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Edited by Hans Arne Nakrem

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Conference logo: Petter Nordenhaug

We wish to welcome you to the 21st EAVP annual meeting in Longyearbyen!

Venues

The workshops, annual EAVP member assembly, auction, conference talks and poster session will take place at the University Centre in Svalbard (UNIS). UNIS has a broad number of lecture theatres and classrooms available for workshop and conference sessions. The University Centre in Svalbard is the core institution of the Svalbard Science Centre, an international Arctic center of expertise in research and education. In addition, UNIS also incorporates other professional and scientific institutions in Svalbard, such as The Norwegian Polar Institute, EISCAT and Svalbard Science Forum.

The Icebreaker event will be held at the Svalbard Museum, adjoined to UNIS. The Svalbard Museum will next year open new exhibits, including sections involving palaeontological excavations in Svalbard.

The conference dinner will be held at Gruvelageret. Situated in a part of Longyearbyen previously used to host working coalminers in the 1940s, the restaurant has a rich history and a delicious menu including local delicacies. Bus ride will be organized to and from the event.

General assembly – As part of this year's EAVP Annual General Meeting, all EAVP board positions will be open for election.

Cultural heritage in Svalbard

Please note that everything in Svalbard which is older than 1946 is automatically protected by law (yes even things that look like rubbish). In addition, all traces of human graves, including crosses and other grave markers, as well as bones and bone fragments found on or below the surface of the ground are automatically protected regardless of their age. The same applies to skeletal remains at slaughter sites for walruses and whales and in connection with self-shooting traps for polar bears. Automatically protected cultural monuments have a 100-metre protection zone in all directions from the visible or known outer edge. The protection zone has the same protection conditions as the cultural monument itself. So please do not touch or approach any old mining equipment lying around in Longyearbyen as these are protected.

Safety!

This meeting is in a polar environment and safety is always first. Polar bears are known to kill people on the Svalbard. As such safety precautions MUST be taken. Do not under any circumstances walk out of Longyearbyen without a polar bear guard with a firearm. This includes travelling to and from the airport. Please take the airport bus or use a taxi. Note that walking to/from Longyearbyen town centre to Nybyen or Sverdrupbyen by road is ok. https://en.visitsvalbard.com/visitorinformation/safety-in-svalbard

Clothing

Svalbard has experienced extreme warming this summer (up to almost 20 degrees), but it shifts very quickly. Dress as for a wet, 7-degree autumn. For more info:

https://en.visitsvalbard.com/visitor-information/travel-information/how-to-dress-in-svalbard

Questions?

You will most of the time find some from the organization committee in the reception or cantina at UNIS.

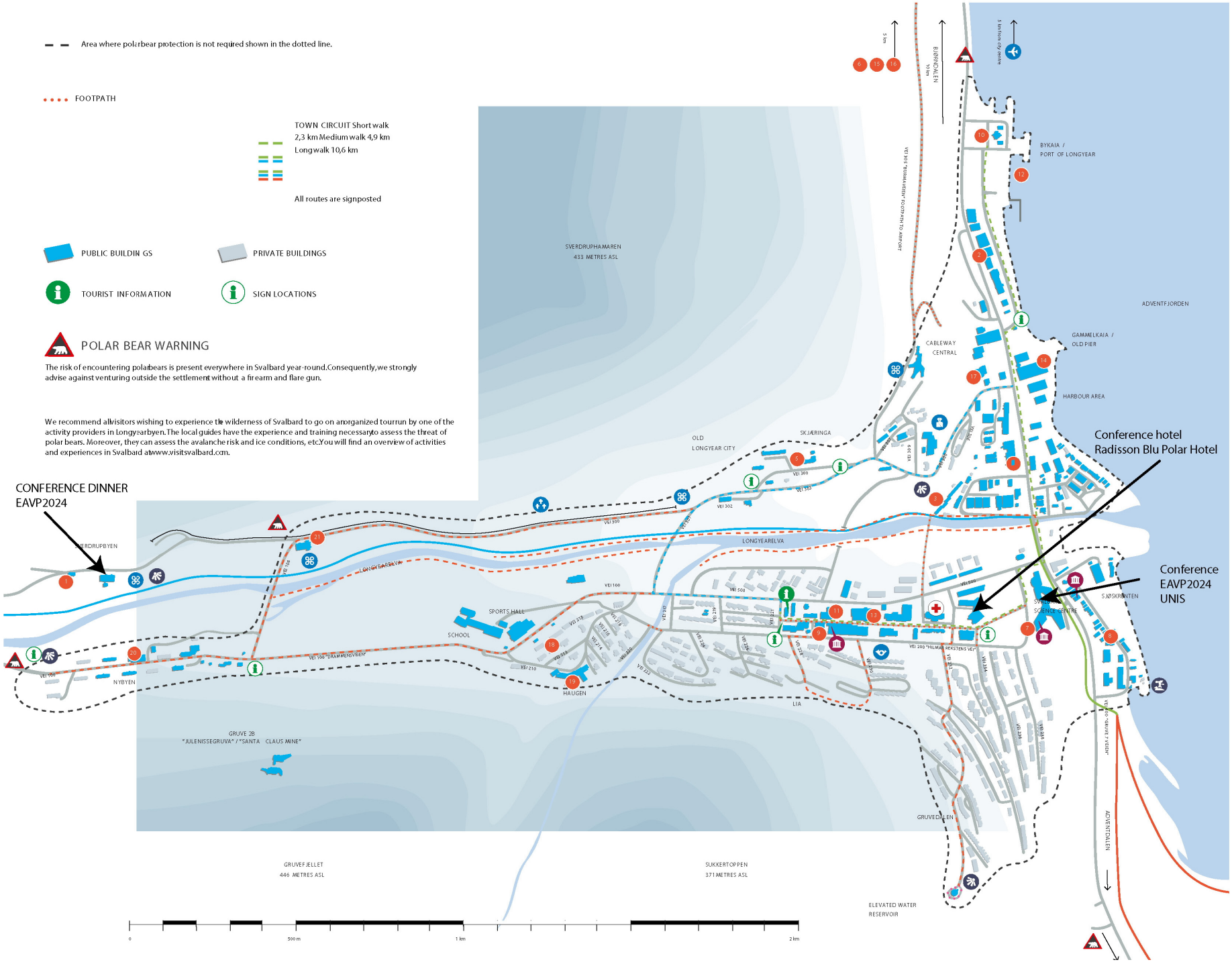
Organization committee

Aubrey Jane Roberts Jørn H. Hurum Hans Arne Nakrem Øyvind Hammer

Victoria Sjøholt Engelschiøn Benjamin Kear Petter Nordenhaug

Vanja Simonsen Lene L. Delsett Mathieu Gabriel Faure Brac

Maciej Roman Rucinski Marion Thaureau Synnøve Saugen


Area where polarbear protection is not required shown in the dotted line.
FOOTPATH
TOWN CIRCUIT Short walk
2,3 km Medium walk 4,9 km
Long walk 10,6 km
All routes are signposted
PUBLIC BUILDIN GS
PRIVATE BUILDINGS
TOURIST INFORMATION
SIGN LOCATIONS
POLAR BEAR WARNING
The risk of encountering polarbears is present everywhere in Svalbard year-round.Consequently,we strongly advise against venturing outside the settlement without a firearm and flare gun.
We recommend allvisitors wishing to experience the wilderness of Svalbard to go on anorganized tourrun by one of the activity providers in Longyearbyen.The local guides have the experience and training necessaryto assess the threat of polar bears. Moreover, they can assess the avalanche risk and ice conditions, etc.You will find an overview of activities and experiences in Svalbard atwww.visitsvalbard.com.
CONFERENCE DINNER
EAVP2024
Conference hotel
Radisson Blu Polar Hotel
Conference
EAVP2024
UNIS
SVERDRUPHAMAREN
433 METRES ASL
OLD
LONGYEAR CITY
SKJÆRINGA
LONGYEARELVA
SVERDRUPBYEN
NYBYEN
SPORTS HALL
SCHOOL
HAUGEN
LIA
GRUVE 2B
"JULENISSEGRUVA" / "SANTA CLAUS MINE"
GRUVEFJELLET
446 METRES ASL
SUKKERTOPPEN
371 METRES ASL
ELEVATED WATER
RESERVOIR
BYKAIA /
PORT OF LONGYEAR
GAMMELKAIA /
OLD PIER
HARBOUR AREA
CABLEWAY
CENTRAL
ADVENTFJORDEN
SJØSKRENTEN
GRUVEDALEN
ADVENTDALEN
BJØRNDALEN
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500 m
1 km
2 km


Svalbard
Arctic Ocean
Kvitøya
Sjuøyane
Nordkapp
Norden-
skiöld-
bukta
Lågøya
Verlegenhuken
Prins
Oskars
Land
Duvefjorden
Gustav V
Land
Orvin Land
Storøya
Nordaustlandet
Italiaodden
Isispynten
Hartogbukta
Walenbergfj.
Gustav
Adolf
Land
Hinlopenstretet
Ny
Friesland
Wijdefjorden
Woodfjorden
Albert I
Land
Andrée
Land
Haakon VII
Land
Kapp
Mitra
Krossfj.
Kongsfjorden
Ny-Ålesund
James I
Land
Austfjorden
1713
Olav V
Land
Dickson
Land
Wahlbergøya
Wilhelmøya
Kapp
Mohn
Klerck-
bukta
Erik Eriksenstretet
Kongeøya
Abeløya
Kapp
Payer
Kong Karls
Land
Svenskøya
Spitsbergen
Pyramiden
Bünsow
Land
Billefj.
Oscar II
Land
Forlandsundet
Prins
Karls
Forland
Ekmanfjorden
Sassenfj.
Tempelfj.
Ginevrabotnen
Barentsøya
Olgastretet
Isfjorden
Longyearbyen
Sabine
Land
Freemannsundet
Barentsburg
Nordenskiöld
Land
Sveagruva
Van Mijenfj.
Heer
Land
Nathorst
Land
Storfjorden
Edgeøya
Barents
Sea
Bellsundet
Van Keulenfj.
Wedel
Jarlsberg
Land
Torell
Land
Tjuvfjorden
Negerpynten
Greenland
Sea
Hornsund
Sørkapp
Land
Hopen
Sørkapp
Norwegian
Sea
Bjørnøya
0
50 m
200 m
500 m
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2000 m
3000 m
4000 m
1750 m
1500 m
1250 m
1000 m
750 m
500 m
250 m
100 m
50 m
25 m
0 m
(km)
100
(mi)
60
12°
16°
20°
24°
28°
32°
80°
79°
78°
77°
76°
75°

EAVP 2024

Programme and abstracts

Registration: Thursday, Friday and Saturday from 08:00 in the UNIS entrance

Presentations: PowerPoint or PDF files must be copied to the relevant PC in the relevant auditorium in the morning or during coffe/lunch breaks.

