paired with increased mean SA:V. Recovery of parameter mean values outpaced that of variance. Together with cluster analysis results, these link Lenticulinid persistence to multiple Cretaceous 'cryptic species' being present at Brazos – only those adapted to limited resource supplies prospered in the earliest Palaeocene. This indicates that the high dynamism of shelf environments can be beneficial in engineering taxon and ecosystem resilience.

Recording allowed: No

A comparative study of end-Devonian tetrapod material from Greenland

***Rebecca Sheng, Per Ahlberg**
Uppsala University, Sweden

The evolution of tetrapods from lobe finned (sarcopterygian) fishes was one of the most significant steps in vertebrate evolution, leading to permanent changes in ecosystems around the world. The tetrapod stem group lineage emerged during the Devonian, with the earliest known crown group tetrapods appearing during the early Carboniferous. The impact of the end-Devonian mass extinction (the Hangenberg extinction) on tetrapods is not well understood. One issue is that we have very little knowledge of the Devonian tetrapod fauna that immediately preceded, and experienced, the mass extinction. New specimens collected in 2022 from an early tetrapod bone bed of the latest Famennian, Stensiö Bjerg Formation of Celsius Bjerg, East Greenland have the potential to shed light on this problem. The assemblage represents the youngest known Devonian tetrapod fossils (alongside Tulerpeton from Russia). The specimens were imaged using propagation phase-contrast synchrotron microtomography (PPC-SRμCT), and then virtually segmented and rendered. The specimens described and interpreted here represent at least two new species, none of which can be assigned to known Devonian early tetrapods from Greenland. It is clear that a new and important faunal assemblage is emerging.

Recording allowed: No

Extinction drivers of a marine megafaunal extinction

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A marine megafaunal extinction at the end of the Pliocene (~2.5Ma) saw significant declines in mammals, birds, turtles and sharks. It has been hypothesized that the primary driver for these extinctions was a drop in global sea levels driven by glacial cooling over the Plio-Pleistocene boundary which resulted in a decrease in the area of neritic zone. The neritic zone consists of highly productive, shallow marine habitats above the continental shelf. As the extent of continental shelf area varies across ocean basins, we hypothesized that if neritic zone loss was a primary driver, extinction impacts would also vary regionally. To address this, we calculated extinction rates of marine megafauna throughout the Neogene which were found to peak across the Pliocene megafaunal extinction event. However, extinction rates were not regionally consistent; the North

Atlantic experienced lower rates than other ocean basins suggesting that oceanic features of the North Atlantic may have provided resilience to climate changes. As the North Atlantic has a larger continental shelf area which could minimize losses of neritic zone under falling sea level conditions, this supports the hypothesis of neritic zone loss as an extinction driver.

Recording allowed: Yes

Trachelosauridae, a new clade of Triassic marine archosauromorphs

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Recently, a new marine clade, Trachelosauridae, was recognized, considerably increasing the known diversity of Triassic marine reptiles, particularly among the generally terrestrial Archosauromorpha. Its best-known member, *Dinocephalosaurus orientalis*, is now virtually completely described based on newly discovered specimens. Up to six metres long, it is characterized by its long tail and even longer neck. Its cranial morphology is similar to that of another long-necked archosauromorph, *Tanystropheus hydroides*, which represents a convergence related to an aquatic piscivorous lifestyle. Based on a re-evaluation of historical European collections, we also redescribe *Trachelosaurus fischeri*, known from a single, disarticulated specimen collected in the 1800s from the Solling Formation of Bernburg, Germany. It possesses short, bifurcating cervical ribs, which are unique among archosauromorphs. *Trachelosaurus* is the first European *Dinocephalosaurus*-like reptile based on several character states, including its high presacral vertebral count, wide dorsal transverse processes, holocephalous dorsal ribs, ilium lacking a preacetabular process, and rod-like femur. Due to seniority, this marine reptile clade should be referred to as Trachelosauridae, with Dinocephalosauridae representing a junior synonym. Finally, we conducted a preliminary comparative analysis of trachelosaurid body proportions relative to other Mesozoic marine reptiles, revealing that trachelosaurids exhibit a unique body plan.