Workshop schedule Thursday 29th:

Room	Tempelet		Kapp room 1		Kapp room 2	
Time	**Workshop title**	**Organiser**	**Workshop title**	**Organiser**	**Workshop title**	**Organiser**
09:00 - 11:30	Best-Practice fieldwork and collections	A. Hellemond, A. Roberts, J. Hurum	PAST – Palaeontological data analysis with PAST	Ø. Hammer	Women in Palaeo roundtable	F. Holwerda et al.
10:30-12:00					Post-hoc on the Post doc	J. Liston
12:00-13:00	**LUNCH - ICARP IV discussion in cantina**					
13:00-14:30	Outreach workshop	Spitsbergen Mesozoic Research Group - J. Hurum	PAST – Palaeontological data analysis with PAST	Ø. Hammer	How to digitally open our collections and foster a more inclusive research culture	D. Schwarz, A. Campell and V. Díez Díaz
14:30-16:00						

	Friday 30th		
Room	Møysalen	Lassegrotta	Kapprom
Time	**Author**	**Author**	**Author**
09:00	Polar session - Chair J. Hurum **Jensen** - Introduction to Svalbard		
09:30	**Druckenmiller et al.** - Polar terrestrial ecosystems from the Upper Cretaceous (Campanian) Prince Creek Formation of northern Alaska: progress and future directions		
10:00	**Hurum et al.** - 20 years of Arctic excavations and research – Spitsbergen Mesozoic Research Group (SMRG)		
10:15	**Pardo-Pérez et al.** - Myobradypterygius hauthali (Reptilia: Ichthyosauria) from the Hauterivian of the Chilean subantarctic region including a gravid specimen		
10:30-11:00	**COFFEE BREAK**		
11:00	Polar session cont. - Chair J. Hurum **Saugen et al.** - A newly described neoselachian fauna from the Grippia Bonebed (early but not earliest Spathian, Early Triassic) of Spitsbergen		
11:15	**Nakrem** - Upper Carboniferous, Permain and Triassic conodonts of Svalbard		
11:30	Marine reptiles - Chair L. L. Delsett **Faure Brac et al.** - Ichthyosaur metabolism: First results		
11:45	**Serafini et al.** - In the belly of the beast: Temnodontosaurus bromalites from the Lower Jurassic elucidate trophic ecology and prey preference of a macropredatory ichthyosaur		
12:00	**Miedema et al.** -The Early Jurassic ichthyosaur fauna of northern Bavaria		
12:15	**Wang** - Hanosaurus from the Early Triassic of China and the Early Evolution of Sauropterygiformes		
12:30-13:30	**LUNCH BREAK**		
13:30	Marine reptiles cont. - Chair L. Delsett **Cornille et al.** - Extant crocodilian osteopathology as a window to phytosaur paleopathology	Fish and early tetrapods - Chair Ø. Hammer **El Fassi El Fehri et al.** - The origin of the modern lungfish: a derived tooth plate from the Famennian of Morocco blurs lungfish evolution across the Devonian-Carboniferous boundary	Mammals, ecosystems and other - Chair M. Thaureau **Decuypere et al.** - Palaeoecological data of South American metatherians inferred by the study of jaw biomechanics in marsupials
13:45	**Cottereau et al.** - The diversity of shapes and structure of aquatic amniote flippers	**Greif et al.** - Tooth wear histology of Devonian chondrichthyan from Morocco provide insights into feeding behaviour and tooth development	**Rawson et al.** - Evolutionary insights into the loss of ossified Meckel's cartilage from the development of the short-beaked echidna
14:00	**During et al.** - Were mosasaurs as marine as commonly thought	**Kean et al.** - Investigating the patterns and mechanisms of skull simplification in tetrapodomorphs	**Matamales-Andreu et al.** - First therapsid fossil from the Permian of the Mediterranean
14:15-14:45	**COFFEE BREAK**		
14:45	Marine reptiles cont. - Chair M Rucinski **Holwerda** - Mosasaur feeding ecology in the Bearpaw Formation, Alberta, Canada: The final chapter	Fish and early tetrapods cont. - Chair Ø. Hammer **Rose et al.** - 3D Range of motion analysis of the forelimb of the Permian recumbirostran 'microsaur' Batropetes palatinus and its implications for fossoriality	Mammals and therapsids - Chair M. Thaureau **Elstrup** - Shortening the neck of Graamocetus longicollis (Mammalia: Delphinida)
15:00	**Rytel et al.** - Extensive internal modifications of cervical vertebrae in Triassic long-necked archosauromorphs	**Jannel et al.** - Stepping Back in Time: Unveiling the origins of bipedalism in early terrestrail tetrapods through innovative biomechanical approaches	**Bader et al.** - Scaling up: investigating limb long bone shape variation among proboscideans
15:15	**Laboury et al.** - Contrasting macroevolutionary patterns in pelagic tetrapods across the end-Triassic bottleneck	**Qi et al.** - Molecular dating of the teleost whole genome duplication (3R) is compatible with the expectations of delayed rediploidization	**Moncunill-Solé et al.** - Are extinct islanders more predisposed to illness? New evidence of pathological conditions in Plio-Holocene ffossil bones from Balearic Islands (Menorca, Spain)
15:30	**Della Giustina et al.** - Niche partitioning and feeding performance in Late Cretaceous marine reptiles from the Western Interior Seaway		**Gigliotti et al.** - Endocranial anatomy of the holotype of Olivierosuchus parringtoni (Synapsida, Therocephalia)
15:45	**Pardo-Pérez et al.** - A hard life for Ophthalmosaurus: survey of osteopathologies in ichthyosaurs from the Middle Jurassic Oxford Clay of England		**Canoville et al.** - First bone microstructural investigation of Suminia getmanovi (Synapsida, Anomodontia) supports its arboreal lifestyle
16:00-18:00	**POSTER SESSION - UNIS CANTINA**		
18:00-19:00	**BREAK and bus to Gruvelageret**		
19:00-22:00	**Conference dinner - Gruvelageret**		

	Saturday 31th		
	Møysalen	Lassegrotta	Kapprom
Time	**Author - Title**	**Author - Title**	**Author - Title**
	Polar session - Chair A. J. Roberts		
09:00	**Roberts et al.** - Triassic Treasures - New Insights into Svalbard's Marine Reptile Heritage		
09:15	**Tałanda et al.** - Severe droughts did not restrict the distribution of large herbivorous dinosaurs in the Triassic - evidence from the lungfish aestivation burrows from Greenland		
09:30	**Delsett et al.** - How to use a vertebral column		
09:45	**Liston** - Reversing the Pachycormid Polarity?		
10:00	**Paterson et al.** - Evolutionarily-informative ancient proteins persist across geological timescales in polar regions		
10:15	**Pardo-Pérez** - Introducing the documentary "Fiona, la madre del Tyndall" to be shown after coffee break		
10:30-11:00	**COFFEE BREAK**		
	Polar session cont. Documentary	Reptiles - Chair M. Rucinski	
11:00	"Fiona, la madre del Tyndall"	**Čerňanský et al.** - Diving in a deep time: the Paleocene of Walbeck reveals the beginning of the Cenozoic	
11:15	Documentary about the excavation of the ichthyosaur in the Tyndall Glacier, Chile	**Beccari et al.** - Studying the postcranial anatomy of the extant tuatara (Lepidosauria: Sphenodon punctatus) to understand the diversity and variability in fossil rhynchocephalians	
11:30		**Burch et al.** - Making the most of the little things: Using teeth from microvertebrate fossil localities to determine a body size, a functional trait for community analysis	
	Dino-bird - Chair P. Nordenhaug		
11:45	**Meyer and Sciscio** - Wildlife in the Late Jurassic of Northern Switzerland - a key to faunal exchange between the Boreal and Tethyan Realms	**Chroust et al.** - Review of the Pliocene turtles from Poland	
12:00	**Mulder et al.** - A Jurassic early bird: Integrative taphonomy and identity of Ostromia crassipes	**Nicholl et al.** -A new notosuchian crocodyliform phylogeny resolves long-standing debates about the placement of sebecids	
12:15	**Voeten et al.** - Reimagining Archeopteryx: Unlocking the 3D anatomy of the incipient dinosaur flight	**Freisem** - The evolution of the early archosauromorph brain	
12:30-13:30	**LUNCH BREAK**		
	Dino-bird cont. - Chair P. Nordenhaug	Reptiles cont. - Chair J. Hurum	Ethics in palaeo - Chair S. Saugen
13:30	**Benito et al.** - New data on a Late Cretaceous stem bird clarifies the ancestral condition of the neornithine postcranial skeleton	**Garcia-Escolà et al.** - Jaw muscle dimensions in extant and extinct lizards	**Schwarz et al.** - A fossil is not just a fossil - fostering transparency, accessibility and preser vation of excavation documentation in a colonial vertebrate palaeontology collection
13:45	**Navalón et al.** - Cretaceous enantiornithine bird from Brazil fills fundamental knowledge gap in the early evolution of the avian skull and brain	**Georgalis -** What does vertebral morphology tell us about the taxonomy and diversity of the Paleogene snakes from Europe	**Rodrigues** - Lessons learned on repatriating fossils
14:00	**Reutter et al**. - A new macronarian (Dinosauria, Sauropoda) from the Late Jurassic Cañadón Calcáreo Formation of Argentina and the systematic incongruences of recent phylogenetic studies	**Keeble and Nesbitt -** Using 3D geometric morphometrics and discrete analysis on teeth of Late Triassic Archosauriformes exhibiting the plesiomorphic condition: tools for distinguishing the isolated and undistinguishable	**Liston** -Justifying the means: The ethics and limitations of social media use for specimen restitution
14:15-14:45	**COFFEE BREAK**		
	Dino-bird cont. - Chair V. Simonsen	Reptiles cont. - Chair J. Hurum	Ecosystems and evolution - Chair S. Saugen
14:45	**Kirmse et al.** - The largest Triassic Neotheropod	**Hoffman et al.** - Growth in alligators and caimans informed by osteohistology of the Eocene alligatoroid Diplocynodon hantoniensis	**Foffa et al.** - Ecological recovery in the early Mesozoic in low-latitude continental vertebrate assemblages
15:00	**Morrison et al.** - The first reported magaraptoran theropod dinosaur from Europe and the implications for megaraptoran origins	**Pellarin et al.** - The thermal metabolism in Metriorhynchidae: a histological quantitative approach.	**Thaureau et al.** - The Phenotypic Evolution Time Series (PETS) database: facilitating research on phenotypic change within lineages.
		Ichnofossils - Chair J. Hurum	
15:15	**Rauhut et al.** - A new metriacanthosaurid theropod from the Middle Jurassic Balabansai Formation of Kyrgyzstan	**Rebillard et al.** - A regurgitalite from the Early Permian Bromacker locality (Thuringia, Germany)	
15:30	**Słowiak et al.** - The mysterious theropod dinosaur Bagaraatan ostromi is a chimaera	**Groenewald et al.** - New discoveries from the Middle Triassic locality La Mora, northeastern Spain	
15:45	**Cuesta et al.** - 'Going around in the head' of Asfaltovenator: new data on the skull of the type specimen of the Patagonian allosauroid (Early Jurassic)	**Sciscio et al.** - Digitizing and sharing of the JURASSICA Museum's extensive Late Jurassic Dinosaur Ichnological Collection	
16:00-18:00	**EAVP General Assembly - Møysalen**		
18:00-19:00	**BREAK**		
19:00-22:00	**Auction - Møysalen**		

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

Anderson, H. E.*, Lundeen, I., Silcox, M. T. & López-Torres, S.

* h.anderson@uw.edu.pl – presenting author

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 to 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 some light on this debate and also possibly clarify how modern lorisoid olfactory and 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. Measurements of the total nasal turbinal area show that *M. shipmani* has comparable values to modern pottos (genus *Perodicticus*), which are of similar body mass to *Mioeuoticus*. When turbinal surface area is plotted against skull length, *M. shipmani* falls very close to the strepsirrhine morphospace. While this points towards *Mioeuoticus* having a keen sense of smell like modern strepsirrhines, the rostro-caudal arrangement of the turbinals is not entirely consistent with that observed in modern lorisids, showing a hybrid state between lorisoids and lemuroids. On the contrary, the inner ear data show remarkably lorisoid-like oval lateral semicircular canals (SCC), as opposed to the more rounded lemuroid SCCs. Additionally, the significant deviation from orthogonality of the angles between SCCs (101-105º) suggests slow rotational head speeds, supporting previous inferences that *M. shipmani* was a slow-moving lorisid, like its modern relatives. Finally, the low values obtained when calculating the optic foramen quotient (16.9) suggest that *M. shipmani* had poor visual acuity and was most likely nocturnal.

These 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 is funded by a Winifred Violet Scott Grant to HEA, an NSERC Discovery Grant to MTS, and a National Science Centre (Krakow, Poland) grant no. 2022/45/B/NZ8/03585 to SLT.

A history of tiny snakes – Tracing wide gaped feeding through the snake fossil record of North America

Armfield, R.E.*, Gauthier, J.A. & Briggs, D.E.G.

*roxanne.armfield@yale.edu – presenting author

The evolution of wide gaped feeding is often cited as the driver to the rapid speciation and subsequent global success of modern alethinophidian snakes. Yet despite this posited panacea to dietary versatility, alethinophidian taxa show significantly higher levels of cranial morphological disparity than most tetrapod clades. Macrostomy is a complex multistate trait designation – and accurate attribution requires combining evidence from morphological, functional, behavioural, and ecological perspectives. Our understanding of the timing, acquisition and origins of these numerous traits is hindered by a poor fossil record lacking diagnostic cranial material, and by conflicting phylogenetic topologies which present contrasting evolutionary scenarios for character acquisition. New fossil specimens containing cranial material, and a new fossil species of alethinophidian snake from the Palaeocene of North America contest the model of a linear stepwise gain of wide-gaped feeding traits suggested by morphological phylogenetics, and instead present a more complex scenario of losses and gains of palatomaxillary mobility across this clade throughout its early history. We combine new fossil data with

musculoskeletal relationships from extant taxa (acquired through DiceCT techniques) to evaluate the potential ecological niches exploited by these prehistoric taxa and predict the possible diet and feasible prey for these snakes living in the wake of the K-Pg extinction event.

The large mammal fauna from the Late Villafranchian locality of Aghia Kyriaki, Aetoloakarnania, Greece.

Arvanitis, A.*, Tzortzi, M. & Iliopoulos, G.

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The site of Aghia Kyriaki is located in the Southwestern part of Central Greece, near the settlement of Aghia Kyriaki, at an altitude of 1300 m, municipality of Nafpaktia, district of Aetoloakarnania, Greece. The fossiliferous site of Aghia Kyriaki was a karstic cavity filled with reddish–brown clay with fragments of limestones and cherts and was formed in the Pindos unit. As a collapsed karstic cavity, conducting a stratigraphical study has been impossible. The cave entrance was recently damaged during the construction works associated with the cutting of a new dirt road.

Excavation at the site began in 2017 and is currently ongoing by the Laboratory of Palaeontology and Stratigraphy of the University of Patras. Based on Parparousi (The Villafranchian mammal fauna of Aghia Kyriaki, Aetoloakarnania, Greece: Taxonomy and taphonomy, Master's thesis, 2022) the determined taxa from the first excavations that took place are as follows: *Ursus etruscus*, *Canis* (*Xenocyon*) sp., *Metacervocerus* sp., *Croizetoceros ramosus*, *Hemitragus* sp., cf. *Gazellospira torticornis* and plenty of non – specified taxa.The latest excavation campaign, conducted in June 2022, yielded over 600 additional skeletal elements, shedding light on the palaeoecology and dating of the fossiliferous site.

Each skeletal element underwent detailed examination and description, in order to be identified and if possible to be determined to a taxon level. The determined dominant species are *Ursus etruscus*, *Panthera gombaszoegensis*, *Gazellospira* cf. *torticornis* and cf. *Croizetoceros* sp., suggesting an open plain/woodland environment based on the morphology, mechanics and predator – prey relationships of the taxa.

The smaller than typical size of *P. gombaszoegensis* may suggest a high sexual dimorphism index as well as an older lineage of the species, considering the age of the locality.

The dating of the site is based on biostratigraphy, and more specifically the species *P. gombaszoegensis* restricts the time frame at approximately ~2.1 – 1.8 Ma, corresponding to the early Late Villafranchian - Epivillafranchian mammal age, which coincides with the important faunal turnover at the Middle Villafranchian – Late Villafranchian boundary.

The fossiliferous material from the locality of Aghia Kyriaki so far is represented mostly by Carnivore elements, something that is not typical in the Villafranchian Mammal fossil record, although the Villafranchian Mammal age is characterized by a strong Carnivoran guild structure.

The Messel salamander, ?*Chelotriton robustus.*

Auste, S. N., Marjanović, D.*, Witzmann, F. & Fröbisch, N. B.

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Amid thousands of extremely well preserved birds, mammals, crocodyliforms, actinopterygians, insects and plant remains, the early middle Eocene site of Messel near Darmstadt and Frankfurt in western Germany has so far yielded about 200 specimens referable to three or four frog species, but only a single specimen of a salamander: the holotype and only known specimen of the pleurodelin salamandrid *Chelotriton robustus* Westphal, 1980. Unfortunately, it was split in the sagittal plane; because Messel shale contains no less than 40% water, the two slices of the fossil had to be transferred to two artificial-resin plates that make many details difficult to see. This may explain why this practically complete peramorphic skeleton was never sufficiently described or illustrated for, e.g., a phylogenetic analysis, even though it shows a number of highly unusual features (some practically unique among salamanders, e.g., honeycombed sculpture on the

skull). We present the first µCT scan of the specimen and compare it to our µCT scan of a specimen of the extant pleurodelin *Tylototriton* (the first to include the entire skeleton of any *Tylototriton* species). The lack of a hyobranchial skeleton (unlike all other known *Chelotriton* skulls), the fully ossified tarsus and largely ossified carpus of this fairly small salamander, its long, robust limbs and its short trunk (shorter than previously interpreted) argue for a terrestrial animal that did not live in the Messel lake or on its shore, explaining the extreme rarity of the taxon in the lake sediment. A revised and expanded phylogenetic analysis confirms the specimen as a pleurodelin newt, but casts doubt on its referral to the Oligocene through Pliocene *Chelotriton*.

Morphological analysis of extant African carnivorans: a starting point for the study of a Late Pleistocene assemblage from Olduvai Gorge (Tanzania).

Azzarà, B.* & Cherin, M.

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Fieldwork conducted by the Tanzanian Human Origins Research (THOR) team at Geolocality 83 in Olduvai Gorge between 2018 and 2022, has yielded a diverse and exceptionally well-preserved faunal assemblage. This discovery offered a unique opportunity to reassess the geological and paleontological features of the uppermost Olduvai Beds, namely the Naisiusiu Beds.

Radiocarbon dating of ostrich eggshells retrieved from Geolocality 83 provided ages ranging from approximately 38 to 33 cal^{14}C ka, indicating that the faunal assemblage is one of the few from the Late Pleistocene of Olduvai and of the whole Eastern Africa.

Supported by the EAVP Research Grant (ERG) and benefiting from the exceptional preservation of fossils at this site, a comprehensive systematic analysis became feasible. Using an approach rarely used in Olduvai research, during my PhD I have meticulously identified all the fossils from Geolocality 83. The identified taxa comprise *Crocodylus* sp., *Struthio* sp., *Crocuta crocuta*, *Lycaon pictus*, *Canis lupaster*, *Vulpes rueppellii*, *Caracal caracal*, *Acinonyx jubatus*, *Panthera pardus*, *Equus quagga*, *Taurotragus oryx*, *Syncerus antiquus*, *Nanger* sp., *Eudorcas* sp., *Madoqua* sp., *Aepyceros* sp., *Alcelaphus buselaphus*, *Connochaetes taurinus*, *Damaliscus* sp., *Phacochoerus africanus*, *Pedetes* sp., and *Gerbilliscus* sp. Whereas many of the identified taxa still inhabit the Serengeti savannah, the presence of taxa which are extinct (e.g., *S. antiquus*) or currently restricted to drier areas of the continent (e.g., *V. rueppellii*), suggests that the Olduvai paleoenvironment during the latest Pleistocene was more arid than it is today, aligning with existing literature on Eastern African paleoclimate.

In addition to the systematic analysis, a comparative digital database of African mammals was created by means of high-resolution 3D scanners. This database incorporates a wide range of morphological data on extant taxa (ca. 20 skulls), serving as a crucial tool for understanding the variation among the examined species and discerning similarities and differences between extant and fossil specimens. The establishment of this online repository upholds open science principles and promotes collaboration within the scientific community. By providing accessible and comprehensive data, it lays a cornerstone for further insights into the extant African mammals not easily available in European museums; furthermore, it plays a crucial role in facilitating future research efforts and interdisciplinary collaborations.

Scaling up: investigating limb long bone shape variation among. proboscideans

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The evolutionary history of the proboscidean order is characterized by a significant increase in body mass, evolving from its earliest small representatives to its later gigantic species. This shift in size is associated with numerous musculoskeletal changes, including important morphological variations of the limb long bones which are heavily

affected by shifts in body mass. In proboscideans, this massive size increase was made possible partly thanks to the acquisition of the columnar posture, i.e. the reorientation of the limbs in the parasagittal plane, allowing a greater axial distribution of the mechanical load. We investigated the shape variation of the six limb long bones among extant and extinct proboscideans in regard to body mass evolution in this lineage, using three-dimensional geometric morphometrics and qualitative comparisons to describe the shape variability. Our results indicate that the shift from a flexed posture to a columnar one results in the six bones in reorientations of articular surfaces and a decrease in robustness, allowing for reduced bending stresses on the bones. Additionally, our results indicate two main morphotypes among graviportal proboscideans: the first morphotype (MA) is characterized by bones with a thin diaphysis and narrow epiphyses, as observed in deinotheres and elephantids; in contrast, the second morphotype (MB) corresponds to bones with a larger diaphysis and wider epiphyses, as observed in gomphotheres and mammutids. Both morphotypes are found in species of similar mass, suggesting that proboscideans have adapted to high body weight support through two different strategies, and that once acquired, it remained fixed within the taxon.

Studying the postcranial anatomy of the extant tuatara (Lepidosauria: *Sphenodon punctatus*) to understand the diversity and variability in fossil rhynchocephalians.

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The diversity of rhynchocephalians during the Mesozoic, especially in the Jurassic of Europe, has been well documented. However, most studies still focus on the cranial anatomy of rhynchocephalians, even when well-preserved, partial to complete specimens are available. The same is true for the extant tuatara (*Sphenodon punctatus*). Although some studies have focused on rhynchocephalian postcranial anatomy, most of these used a low number of specimens and measurements to study the ontogenetic and interspecific variability in this taxon. Our study increases this sample size, utilizing 55 rhynchocephalian specimens, 21 of tuatara, and 34 fossil rhynchocephalians of different groups (e.g., pleurosaurids, sapheosaurids, and sphenodontines). These specimens were measured, and their ossification patterns were qualitatively described. The tuatara shows a clear pattern of postcranial bone ossification throughout its ontogeny, the sequence being vertebrae, pectoral girdle, appendicular skeleton, and pelvic girdle, with some bones fully developing only in adults (i.e., the fusion of pelvic girdle elements to each other, and the fully ossification of appendicular bone epiphyses). When compared to fossil rhynchocephalians, some taxa show a shift in the ossification timing. Pleurosaurids show delayed ossification of vertebrae and long bones, in *Kallimodon* the carpus fully ossifies before the manus (opposite from tuatara), and adult specimens of different taxa show unfused pelvic girdle elements (e.g., *Sapheosaurus* and *Oenosaurus*). Some of these patterns (e.g., late ossification of appendicular skeleton) have been associated with an aquatic lifestyle, but others might be correlated with phylogeny. When analysing the metric data, we see a trend in the variability of tuatara, with clear distinction between hatchlings, post-hatchling juveniles, and subsequent ontogenetic stages. The tuatara occupies a similar morphospace to sapheosaurids and some *Kallimodon* specimens. The latter, however, shows a larger amplitude of variability than expected for tuatara, which might indicate that more than one taxon is present in the sample of specimens referred to *Kallimodon pulchellus*. Taxa which were described based on young (hatchlings or post-hatchling juveniles) specimens, i.e., *Acrosaurus*, and *Leptosaurus*, are recovered in our analysis in a distance to *Pleurosaurus* and *Kallimodon*, respectively, similar to that of specimens of early ontogenetic stages of tuatara and its adults. It has been suggested that *Acrosaurus* specimens would pertain to juvenile *Pleurosaurus*, and our analysis confirms that this could be the case. The morphospaces seem to indicate possible habitat preferences (e.g., marine environment for pleurosaurids, and arboreal environment for *Homoeosaurus*), but more data, possibly including extant squamates, is necessary.