Recording allowed: No

Scaling properties of geological time scales reveal the nature and limits of Earth system variability

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The Earth system events, trends, oscillations and dynamical processes in general are measured using different kinds of internationally standardized time scales. The geological time scale boundaries are

defined by the most consistent and easily recognized events which qualitatively or quantitatively perturb stratigraphical record on regional to global scales. These boundaries, and thus the durations of discrete intervals used in data aggregation are highly uneven. Here we present a hierarchical scale-by-scale analysis of stratigraphic boundary temporal densities (concentrations of boundaries per unit time). The multifractal analysis of the international Geological Time Scale (GTS), and graptolite, conodont, ammonoid, and calcareous nannoplankton biozonal time scales revealed their scaling properties. The trace moment analysis shows the presence of a single scaling geobiological regime in all time series of temporal densities of stratigraphic boundaries. The trace moments of densities converge with increasingly long time scales, and thus allow the estimation of so called 'outer scale' of the Phanerozoic boundary generating process (where variability vanishes), which in this case is ~1 Ga, close to an average duration of Earth's eons.

Recording allowed: Yes

Secondary succession processes in Ediacaran Avalon communities

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In the early animal communities of the Avalon (Ediacaran, ~570-560 Ma), frequent disturbances killed entire communities, preserving these sessile organisms *in situ*. Strategies to re-colonize disturbed areas could occur through long-distance dispersal, *i.e.* primary succession (metacommunity dynamics) or survivors repopulating locally (secondary succession). Previous work suggested that taller individuals were more likely to survive minor disturbances and thus seed secondary successions, and disturbance might, therefore, have driven the evolution of large body size. Alternative strategies of recolonization could occur where organisms are able to recolonize areas from broken fragments. The exceptional, census-style preservation of Avalon fossils allows us to interrogate the nature of secondary succession processes using spatial analysis. We tested hypotheses of secondary successions using spatial point process analyses by investigating whether out-sized specimens in 18 populations and *Fractofusus* fragments changed community dynamics. We found that in most instances where out-sized specimens were present, they represented the most abundant taxa in a community, but we found no significant effect on population density or intra or inter-specific interactions when comparing inferred primary and secondary populations. This research indicates that large body-size has a limited impact at small spatial scales, and instead, metacommunity dynamics were important in early animal communities.

Recording allowed: No

Stable isotope ecology of Southeast Asian cervid and bovid species with implications for wildlife conservation

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Southeast Asia, a major biodiversity hotspot, faces severe species loss, with over 70% of endemic taxa threatened by habitat loss. As herbivores play a crucial role in shaping the structure of environments and the ecosystem dynamics of the region, protecting endangered species is thus required. Here we measured stable carbon isotopic ratios ($\delta^{13}C$) of tooth enamel samples of eight living Southeast Asian cervid and bovid taxa, mostly endangered or vulnerable species listed by the IUCN, and compared them with Pleistocene counterparts in order to investigate their dietary and preferred habitat changes over time. As a result, three distinct categories of dietary patterns among these ruminant taxa are observed: species with dietary and habitat changes through time; those with more flexible diets and habitats during the Pleistocene; and those with stable diets and habitats over time. In the case of species with dietary and habitat changes, the Pleistocene C4-grazer enamel isotopes showed a shift towards greater reliance on C3 plants or more closed environments during the Holocene. This observation contrasts with the diet of living ruminants and their current environments and can contribute to the understanding of future conservation outlooks of existing wildlife populations in Southeast Asia.