Reappraisal of sauropod dinosaur diversity in the Upper Cretaceous Winton Formation of Queensland, Australia, through 3D digitisation and description of new specimens.

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Skeletal remains of sauropod dinosaurs have been known from Australia for over 100 years. Unfortunately, the classification of the majority of these specimens to species level has historically been impeded by their incompleteness. Recently, this has begun to change, primarily through the discovery and description of several partial skeletons — including rare articulated specimens — from the Cenomanian–lower Turonian (lower Upper Cretaceous) Winton Formation in central Queensland, with four species erected to date: *Australotitan cooperensis*, *Diamantinasaurus matildae*, *Savannasaurus elliottorum*, and *Wintonotitan wattsi*. The first three of these appear to form a clade (Diamantinasauria) of early diverging titanosaurs (or close relatives of titanosaurs), whereas *Wintonotitan wattsi* is typically recovered as a distantly related non-titanosaurian somphospondylan. The described specimens of the named sauropod species from the Winton Formation are all incomplete, making it difficult to assign new, similarly incomplete specimens to existing taxa based on shared autapomorphies. Through the use of 3D scanning, we digitised numerous specimens of Winton Formation sauropods, facilitating enhanced comparison between type and referred specimens, and heretofore undescribed specimens. We present new anatomical information on the holotype specimen of *Diamantinasaurus matildae* and referred specimens of *Australotitan cooperensis*, and describe new remains pertaining to twelve sauropod individuals. Firsthand observations and digital analysis enabled previously proposed autapomorphic features of all four named Winton Formation sauropod species to be identified in the newly described specimens, with some specimens exhibiting putative autapomorphies of more than one species, prompting a reassessment of their taxonomic validity. Supported by a specimen-level phylogenetic analysis, we suggest that *Australotitan cooperensis* is probably a junior synonym of *Diamantinasaurus matildae*, but conservatively regard it herein as an indeterminate diamantinasaurian, meaning that the Winton Formation sauropod fauna now comprises three (rather than four) valid diamantinasaurian species: *Diamantinasaurus matildae*, *Savannasaurus elliottorum*, and *Wintonotitan wattsi*, with the latter robustly supported as a member of the clade for the first time. We refer some of the newly described specimens to these three species and provide revised diagnoses, with some previously proposed autapomorphies now regarded as diamantinasaurian synapomorphies. Our newly presented anatomical data and critical reappraisal of the Winton Formation sauropods facilitates a more comprehensive understanding of the mid-Cretaceous sauropod palaeobiota of central Queensland.

New data on a Late Cretaceous stem bird clarifies the ancestral condition of the neornithine postcranial skeleton.

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Neornithes (the bird crown group) originated during the Late Cretaceous, yet their fossil record predating the end-Cretaceous Mass extinction is extremely scarce. A large number of fragmentary Late Cretaceous avian remains have been suggested to exhibit affinities to Galloanserae (waterfowl + landfowl), and the only two well-supported Cretaceous neornithines are thought to belong to this clade. Similarly, total group Anseriformes (waterfowl) are amongst the most diverse and abundant early Cenozoic neornithines. Recent insights on the ancestral crown bird palate suggest that a galloanseran-like palate may 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

several aspects of its postcranial morphology, particularly aspects of its pectoral and forelimb anatomy, are remarkably similar to those of early Cenozoic Anseriformes such as *Presbyornis*. However, these 'galloanseran' features are combined with hindlimb morphologies shared with stem palaeognaths and Neoaves, raising the intriguing possibility that numerous aspects of the postcranial anatomy of early total-group Anseriformes could be plesiomorphic for Neornithes. These results may force reconsideration of the purported galloanseran and neornithine affinities of several Cretaceous and early Cenozoic fossil birds, with potential implications for assessing the age of the deepest divergences among Neornithes in the Cretaceous. Furthermore, the postcranial similarities of crownward stem birds and earliest Cenozoic Anseriformes may hint at the ecology of the earliest crown birds and their survivorship through the end-Cretaceous mass extinction.

From physical to digital and back. Developing and testing 3D-based educational activities.

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Over the last two decades, the diffusion of rapid, accessible, and often affordable, digitisation techniques (e.g., surface scanners and photogrammetry) has driven a digital revolution in paleontological studies, museum conservation and education strategies. Digital specimens and collections can be used by museums to improve accessibility and remove physical barriers; 3D prints allow visitors to get the same experience as if they were touching actual delicate or inaccessible specimens, helping the museum leaving behind the so called "glass case" paradigm, and improving visitor experience.

The specimen utilized, currently housed in the exposition area of the Museo di Geologia e Paleontologia of the Università di Firenze (MNHF), is a bone assemblage made by the short-snouted hyena *Pachycrocuta brevirostris* around 1.8 Ma (Middle Pleistocene). It accounts for bone remains of 9 different taxa including, e.g., the giant deer *Eucladoceros dicranios* and the saber-tooth cat *Homotherium crenatidens*. Since it's first display, in 1997, the specimen has been often overlooked by visitors, because of its cryptic nature. The specimen was 3D digitised and the mesh was used to set up educational and outreach interactive activities, that are now are being tested with the public for an accurate feedback on their impact. The activities developed are: 1) simple 3D-printed small (14x6 cm) replicas of the slab that can be painted by younger visitors to understand which animals are present in the bone accumulation and their features; 2) from the 3D model of the assemblage, bones of the most relevant specimens were digitally isolated and all the pieces were 3D printed to create a tridimensional puzzle; 3) a mystery/detective story is being developed: clues are hidden in the museum and the young visitors involved have to find them and solve the "crime" that caused the bone accumulation. Once fully developed and tested, the third and second activities will be merged using both the hidden clues and the 3D puzzle.

Making the most of the little things: Using teeth from microvertebrate fossil localities to determine a body size, a functional trait for community analysis.

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Functional traits impact an organism's relationship with its environment (e.g., diet, feeding mode, mobility, tiering, and body size) and are commonly used to determine its ecological role in a community. Characterization of functional traits is challenging in modern vertebrate ecosystems and is even more problematic for extinct communities. Vertebrate community paleoecology studies often fail to utilize microfossils–teeth and bone fragments are largely overlooked. Teeth are excellent indicators of ecological roles as they are linked to body size, reflect dietary changes through ontogeny, and can be broadly assigned to larger clades. In reptile-dominated communities, like those of the Triassic Period, isolated teeth are abundant; an enamel coating enables teeth to survive transport

and burial, and most reptiles continuously replace their teeth throughout their lifetime. Incorporating isolated teeth in ecological analyses therefore samples a larger portion of the community in comparison to using only skeletal material. Our research aims to determine relationships between tooth crown height and body mass to increase the utility of isolated teeth in modelling community ecology. Crown height is known to strongly correlate with body mass in small groups (e.g., primates, single species of rabbit, shark, and alligator), but this relationship has yet to be characterized more broadly across vertebrates. Body mass data from specimens among lepidosauromorphs, archosauromorphs, and temnospondyls were recorded from museum collections and computed tomography data for various extinct and extant taxa (n ~ 200). Body mass was recorded for each specimen from direct measurements, if available, or from reliable correlates (e.g., femoral and skull dimensions). We analyzed a suite of tooth measurements with the body mass data in each group sampled, recovering a strong correlation between the average tooth crown height and body mass within Archosauromorpha and Lepidosauromorpha, respectively (r^2=0.83, r^2=0.80). We show tooth crown height and body mass can be modeled using a log-transformed linear regression for community members only represented by teeth. For any isolated tooth, body mass can be estimated and bracketed by the maximum and minimum mass for the animal assuming smallest/biggest tooth in the mouth. Our methods will greatly expand the quantity of specimens, and further, the number of microvertebrate assemblages, that are fit to be included in paleoecological analyses across the entire Mesozoic Era. This will ultimately improve the resolution (both geographical and stratigraphic) of ecological analyses and evolutionary patterns.

The collection of a Sauropod mandible from Quarry Ig – Contextualising the dinosaur fossils of the Colonial Tendaguru Collection.

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The fossil collection from the German Tendaguru Expedition (GTE) of 1909-1913 provides a unique opportunity to build our understanding of colonial collection practices in museums due to its extensive historical documentation and longstanding importance to the field of palaeontology. As part of a recently started project both the dinosaur remains and the archival documents from the GTE, now at the Museum für Naturkunde, Berlin (Germany), are undergoing digitisation with the aim of linking the fossils with the related historical documentation. The digitised materials will be made freely available through a searchable online data portal.

Here we present an early example of the digitisation methodology and historical context found relating to a single sauropod mandible. The mandible was originally packed in a bamboo corset along with other small fossil finds, the contents of the corset were known only after it underwent CT scanning. The historical context of this particular mandible and corresponding bamboo corset charts the journey of this fossil through its discovery in quarry Ig, packaging for travel, and shipment to Berlin where it remained unprepared in the bamboo corset for over 100 years. The work presented here shows the wealth of historical context available for the fossils of the Tendaguru dinosaur collection that will be openly available and intrinsically linked with the specimens from the GTE.

First bone microstructural investigation of *Suminia getmanovi* (Synapsida, Anomodontia) supports its arboreal lifestyle.

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Anomodontia, one of the major clades of Permo-Triassic therapsids, is comprised of a few basal forms with a relatively sparse fossil record, as well as the more derived and much more speciose Dicynodontia known from widespread and abundant remains. The paleohistology of dicynodonts has been extensively studied and all species, independent of body size and lifestyle, exhibit a pattern of rapid growth to adulthood, as shown by

the presence of fibrolamellar tissue in their limb bone cortices. Moreover, dicynodonts have been hypothesized as fully terrestrial and/or fossorial animals and uniformly show a relative bone cortical thickness (RBT) exceeding 30% in subadult and adult individuals, and a medullary cavity generally filled by trabeculae. In contrast, the paleohistology of basal anomodonts has been poorly investigated, with the only exception being *Galeops whaitsi* that shows a bone microstructure comparable to dicynodonts. In the present study, we aim to expand the taxonomic sample of basal anomodonts by focusing on the paleohistology of *Suminia getmanovi* from the late Permian of Russia. This species, unlike other basal forms, is known from numerous well-preserved skeletons and has been hypothesized as one of the earliest arboreal tetrapods based on skeletal morphology and limb proportions. In order to test this lifestyle hypothesis and assess the life history traits of *Suminia*, we studied the microstructure of five isolated long bones (humerus, two femora, tibia, fibula) recovered from the Kotel'nich locality, and catalogued under specimen number KPM 20/99. Histology and skeletal element proportions revealed that our sample comprises at least two individuals that died at a subadult stage. Most of the cortex is composed of a well vascularized and uninterrupted fibrolamellar bone tissue, suggesting a high and sustained growth rate up to the subadult stage; a growth pattern analogous to other anomodonts. However, all investigated skeletal elements present an open medullary cavity virtually free of bone trabeculae and a RBT lower than 18%. The microanatomy of *Suminia* thus differs from that of all other anomodonts studied so far, including its closest relative *Galeops*, as well as more basal synapsids that tend to show higher RBT values and/or a medullary territory obstructed by a trabecular network. Therefore, the long bone architecture of *Suminia* deviates strongly from the expected plesiomorphic condition in anomodonts and is thus in support of an arboreal lifestyle for this species.

Diving in a deep time: the Paleocene of Walbeck reveals the beginning of the Cenozoic story of European herpeto-faunas with a special focus on lizard fauna.

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The Paleocene paleoherpetofaunas are extremely rare in Europe, and, thus, very little is known about this epoch. We here revised part of Kuhn's original material from Walbeck fissure filling in Sachsen-Anhalt in Germany (~MP 5; the middle Selandian age). Walbeck is the only known Paleocene fossil site from Germany and one of the few Paleocene localities known from Europe. Thus, this locality represents one of the unique and rare exceptions, serving as a window into the late Paleocene world. The collection was considered to be lost but is consistently discussed in the literature due to its importance. The material contains eleven taxa of salamanders, frogs, lizards, a crocodile, and a turtle. The amphibian fauna includes three salamanders firstly described in the '30 (*Wolterstorffiella wiggeri*, *Geyeriella mertensi, Koalliella genzeli*), and frogs: a palaeobatrachid, a new alytid and a probable *Eopelobates*. The lizards are represented by *Camptognathosaurus walbeckensis*, a lacertid, and a scincoid. The material has been originally described by Kuhn in 1940 as aff. *Parasauromalus paleocenicus* and aff. *Glyptosaurus walbeckensis*. The former was originally allocated to Iguania, the latter to Anguimorpha, though later, these identifications were doubted by several authors. We show that such classifications cannot be upheld. *P. paleocenicus* resembles the morphology of typical insectivorous lacertids showing their presence in Europe already around MP 5. The name is nomen dubium. The material of aff. *G. walbeckensis* was later suggested to belong to Lacertidae and also considered as a potential amphisbaenian. Although it differs from modern amphisbaenians, it shares features with one supposed polyodontobaenid – *Camptognathosaurus parisiensis*. The Walbeck form is identical to this species. However, this taxon differs significantly from *Polyodontobaena* and new data doubt the attribution of *Camptognathosaurus* to Amphisbaenia. We consider this taxon to be a potential lacertid (it resembles forms such as *Cryptolacerta* and *Pseudeumeces* in some aspects). In general,

both amphibians and reptiles include Mesozoic (association of palaeobatrachid, alytid and pelobatid) and Cenozoic (*Geyeriella, Koalliella*, lacertids) elements suggesting a transitional position of herpetofauna between two eras. These finds also support the hypothesis of Čerňanský and Smith (2018) that the Paleogene of Europe, rather than being dominated by archaic forms only distantly related to Lacertidae, in fact, hosted large radiation of pan-lacertids.

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Review of the Pliocene turtles from Poland.

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The Polish fossil turtle fauna has been known for decades, however, it has received little attention in the international literature. Several fossil sites located in southern Poland, approximately 30 km from the city of Częstochowa, yielded numerous shell fragments of Pliocene age (Piacenzian, MN 16). Our revision of this historical material allowed us to confirm the presence of several species and revealed a rather surprising chelonian assemblage. We preliminarily identified members of the families Emydidae, Geoemydidae, and Testudinidae. Emydids are represented by *Emys orbicularis*, i.e., the extant European species, and these finds constitute one of its oldest occurrences worldwide. Geoemydids pertain to *Heosemys mossoczyi*, an enigmatic species closely related to the extant spiny turtle *Heosemys spinosa*, that is currently confined to southeastern Asia. The tortoise material is attributed to *Testudo szalaii*, a close relative of the extant European *Testudo hermanni*, and these finds represent the northernmost occurrence of the subgenus *Chersine*. The studied turtles are, therefore, a unique combination of typical European taxa with an influence of Asian fauna. It seems that certain extant Asian genera were inhabiting Europe during the Pliocene and subsequently went extinct due to climatic changes. The only exception is the genus *Mauremys*, recently distributed in the Western and Eastern Mediterranean and the Near East, with distant relatives in the Far East. Overall, the Polish Pliocene turtle fauna demonstrates some affinities with the fauna from the Black Sea region. Lastly, the findings of *Testudo szalaii* seem to provide evidence of the Pliocene climatic optimum in Central Europe and, therefore, climatic conditions similar to the modern Mediterranean region are envisaged.

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Extant crocodilian osteopathology as a window to phytosaur paleopathology.

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Paleopathology is a powerful tool to reconstruct different aspects of the physiology and paleoecology of long-extinct animals. However, most studies on bone physiology and pathology in extant vertebrates focus on humans or domesticated animals. Nonetheless, physiological and ecological differences should be considered between phylogenetically remote groups. The middle to late Triassic phytosaurs have an abundant fossil record ideal for a large-scale study of their paleopathologies. They have striking ecomorphological parallels with extant crocodilians and are either placed as sister group of archosaurs or basal pseudosuchians, which make extant crocodilians an ideal analogue model. We present here the first results of an epidemiological survey of skeletal pathologies in extant crocodilians based on first hand studies of 845 specimens. Pathological cases are present in 349 specimens from which 57% belong to the skull. Preliminary diagnoses show a dominance of traumatic injuries in 42% of cases

from which 16% are bone fractures. Infectious diseases represent 21% of cases, joint disorders 15%, dental diseases 6%, congenital malformations and metabolic diseases represent 5% each, the rest is represented by tentative neoplastic diseases, and ankylosed vertebrae. The main pathologies of the cranium and mandibles are traumatic injuries, representing 50% and 43% of cases respectively, and interpreted as a consequence of intraspecific fighting and feeding behaviour. The appendicular skeleton is primarily affected by trauma (33%) and infectious diseases (30%). The spine exhibits 29 % of joint disorders and infectious diseases each. On the ribs, traumata represent 42% of observed pathologies, of which 91% are fractures. The girdle structures show 43% of joint disorders and 39% of infectious diseases. Finally, 94% of osteoderm pathologies are traumatic injuries. These data, together with our ongoing work on phytosaur paleopathology, which has yielded 270 pathological bones, will undoubtedly be beneficial for future paleopathological studies of archosaurian clades, including dinosaurs.

The diversity of shapes and structure of aquatic amniote flippers.

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Moving from a terrestrial to an aquatic environment is a major anatomical challenge. Yet dozens of amniote lineages have taken the plunge. These independent transitions resulted in a plurality of ways to swim using locomotor appendages, as limbs evolved into flippers. However, no study has quantified the external shape and the structural diversity of these limbs in extant and extinct reptiles and mammals. Here, we quantify this diversity in a comparative framework by (i) studying two-dimensional foreflipper external shape using elliptical Fourier analysis in combination with skeletal organisation; and (ii) testing for relationships between these features and body proportions, swimming styles, and phylogenetic distances. Our results show that distantly related taxa share convergent external flipper shapes, likely due to strong constraints imposed by the aquatic realm. These similarities are, however, counterbalanced by the broad range of locomotor patterns and varied internal flipper anatomies characterising different amniote lineages. Surprisingly, some species with comparable flipper morphologies swim very differently. The functional implications of such similarities across species with distant evolutionary histories and different swimming styles continue to elude our understanding.

‘Going around in the head’ of *Asfaltovenator*: new data on the skull of the type specimen of the Patagonian allosauroid (Early Jurassic).

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Asfaltovenator vialidadi is the most complete tetanuran theropod known from the Cañadón Asfalto Formation (Chubut province, Argentina). This formation represents the most important vertebrate-bearing unit of the latest Early Jurassic in Gondwana and one of the very few units that have yielded terrestrial vertebrate fauna from this critical time period globally. *Asfaltovenator* is represented by an almost complete skeleton, including a disarticulated skull. This taxon shows a combination of features hitherto regarded as synapomorphies of different tetanuran groups, mainly Megalosauroidea and Allosauroidea. Its early temporal position and the high level of homoplasy in early tetanurans are the main problems in establishing its phylogenetic position within this clade. Here, we review the cranial elements of *Asfaltovenator* in detail and present a preliminary phylogenetic analysis to test how far the cranial character combination seen in this taxon may help to understand character distribution in early branching tetanurans.

In the preliminary results of the phylogenetic analyses, *Asfaltovenator* was recovered as an early branching allosauroid, forming a clade with *Allosaurus* in some trees. Distinct from previous studies, a monophyletic Carnosauria is not recovered here, and *Asfaltovenator* is not closely related to *Piatnitzkysaurus* and *Condorraptor,* the other tetanurans from the Cañadon Asfalto Formation.

The new description and character mapping reveal some features shared with megalosauroids (although not exclusively) and not present in other allosauroids, such as an enlarged foramen above the second premaxillary tooth (also observed in *Dilophosaurus, Dracovenator,* and *Proceratosaurus)*, unfused paradental plates (also observed in other theropods), and the absence of a medial palatal shelf extending from the anteromedial process posteriorly (also in ceratosaurs and some early-branched theropods). The skull of *Asfaltovenator* has numerous features shared with allosauroids (although not exclusively), such as an anteroventral narial fossa in the premaxilla (also observed in *Dubreuillosaurus, Marshosaurus,* and *Eustreptospondylus,* among others), a moderate ventral extension of the antorbital fossa in the maxilla (also observed in piatnitzkysaurids), a dorsoventral groove in the anterior surface of the ventral process of the lacrimal (but not in *Allosaurus*, and also observed in *Wiehenvenator, Monolophosaurus,* and *Dubreuillosaurus*), a low supraantorbital crest in the lacrimal (also in *Afrovenator*), and a posteroventral process in the quadratojugal (also observed in some tyrannosaurids and abelisaurids).

This combination of cranial characters suggests the placement of *Asfaltovenator* as an early branching allosauroid. It underscores the potential of this taxon has the potential to provide pivotal information to understand morphological evolution in this group.

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Reevaluating the taxic diversity of Rhabdodontidae in the Late Cretaceous European archipelago.

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Rhabdodontidae is a peculiar group of small and medium-sized ornithischian dinosaurs endemic for the Late Cretaceous European archipelago. Eight to nine distinct species are being recognized based on specimens collected from eastern Austria, southern France, western Hungary, western Romania, and northern Spain. Still, the diversity of Rhabdodontidae and their intrarelationships remain incompletely understood. Recent studies focusing on the histology of long bones suggested that the taxic diversity within the clade may be greater than traditionally thought, with possible co-occurrences of multiple sympatric taxa at least in the sample from southern France.

Owing to the fact that the type specimens of six of the rhabdodontid taxa (*Mochlodon suessi*, *M. vorosi*, *Rhabdodon priscus*, *R. septimanicus*, *Zalmoxes robustus*, and *Z. shqiperorum*), are known from well-preserved and distinctive dentary bones, determining the diagnostic features present in these elements has the potential to provide crucial information improving the knowledge of their distinguishability and phylogenetic affinities. A thorough reevaluation of the dentary bone morphologies of these taxa, including multivariate assessment of their character distribution, unveiled a greater morphological disparity in rhabdodontid dentaries than usually assumed. Intriguingly, our results show that the type specimen of *Rhabdodon septimanicus* from southern France represents a morphological outlier among rhabdodontids, occupying a different morphospace than the remaining members of the clade. Although some authors considered it a junior synonym of *Rhabdodon priscus*, the new results indicate that *R. septimanicus* should be treated as a separate taxon that cannot be referred to any of the currently recognized rhabdodontid genera.

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Palaeoecological data of South American metatherians inferred by the study of jaw biomechanics in marsupials.

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Marsupials first emerged on the Laurasia continent in the Cretaceous period and expanded to a cosmopolitan distribution during the Cenozoic era.