Recording allowed: No

posters

Environmental and biotic drivers of dietary strategy in herbivorous theropods

***Eren Tasimov[1], Stephan Lautenschlager[2], Alexander Farnsworth[3], Ádám Kocsis[1], Laura Mulvey[1], Emma M. Dunne[1]**
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Throughout the Mesozoic, most non-avian theropod dinosaurs were famously carnivorous. However, by the Early Cretaceous (145–100.5 Ma), some theropods, such as the coelurosaurian clades Therizinosauria, Ornithomimosauria and Oviraptorosauria, had adopted herbivorous or omnivorous diets. What caused this dietary shift and the subsequent diversification of these groups remains poorly understood. A prevailing hypothesis is that they were responding to environmental changes, both in the climate and floral composition of their ecosystems. We integrated Late Jurassic–Late Cretaceous dinosaur occurrence data and phylogenetic information with output from a general circulation (palaeoclimate) model to investigate how patterns of herbivorious theropod diversity and distribution were influenced by climatic conditions. Our results demonstrate how herbivorous theropods were constrained in their palaeoclimatic niche compared to other dinosaurs, occupying cooler areas with increasingly higher seasonal variability. We hypothesize that this pattern is linked with coelurosaurian adaptations, like feathers or meso-/endothermy, that make them suited for cooler climates. Our results also show diversification patterns that are consistent with the competition with thyreophoran dinosaurs, another highly specialized herbivorous group.

Ongoing work involves analysing the evolution of feeding morphologies across herbivorous dinosaur taxa to further investigate the role of climate in driving the evolution of herbivory in theropods.

Recording allowed: No

New insights into the taxonomy, morphology and phylogeny of Late Jurassic rays (Chondrichthyes: Batomorphii)

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The Late Jurassic fossil deposits of southern Germany, collectively known as the Solnhofen Plattenkalks, provide an exceptional source of holomorphic cartilaginous fishes (Chondrichthyes), including sharks and rays. While the fossil record of this group is predominantly based on isolated teeth, whole-body specimens from these deposits offer significant potential for advancing research in taxonomy, morphology, palaeoecology and phylogeny. However, studies of these fossils remain limited. The present study revises the morphology, diversity, and phylogeny of the ray fauna from Solnhofen and other coeval European deposits using morphological characters and morphometric analyses. Two new taxa are described, including the first ray discovered from the Upper Kimmeridgian of Painten, which represents the oldest Late Jurassic ray taxon from Germany based on skeletal remains. In addition, an updated phylogenetic analysis suggests that all holomorphic Late Jurassic rays form a monophyletic group representing a stem group order. Despite progress in understanding the diversity and phylogeny of early rays, challenges remain in resolving their phylogenetic relationships. This research highlights the need for comprehensive studies of well-preserved fossil chondrichthyans to improve our understanding of their diversity, evolutionary history, and deep-time systematics.

Recording allowed: No

Micro- to sub-microscale investigation of fossilization in amber using infrared spectro-imaging

Antoine Vite[1], Mathieu Thoury[1], Pierre Gueriau[2], Jérémie Mathurin[1], Alexandre Dazzi[1]

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Amber is an exceptional medium for fossilizing fine anatomical structures of past organisms in 3D. Fossil inclusions exhibit varying states of preservation, with some being empty and others filled with dark fossil matter, sometimes even within the same site. While the taphonomic processes behind this range are not well understood, preservation fidelity has been linked to the resin type. This suggests that the resin's chemical composition influences fossilization. Although the chemical composition of fossil-bearing amber classes is well known, the structural and chemical

interactions between the matrix and the fossilized organisms remain unexplored. This is primarily due to the technical limitations of classical spectroscopy systems, which lack the lateral resolution needed to map and analyze the micrometric-thick fossil tissues in contact with amber. Here we use novel super-high-resolution photothermal Infrared (IR) spectroscopic techniques, namely optical-photothermal IR (O-PTIR) and atomic force microscopy–IR (AFM-IR), to characterize the organic composition of Baltic amber insects with micrometric and nanometric lateral resolutions, respectively. Our IR chemical maps reveal significant lateral chemical heterogeneity at the micro- and sub-microscale, with a clear fossil signal distinct from the amber. We also address the substantial constraints imposed by these non-trivial techniques regarding sample preparation.

Recording allowed: No

The Messel collection of the State Museum of Natural History Karlsruhe

Jannik Weidtke, Julien Kimmig
Staatliches Museum für Naturkunde Karlsruhe, Germany

The palaeontological collections of the Natural History Museum Karlsruhe (SMNK) contain over 70,000 specimens. One of the most significant parts of these collections is the fossils of the Messel Pit near Darmstadt, Germany. These collections started with regular excavations conducted by the SMNK during the 1980s and early 1990s. The fossil collection was also expanded through the acquisition of specimens from excavations organized by other entities, through donations, as well as the targeted purchases of fossils. The Museum today houses approximately 6,000 fossils from Messel. As such, the SMNK houses one of the most important publicly accessible collections of Messel fossils, only trailing the Senckenberg Museum and the Hessisches Landesmuseum. Under the new curatorship, the collection has undergone a significant overhaul to improve accessibility and digitization. All fossils and their associated labels have been checked and transferred into the database. Existing entries were revised and extended with up-to-date information, each specimen was assigned a unique collection number, and photos of every fossil were taken. The collection contains a remarkable diversity of birds, as well as squamates, amphibians, mammals, and a large number of invertebrates, especially insects. A significant portion of these fossils remains unstudied over the last 20 years.