Despite their multiple dispersals on the Australian, Antarctic and American continents, the South American radiation remains one of the unresolved points in their evolutionary history. A mixing of biomes caused by the end of the isolation of South America led to a massive extinction of South American mammals, only a small number of which reached North America. Today, the remaining marsupials have adapted to their arboreal environment in the forests of South and Central America. The study of the maximum possible bite force allows a link to be made with their feeding capacity and their craniomandibular adaptations. Some authors have studied biting in modern vertebrates, such as lacertids, chiropterans and mustelids. Reconstructing this trait in fossil species will provide keys to understanding their past ecology. The interpretation of palaeoecological data from extinct species is a delicate process, mainly because it depends on the quality of the fossil remains, but also on the development of appropriate models. We have described the osteo-muscular masticatory system and established a model for rebuilding the maximum bite force of the species *Marmosa murina* Linnaeus, 1758 (Marsupialia, Didelphidae). The model thus constructed by static equilibrium highlights a potential adaptation of marsupials to exert a more optimised and powerful bite than their placental cousins. This study is complemented by geo-morphometric analyses examining the link between diet and feeding capacities in relation to craniomandibular morphology. The aim is to infer diet assumptions for extinct species from their morphology. Finally, finite element analysis (FEA) will enable us to observe the accumulation of constraints in the skull and mandible during mastication. By combining all these interpretations, the paleoecology of past South American metatherian species can be reconstructed. This work was supported by the Paris Ile-de-France Region – DIM “Matériaux anciens et patrimoniaux.

Preliminary morphological characterization in fore- and hind fins of ophthalmosaurian ichthyosaurs (Reptilia: Ichthyosauria) from the Early Cretaceous of Torres del Paine National Park, Southern Chile, to distinguish morphotypes.

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Among marine reptiles, ophthalmosaurian ichthyosaurs stand out starting in the Jurassic by developing a tunniform body shape, which provides them with greater stability in the marine environment. The fossil record shows morphological variability in the fins of ophthalmosaurians with a multiplicity of shapes that reveal both intra- and interspecific variation but also different priorities of use. The latter is based on the hydrodynamics of the bodies and biomechanical parameters specific to the animal and its surrounding environment. This research shows preliminary results of a study on the outline of different fore- and hind fins of Cretaceous ophthalmosaurian ichthyosaurs (Hauterivian 131.07 +/- 0.07 Ma) recorded from the rocky edge of the Tyndall Glacier in the Torres del Paine National Park, southernmost Chile. The objective of this study was to characterize the morphology of the fin skeleton in order to address questions related to their biomechanics and paleoecology. For this, we worked with five almost completely exposed and articulated fins, and a three-stage analysis was carried out: 1) initial anatomical and morphological description of the fins; 2) analysis of the outline of the fins by using geometric morphometry to evaluate their form and function; and 3) mechanical analysis. To reduce the taphonomic effect on the material, reconstructions of the fins were implemented by using modular grids. The results show, based on the outline of the fins and proportions of the stylopodium, zeugopodium and autopodium, that the fins available could be classified as orbicular (proximo-distally short and antero-posteriorly wide) and lanceolate (proximo-distally elongated and antero-posteriorly narrow). Therefore, we recognized that the two morphotypes (ichthyosaurs with orbicular and lanceolate fins) cohabited in the study area. This information indicates the existence of potentially at least two ecological niches in the area. For the advancement of this study, it is expected to complement the mechanical performed analyses with biomecha-

nical and functional inferences, and to a long term, to include analysis of other anatomical units, to allow better comprehension of the swimming dynamics and paleoecology of Tyndall's ichthyosaurs.

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Niche partitioning and feeding performance in Late Cretaceous marine reptiles from the Western Interior Seaway.

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The coexistence of sympatric predatory marine reptiles in the Late Cretaceous suggests ecological partitioning of higher trophic niches. The Western Interior Seaway, a vast inland sea that stretched across a significant portion of North America, was home to a diverse array of marine life, most notably a multitude of reptilian predators.

Previous studies have utilized tooth morphology and dental microwear as proxies for inferring the feeding habits of marine reptiles. However, teeth are only part of the feeding apparatus. Ecological insights may be elucidated through biomechanical simulations of craniodental remains, focusing on mechanical performance.

Here, we performed the first, large-scale, comparative study on WIS marine reptile jaw performance using high-definition three-dimensional models and muscle-driven finite element analyses (FEA). The jaws of mosasaurids and polycotylid plesiosaurians from the Campanian-Maastrichtian were 3D scanned and processed for FEA simulations. For comparative purposes, mosasaur jaws were modeled with a fused symphysis and immobile intramandibular joint, forming a single functional element. Muscle insertions were identified to reconstruct jaw adductor muscles and assess respective muscle and bite force. We used Metafor to simulate realistic, muscle traction dynamics during biting, including simulations at different opening angles and biting locations.

Results revealed distinct stress distributions per morphotype, demonstrating biomechanical variation between robust mosasaur mandibles (e.g. *Globidens*) and the more gracile mandibles of polycotylids and the mosasaurid *Clidastes*. High deformation values in polycotylid jaws suggest that maximum bite force (estimated from muscle attachments) was not exerted, resulting in divergent feeding techniques to mosasaurs (e.g., snapping and swallowing). Moreover, polycotylids and some mosasaurid taxa (e.g., *Clidastes* and *Jormungandr*) appear better adapted to bite at wider gape angles, whereas mosasaurids with high mechanical efficiency at wide and narrow gape angles (e.g., *Mosasaurus* and *Prognathodon*) are more suited to prey on large items with powerful bites.

Our results align with niche partition inferences from dental remains and offer deeper insight into feeding techniques in Late Cretaceous marine predators, providing a unified canvas and protocol to assess niche partitioning in sympatric marine reptiles from well-sampled (and well-preserved) regions.

How to use a vertebral column.

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The vertebral column is a defining trait of all vertebrates. Vertebral centra are commonly found both in the field and in museum collections, and probably carry an untapped potential for valuable information about the biology of both extant and extinct species. However, much knowledge is lacking for this part of the body, especially for marine tetrapods, which are important inhabitants of the polar areas, in the Mesozoic and today. Marine tetrapods have vertebral columns that are evolutionary modified from their terrestrial ancestors for life in water. The skeleton lost its weight-bearing role, but not its role in supporting locomotion and protecting inner organs. The ancestral state also implies some constraints, visible in the different directions of movement of

the tail in e. g. cetaceans and ichthyosaurs. This work assesses how common vertebral centra are, summarizes knowledge on the use of the vertebral column in marine tetrapods, and highlights some possible uses and limitations for vertebral centra data.

For extinct marine tetrapods, Mesozoic marine reptile finds in Spitsbergen, Greenland and Ellesmere Island show that vertebral centra are commonly preserved, but that bias might affect the collection. Building on this, the question is whether vertebral centra can be used for understanding taxonomy, growth, ecology, physiology and locomotion. One case study from Greenland uses the height, length and width of ichthyosaur vertebrae for assignment to vertebral region, and taxonomic status. A second example maps histology and microstructure in Triassic ichthyosaur vertebrae compared to three species of modern odontocetes. This is used to discuss possibilities and limitations for using vertebral data, and what is actually recorded in the structures of these bones.

Polar terrestrial ecosystems from the Upper Cretaceous (Campanian) Prince Creek Formation of northern Alaska: progress and future directions.

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The Upper Cretaceous Prince Creek Formation (PCF) of northern Alaska is among the most important units for understanding polar terrestrial ecosystems in the Mesozoic. The formation preserves a rich body fossil assemblage of avian and non-avian dinosaurs, mammals, and fishes as well vertebrate ichnofossils. The PCF is a tidally influenced continental succession deposited on a low gradient coastal/alluvial plain. New U-Pb zircon geochronology using the high-precision CA -ID-TIMS method constrain deposition of the fossiliferous portions of the PCF to the late Campanian (72.9 Ma to 72.8 Ma)— nearly 4 million years older than previously reported. Significantly, it was deposited at the northernmost extremes of North America, well above the palaeo-Arctic Circle at ~80°–85° N palaeolatitude. Palaeoclimate proxies suggest a mean annual temperature of ~6 °C and a cold month mean of -2 °C, suggesting freezing winter conditions, including snow.

By virtue of its geographic location and climatic extremes, the PCF provides key faunal and floristic data necessary to test broader questions regarding dinosaur physiology and migration, faunal provinciality and the evolution of modern polar ecosystems. Recent discoveries, particularly from newly discovered microvertebrate localities, greatly expand the taxonomic richness of PCF vertebrates. Among fishes we recognize a dominance of teleosts, including several esocoids, an acanthomorph, and the oldest record of Salmonidae. Although only four taxa have been formally named, the PCF preserves the northernmost dinosaurs known, including two hadrosaurids (*Ugrunaaluk kuukpikensis* and a lambeosaurine), two thescelosaurids, the ceratopsid *Pachyrhinosaurus perotorum*, an undescribed leptoceratopsid, and the pachycephalosaurid *Alaskacephale gangloffi*. Among theropods, we recognize an ornithomimosaur, two dromaeosaurids, a large-bodied troodontid, *Richardoestesia* indet., and the large tyrannosaurid *Nanuqsaurus hoglundi*. The PCF also preserves one of the most prolific records of fossil birds in North America, including at least one hesperornithine, at least one ichthyornithine, and some of the most crownward-known Cretaceous taxa. Abundant perinatal remains also indicate both avian and non-avian dinosaurs nested in polar settings. Based on dental and non-dental remains, we recognize eight mammalian taxa, including two metatherians, three multituberculates, two eutherians and a large housecat-sized taxon. However, there is a conspicuous absence of clades typical of lower latitude vertebrate microfossil assemblages, including aquatic forms such as lepisosteids and *Myledaphus* and terrestrial taxa such as crocodilians, lizards, turtles and lissamphibians. Ongoing systematic work continues to elucidate the degree of faunal endemism in the unit and test the existence of a distinct polar fauna, named the Paanaqtat Province.

Were mosasaurs as marine as commonly thought?

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In 2022, a mosasaurine tooth crown was unearthed in a freshwater mudstone bed in North Dakota's Hell Creek Formation. This find, positioned near a Crocodyliform maxilla, a shed *Tyrannosaurus* tooth, and many *Edmontosaurus* bones, challenges the assumption of mosasaurs exclusively inhabiting marine environments during the Late Maastrichtian.

Skeletal material of Mosasaurinae incertae sedis confirmed the presence of large mosasaurs in the receding Western Interior Seaway, but these came from the marine Breien Member. The shed mosasaurine tooth, however, was found in a freshwater deposit without signs of long-distance transport or reworking from older marine deposits, approximately 1.6 kilometres west of where the skeletal material was previously collected.

Laterally compressed with carinae lacking serrations, the tooth, with its rugose enamel texture aligns morphologically with *Prognathodon*, suggesting a unique instance of a mosasaur in a freshwater riverine environment. Stable carbon, and oxygen, as well as strontium isotope analyses will unveil migrational patterns between freshwater, brackish, and marine environments and ultimately reveal whether some mosasaurs entered freshwater environments persistently.

This comprehensive approach aims to provide insights into the mosasaur's behaviour, ecology, and migratory patterns beyond known marine habitats, enhancing our understanding of their adaptation to changing environments. The isotopic composition of structurally bound carbonate ($\delta^{13}C$ and $\delta^{18}O_{sc}$), and phosphate ($\delta^{18}O_p$) and $^{87}Sr/^{86}Sr$ point to meteoric continental aquatic conditions for this mosasaur. These values are more consistent with those of dinosaur remains from the Hell Creek than with the values measured from mosasaurian and other archosaurian teeth from the marine Breien Member or the marine Fox Hills Formation. Further analyses will reveal to which degree diagenetic alteration may have affected these isotopic signatures.

The discovery of a mosasaurine tooth in a freshwater riverine environment challenges traditional assumptions about mosasaur habitat preferences, suggesting a previously unrecognized level of ecological versatility. Through the application of isotopic analyses, this study not only sheds light on the migratory behaviours of these ancient marine reptiles but also highlights the importance of reevaluating established paradigms in paleontological research. These findings offer a glimpse into the interactions between mosasaurs and their changing environments, enriching our understanding of their evolutionary history.

The origin of the modern lungfish: a derived tooth plate from the Famennian of Morocco blurs lungfish evolution across the Devonian-Carboniferous boundary.

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Lungfishes are an extant clade of lobe-finned fishes that evolved in the earliest Devonian, and reached a peak of diversity during this period. Following the end-Devonian mass extinction, it was thought that lungfishes had suffered a great loss in diversity, with very few taxa surviving into the Early Carboniferous, much like other sarcopterygian groups. Palaeozoic lungfishes were long classified as two distinct phylogenetic entities across the Hangenberg event: Devonian lungfishes, considered as the “primitive” group, and post-Devonian lungfishes, from which the crown group stems. This distinction is based on a number of characters of cranial elements, as well as tooth plate morphology. Notably, while the former group shows an incredible diversity of tooth plate forms, the latter shifts to a more uniform morphotype with fewer and sharper ridges, and fused tooth cusps, which is what we see in modern lungfishes. These morphogroups apparently occurred exclusively in the Devonian and after the Devonian respectively, supporting the idea that this large-scale loss of

diversity was caused by the Hangenberg event. Recent work on Late Devonian and Early Carboniferous material challenges this idea and suggests there was a significant amount of overlap across the boundary. New material shows some Late Devonian taxa bore derived traits, characteristic of Early Carboniferous groups. Here we describe a tooth plate from the Famennian of Morocco showing highly derived features akin to those of Carboniferous sagenodontids, and never before seen in any Devonian taxa. This is only the fourth known instance of a Devonian lungfish from the African continent, and the only one with such a derived morphology. This find strongly supports the current hypothesis that many Carboniferous forms may have deep roots in the Devonian, suggesting lungfishes were not as strongly affected by the Hangenberg event as other sarcopterygian groups, and that their evolution across this boundary was much more flexible than previously though.

Shortening the neck of *Graamocetus longicollis* (Mammalia: Delphinida).

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Gram Claypit (Late Miocene, Gram Formation) in Southern Jutland, Denmark is known for a rich marine fossil assemblage, including almost complete skeletons of whales and a total of 11 known marine mammal species. One of these is a small odontocete whale *Graamocetus longicollis*. Small toothed whales are known from more than 40 individual collection events, but only from relatively fragmentary remains. This is also true for the holotype of *G. longicollis* that consists of only five small vertebrae with incomplete processes. When described, these were interpreted to be the posterior five cervical vertebrae and due to their robustness and length, the specimen was considered to have a long and mobile neck. Consequently, it was interpreted as "a coastal, lagoonal/estuarine delphinoid that occasionally may have ventured up the rivers" when described.

Here the relative position of the vertebrae is reinterpreted to be placed further back in the vertebral column. The lack of parapophyses and the robustness and elongation of the centra are considered indicators of a more posterior position, rather than apomorphic and diagnostic characters for the species. Anterior thoracic vertebrae in other members of Delphinida are also more commonly wider than high which is the case for the five vertebrae of *G. longicollis*. The anterior-most vertebra of the type specimen is more likely either C7 or T1. Following this interpretation there is no indication that *G. longicollis* had a particularly long or mobile neck, or that it occupied a near-shore or riverine habitat.

Following this interpretation, an emended diagnosis for *G. longicollis* is needed. The centra of the five vertebrae are f.ex. exceptionally wide (with/height proportion is about 1,5). The vertebrae are relatively small while completely ossified, and therefore likely originating from an adult specimen of a small species.

Although the type material is scarce, it cannot currently be ruled out, that more complete material can be referred to this species in the future and the name must therefore remain valid. Other fragmentary but potentially more diagnostic specimens of small odontocetes, like periotics and bullae, may shed new light on the small odontocete fauna from Gram.

Indarctos anthracitis: Dietary ecology and insularism in an enigmatic Late Miocene bear

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The uppermost Miocene sedimentary record from the Italian peri-Tyrrhenian areas, specifically Tuscany and Sardinia, reveals the occurrence of a distinctive and unique paleobiogeographic region. This region stands out for its peculiar vertebrate ecosystem, displaying endemic features that differentiate it from the contemporaneous mammal faunas of Europe and Africa and are commonly known as the Tusco-Sardinian paleobioprovince. The occurrence of fossil carnivores in insular ecosystems, apart from rare cases, is predominantly constituted by otters, whereas other carnivores are generally absent from endemic

insular faunas. The Baccinello-Cinigiano Basin fauna represents an exception to this rule due to the occurrence of the endemic bear *Indarctos anthracitis*. This occurrence represents a uniqueness in the fossil record as insular records of bears are lacking in the fossil record (especially this old). Here, we revise and describe in detail all the material attributed to *I. anthracitis*. In the late Miocene, *Indarctos* has been reported in Eurasia, Northern Africa and North America. The taxonomy of the genus Indarctos has been revised several times but there is not a full consensus about their phylogenetic relationships. The results of comparative morphological and morphometric analyses allow us to reaffirm the distinction of this taxon from the other *Indarctos* species. *Indarctos anthracitis* probably originated from *Indarctos atticus*, a large sized species with Eurasian distribution, and went towards size reduction as a result of evolution in an impoverished and unbalanced insular environment. This partially disagrees with what is seen in modern populations of bears confined on islands, which are usually characterized by similar (or even larger) size. A preliminary study of the dental microwear, despite the small sample size, allows us to hypothesize the dietary ecology of this endemic carnivore and better clarify how this enigmatic bear survived in an impoverished environment.

New insights into *Sinohelicoprion qomolangma* (Chondrichthyes, Euchondrocephali) from the Tibetan Plateau based on micro-CT data.

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The symphyseal tooth-whorl of Eugeneodontiformes (Chondrichthyes, Euchondrocephali) are among the most peculiar dentitions in vertebrates, garnering widespread attention from both the public and the academic community. Examples include *Helicoprion* and *Edestus*. However, some other groups within Eugeneodontiformes have received insufficient attention. *Sinohelicoprion* (Eugeneodontiformes, Edestoidea) includes six published specimens excavated from China and North America, ranging from Early Permian to Early Triassic in age. *Sinohelicoprion qomolangma* Chang, 1976 was discovered in an Early Triassic fossil site near Mount Qomolangma (also known as Mount Everest). The specimens of *S. qomolangma* include a segment of symphyseal tooth-whorl and a three-dimensionally preserved preorbital portion of chondrocranium, which is relatively rare among fossil records of cartilaginous fish. Only surface morphology and polished cross-sections were described in the initial report in 1976. Here, we present a redescription of *S. qomolangma* based on micro-CT scans. We reconstruct the complete external morphology of the tooth-whorl and the three-dimensional micro-anatomy of separated crowns and the unsegmented root, elucidating the development pattern of tooth addition. Several lateral teeth embedded in the surrounding matrix have been identified and extracted from the scanning data. Furthermore, we reconstructed the three-dimensional morphology of the partially preserved rostrum and nasal capsules, while also studying the histological characteristics of calcified cartilage through virtual thin sectioning. Additionally, we report an unpublished specimen of *Sinohelicoprion changhsingensis*, exhibiting possible use-related failure in the tooth crowns and so testing recent hypotheses about the orientation and function of the tooth-whorl. Taken together, these findings provide new data on the morphological, histological and functional diversity of Eugeneodontiformes.

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Ichthyosaur metabolism: First results.

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Ichthyosaurs were tuna-shaped marine reptiles which ruled the oceans during the Mesozoic era. These wonderful organisms stimulated palaeontological research for almost two centuries now. However, we are far away from understanding their biology and evolutionary history as com-

pletely as other major Mesozoic groups. While paleophysiological studies were growing these last two decades, ichthyosaurs were pretty much ignored by them. However, there is evidence they were fast growing, and potentially endothermic organisms, based on their osteohistology and on isotopic studies. Nevertheless, this assumption should be formally tested using quantitative methods to establish clearly what was their metabolic regime.

We present here preliminary results based on the study of three genera: †*Mixosaurus*, †I*chthyosaurus*, and †*Stenopterygius*. For each of them, thin sections of their humeri were studied and several variables, such as the harmonic mean of their vascular canals and the relative primary osteons area were quantified. These data were incorporated in models based on extant amniotes and using phylogenetic comparative methods to infer the value and associated confidence interval of two metabolic parameters: the resting metabolic rate and the mean corpuscular volume of their erythrocytes, both being highly linked to metabolism.

These first results gave us insight into the putative metabolism of ichthyosaurs. But it needs to be expanded to represent more their extinct diversity and possible future expansions will be presented and discussed in this talk.

A monofenestratan pterosaur from the late Early Jurassic of the Chubut province of Patagonia, Argentina.

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Pterosaurs, the first actively flying vertebrates, first appeared in the Late Triassic and developed a global distribution, with an equally-staggering geochronologic range from the Triassic through to the end of the Cretaceous. However, a notable gap occurs in the evolutionary history of the Pterosauria during the Early-Middle Jurassic, largely due to an absence of available exposures, coupled with the poor preservation potential of pterosaur bones due to their physical fragility. While known fossil-bearing localities within Argentina encompass the early Middle Jurassic to the Late Cretaceous (Turonian–Coniacian), over approximately 85ma, most of their pterosaur notoriety comes from the Northern (Cretaceous) region of the country, where abundant assemblages have yielded numerous fossils. The Chubut region of Patagonia is much less prolific for pterosaurs than northern Argentina, but is especially significant for its older age, and with recent ongoing collection efforts over the past few years substantially increasing, its pterosaur fossil representation has also proliferated. Here, a new pterosaur taxon, represented by a partial skull and associated post-cranial elements, is reported on from the Early Jurassic (Toarcian) locality of Queso Rallado, within the Cañadón Asfalto Formation. The skull shows a single, undivided large opening anterior to the orbit and can thus be referred to the Monofenestrata. This is the second and oldest Gondwanan pterosaur occurrence for this clade, increasing the known taxon diversity for this rare group and region during the late Early to early Middle Jurassic. Furthermore, the new material represents the oldest record of the Monofenestrata globally and helps to shed critical light on the evolutionary processes undergone during the "rhamphorhynchoid" (non-pterodactyloid)-to-pterodactyloid transition for the Pterosauria.

Ecological recovery in the early Mesozoic in low-latitude continental vertebrate assemblages.

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Geographic and stratigraphic gaps in the fossil record obscure the patterns of recovery and diversification of ecosystems following the Permian-Triassic Mass Extinction, especially at low latitudes. Here we address this issue by presenting new data from the Triassic terrestrial vertebrate records from the western United States. To begin with, we reviewed the vertebrate faunas of the Moenkopi Formation (Middle Triassic, Anisian)—the oldest exposed Mesozoic geological unit—based on newly collected macro and microfossil assemblage from Arizona. Although we

record numerous new occurrences, our study confirms the lower diversity of Anisian ecosystems compared to those of younger stages. To track whether taxonomic diversity translates into ecological diversity, we developed a new trait-based approach that we applied to a high-detailed succession of vertebrate occurrences in Arizona, and lateral equivalents in New Mexico and Texas. We integrated unpublished fieldwork and museum collection data with literature searches and incorporated entries that are often ignored in palaeoecological studies (e.g., microfossils, indeterminate specimens). Each of the over 500 taxonomic entries entry was scored for five functional traits (i.e., diet, locomotion, habitat, growth, body size) that together describe their ecological role in the ecosystem. We assessed the functional properties of each assemblage and their variation over time using a multivariate approach borrowed from modern ecology. Results show that taxonomic and ecological richness are low in the Middle Triassic (Arizona and New Mexico), and increase through the Upper Triassic with a steady increase through the Carnian (of Texas), and peak in the early Norian (in Arizona, New Mexico and Texas). The patterns are maintained even following the removal of small bodied-taxa as a test for sampling biases. While certain ecological roles are stable through time (i.e., large land carnivore and aquatic predator roles are consistently occupied by pseudosuchian and temnospondyls), the diversification of herbivore and semi-aquatic pseudosuchians (i.e., aetosarus and phytosaurs), as well as the radiation of avemetatarsalians (i.e., pterosauromorphs and dinosauromorphs) account for the increase of ecological diversity by the appearance of new long-lived ecological modes through the interval.