Recording allowed: No

Origin of angiosperms: quantitative integration of fossil records and the molecular clock

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Evolutionary timescales often rely on fossil calibrations to align molecular evolution with geological time, but traditional methods use only a small fraction of fossil data, often subjectively interpreted.

Ideally, calibrations should be numerous and well-distributed across the phylogenetic tree, though excessive numbers can increase computational complexity. We propose a new approach, generating calibrations from large amounts of fossil data using the Bayesian Brownian Bridge (BBB) model, which estimates the timing of clade origination and extinction based on extant and historical diversity, independent of phylogenetic relationships. Subsequently, we transform BBB estimations into probabilistic calibrations for molecular clock analysis conducted using MCMCTree. We used this big data approach to establish the timescale of angiosperm evolutionary history based on 83 genes from 644 species, incorporating 110 calibrations from over 25,000 fossil occurrences. The results of our analysis allow us to reject a post-Jurassic origin of angiosperms, supporting the notion of a cryptic early history of angiosperms. Our study explores the utility of a mechanistic approach for deriving node-calibrations based on big data for molecular clock analyses, combining the best of molecular and palaeontological data and methods to derive holistic timescales for evolutionary history.

Recording allowed: No

Biodiversity estimates and biases across the Ediacaran-Cambrian boundary

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The drivers of Ediacaran–Cambrian metazoan radiations remain unclear, as does the fidelity of the geologic and fossil record. We use a global age framework (*c.* 580–510 Ma) to estimate changes in marine sedimentary rock volume and area, reconstructed biodiversity (mean genus richness), and sampling intensity. Even though sampling intensity correlates with overall mean reconstructed biodiversity >535 Ma, the abundance and distribution of different marine sedimentary rocks in the global record seem to have influenced the available habitats for early metazoans to occupy and diversify. The Avalon assemblage's temporal distribution is partly controlled by the temporally and spatially limited record of deep-marine siliciclastic rocks. The decline of the White Sea assemblage appears to represent a true extinction of distinctive White Sea morphogroups, as it does not coincide with a decrease in its host lithology. The lack of shallow carbonate rocks from ~555 to 550.5 Ma suggests that the origin of metazoan calcareous biomineralization may be constrained by the preserved carbonate record. The available rock record, sampling effort, and preservation potential all exert a relevant control on the reconstructed biodiversity trends across the Ediacaran-Cambrian transition and must be carefully considered when investigating potential drivers of early animal evolution.

Recording allowed: No

Modelling punctuated evolution in Bayesian total-evidence dating

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Establishing divergence times is critical to resolving macroevolutionary history. Discrepancies in divergence time estimates between fossil records and molecular data have been observed and fiercely debated in a range of clades, including modern birds and placental mammals. One

hypothesis suggests that current clock models, which assume the gradual accumulation of trait or genetic changes through time, may overestimate node ages. Recently, a new gamma spike relaxed clock model in BEAST2 has been developed to account for punctuated evolution, where bursts of rapid trait or nucleotide evolution occur at speciation. Here we investigate the impact of incorporating punctuated evolution when inferring the evolutionary history of penguins (Spheniscidae) using a Bayesian total-evidence approach. We performed and compared the resultant topologies and divergence times from two analyses: one using only the optimized relaxed clock and the other incorporating bursts of evolution at both observed and hidden speciation events. Contrary to our expectations, we found shifts in relationships among extant penguin species and a combination of older and younger node ages when allowing for punctuated evolution. Our results suggest that failing to account for punctuated evolution may bias the reconstruction of clade evolution through time.

Recording allowed: No