The evolution of the early Archosauromorph brain.

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Over their 250-million-year history, archosaurs underwent major evolutionary radiations and adapted to changing environments, ecological niches, and novel behaviors. As they evolved, archosaurian brains developed incredibly disparate forms, including independent occurrences of extremely enlarged forebrains in avians and pterosaurs, the only other aerial reptile clade. In contrast, crocodile-line archosaurs show linearized and elongated brains. A potential connection between proportional development of regionally restricted brain components and the importance of their relative behavioral and ecological functions has been an area of study for decades. However, whereas much attention has gone towards bird-line archosaurians including dinosaurs, little is known about the origin of the archosauromorph brain bauplan. Exploring the early archosauromorph brain is therefore critical for understanding archosaurian brain diversity and evolutionary trajectories. This research explores the morphological bauplan of early archosauromorphs via 3D geometric morphometrics on brain endocasts. Preliminary data reveal significant phylogenetic signal in endocranial shape, separating dinosaurs from non-dinosaurian archosauromorphs, while suggesting a relatively conserved endocast morphology within stem Archosauromorpha. Time of occurrence does not show clear correlation with endocranial shape, whereas diet is recovered as a major driving factor for endocranial variance, separating herbivorous from animalivorous taxa throughout all archosauromorph clades. Our results support previous hypotheses on the effect of diet and lifestyle on endocast morphology in archosauromorphs and provide new information and insight into the origin of the archosauromorph brain bauplan.

Jaw muscle dimensions in extant and extinct lizards.

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The arrangement of muscles in vertebrates is determined by the size of the bones and the available area of insertion for each muscle. But how does the musculature system adapt as the animal becomes larger? Since the surface area of the muscle insertions increases in two dimensions, it must provide enough space for a more rapid

increase in muscle volume, as muscles grow cubically. To comprehend this evolutionary effect, we use the insular lizards of the genus *Gallotia* as a case study, whose morphological variability is helpful in establishing a relationship between the cranial muscle distribution and the area of the skull, since *Gallotia* species display a significant size range. This genus includes nine lizard species from the Canary Archipelago, including seven living species as well as two extinct ones. This allows a detailed study of the living taxa and their environmental context, and the extrapolation of this information to the fossils. Here we describe the procedures used to create an accurate model of the cranial anatomy of the fossil taxa, including detailed muscle morphology, to better analyse the square-cube law in the largest members of *Gallotia*. Two methods were used: firstly, the dissection of various specimens to observe the organisation between the cranial muscle distribution and the corresponding insertion areas upon bones of the skull in living species, and secondly, the 3D reconstruction of the cranial muscles based on microCT technology. Thirteen 3D reconstructions were generated for extant taxa with the Blender add-on MyoGenerator, allowing the calculation of Physiological Cross-Sectional Area (PCSA), a parameter directly related to the maximum force a muscle can generate. These reconstructions were then used to reconstruct the adductor muscles of the two extinct species, *Gallotia goliath* and *Gallotia auaritae*. After completing the reconstructions and dissections, we identified a pattern in larger individuals where groups of muscles tend to merge to compensate for limited space upon the surface of skull bones. This observed phenomenon suggests a limited muscle growth, likely present in the largest species of the genus including the fossil ones. The PCSA results support a correlation between body size and cranial muscle dimensions. This information, along with the resulting models, will serve as the basis for further studies using finite element analysis (FEA) and musculoskeletal analysis to predict how fossil taxa would respond to different biomechanical loadings.

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What does vertebral morphology tell us about the taxonomy and diversity of the Paleogene snakes from Europe?

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Snakes achieved a spectacular diversity during the Paleogene of Europe, particularly across the Eocene epoch, witnessing a plethora of sizes, shapes, locomotion strategies, functional morphologies, and dermal and skeletal features. The vast majority of the snake fossil record is represented by isolated vertebrae and as a result, the taxonomy of extinct snakes is heavily based on vertebral features. The Paleogene European snake diversity encompassed an array of taxa, most of which are known exclusively upon vertebral material and many of which are of totally unclear systematic and phylogenetic relationships. Such taxonomic uncertainty is further hindered by the fact that many of these enigmatic taxa were originally described in the 19th century and have never since been comprehensively figured and documented. Recently, new and ongoing revisions of this historic material provide novel insights and clarifications about the anatomy and taxonomic status of some of these historic taxa. Moreover, abundant new vertebrae, originating from several Eocene and Oligocene localities, decipher novel insights into the anatomy and variation, whereas the identification of new taxa among this new material provides more accurate implications of the past ophidian diversity. Most importantly though, it is the proper knowledge of the vertebral morphology of extant snakes that can afford some more

secure conclusions about the affinities and identifications of fossil vertebrae: this can only be done through a thorough investigation of the “extreme” intracolumnar variation of snake vertebrae (across multiple taxa), aided also by novel, non-invasive technologies, such as micro-computed tomography (μCT) scanning, which will eventually lead to a more proper assessment of the diagnostic features of snake vertebrae and have direct and valuable applications to ophidian palaeontology.

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High theropod track diversity from the Chacarilla Formation of the Quebrada de Arcas in NE Chile.

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We present an updated dinosaur track record from the Chacarilla Formation (Jurassic-Cretaceous boundary) in the Quebrada de Arcas (NE Chile). 94 new tracks, and unidentified tracks in cross section were found in a succession of alluvial siltstone and fine sandstone, that were deposited in an alluvial plane. Track-bearing surfaces were studied with 3D modelling and false-colour depth maps, derived from UAV pictures. A total of 5 different morphotypes are described. The distinction was made not only on a morphological basis but also on a morphometrical one ("FL/FW vs. AT l/W" plots). Morphotype I groups all the sauropod track because of their poor preservation quality. Trackways shows a consistent narrow-gauge and resemble *Parabrontopodus*. Diplodocids or small titanosaurids are the most probable trackmaker. The remaining four are attributable to large to small-sized theropods. Morphotype II is one of the largest theropod tracks recorded from South America (max FL 51cm). There is a clear affinity with *Abelichnus*, which was previously identified in the Chacarilla Fm. in Quebrada Chacarilla (further north). However, the ichnotaxon *Abelichnus* is in dire need for a revision. The trackmaker of this ichnotaxon is most likely a carchadontosaurid. Evident metatarsal impression is a distinctive feature of Morphotype III that shares morphometrical affinities with *Changpeipus carbonicus* but must remain indeterminate because there are no clear morphological similarities with other coeval ichnotaxa that have metatarsal impression. Morphotype IV and Morphotype V belong to a small-sized tridactyl, likely theropod, trackmakers. Both tracks morphometrically fit respectively within the groups Grallatoridae and *Kayentapus*-like forms. An identification of potential trackmakers couldn't go too far due to the medium-poor morphological quality of the footprints. Despite this, three distinct sizes (small, medium and large) are recognisable from the theropod's morphotypes indicating a high diversity at the J-K boundary in arid Gondwana environments.

Endocranial anatomy of *Olivierosuchus parringtoni* (Synapsida, Therocephalia).

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Therocephalians represent one of the major lineages of Permian-Triassic non-mammalian therapsids, surviving the end-Permian mass extinction. Among Therapsida, they are most closely related to Cynodontia, the clade including mammals, which is derived from within Therocephalia, rendering the latter paraphyletic. Despite their importance, abundance, broad geographic distribution and species richness, therocephalians are significantly under-studied. Here, we provide a detailed and comprehensive restudy of the holotype of the therocephalian *Olivierosuchus parringtoni* (BP/1/3849) from the Early Triassic *Lystrosaurus declivis* Assemblage Zone of the main Karoo Basin of South Africa. The specimen consists of a complete skull, mandible, and the anterior portion of the skeleton. By using a computed tomographic (CT) reconstruction, we provide novel information on its endocranial anatomy, including soft tissue structures such as the brain and inner ear endocasts.

Comparisons with closely related therapsid taxa permit a broader understanding of character variability within Therocephalia and other therapsid lineages, also in the light of evolutionary events, such as the end-Permian mass extinction. The inner ear endocast reveals a combination of primitive and derived features described for non-mammalian therapsids. Of particular note is the absence of a cochlear recess as in most non-cynodont therapsids with described inner ears. The fenestra vestibuli faces laterally from the vestibule, a condition that has otherwise only been described for cynodonts. The brain endocast generally displays the plesiomorphic morphology described for most non-probainognathian therapsids in having relatively narrow olfactory bulbs (compared with mammals), an elongated and tubular forebrain, and a hindbrain, which appears shorter and wider than the forebrain region. Hence, the concept of neurological conservatism in basal therapsids is supported. Moreover, the synapsid encephalization quotient (EQS) was calculated, which ranges at the low value of EQS = 0,87. A survey of late Permian and Early Triassic synapsids show no relation between brain size and survival across the end-Permian mass extinction event, indicating that enhanced behavioral plasticity associated with larger brain sizes was no factor for survival. As ancestors to modern mammals, understanding morphological adaptations and evolutionary trends within Therocephalia can enlighten our understanding of evolutionary processes at the mammalian base, especially with regard to patterns of survival and adaptation across events like the end-Permian mass extinction. Therefore, an increased taxon sampling is necessary, to which this study provides an important contribution.

New northernmost occurrence of Miocene crocodiles in Central Europe extends the global geographic range of this group.

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Crocodiles have inhabited tropical and warm temperate zones throughout their evolutionary history, which makes them good palaeoclimate indicators. Here we describe Early to Middle Miocene crocodile remains from three localities: Židlochovice in Czechia, and Pińczów and Szczerców in Poland. Two of them are new occurrences and one is redescribed herein. All are tentatively assigned to *Diplocynodon*, including one specimen previously misidentified as *Tomistoma*. *Diplocynodon* was a basal alligatoroid that could reach about 1.5 m in length. This taxon was never reported from Poland before. Szczerców was located approximately 47° N in the Miocene which makes it the northernmost known occurrence of any crocodile in the whole Neogene. This indicates that increased temperatures during the Middle Miocene Climatic Optimum enabled expansion of crocodiles north of the Paratethys coasts.

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Tooth wear and histology of Devonian chondrichthyans from Morocco provide insights into feeding behavior and tooth development.

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A characteristic feature of modern sharks (neoselachians) is a fast tooth replacement rate combined with a highly differentiated tooth mineralogy. A combination of these features enabled sharks to develop a great variety of lifestyles and feeding strategies. In comparison, the tooth replacement rate in early chondrichthyans (early branching elasmobranchs) is evidently much slower including teeth being retained instead of being quickly shed in some taxa. Tooth wear analysis on the large Devonian chondrichthyan *Ctenacanthus concinnus* support a long-term functionality of these teeth. By combining Dental Microwear Texture Analysis (DMTA), Finite Element Analysis (FEA), and palaeoecological

information, we conclude that *C. concinnus* most likely was an opportunistic macrophagous feeder, using horizontal head shaking movements similar to modern sharks to cut larger prey items. This behavious was not possible for species whose cusps were conical rather than carrying blade-like edges. The teeth of *C. concinnus* as well as other chondrichthyans withstand extreme loads during feeding. Accordingly, strong usage, breakage, and loss of teeth is not uncommon. Therefore, establishment of a fast tooth replacement rate is a key component of elasmobranch evolution. This was enabled by a series of developmental changes that allowed tooth stability to be maintained or even increased. Tooth histology plays an important role in chondrichthyan evolution. Histological thin sections of three different taxa from the Devonian of Morocco give insights into the microstructure of early chondrichthyan teeth. These specimens preserve tooth files in situ and allow us to study histological development. The teeth confirm the pseudoosteodont histotype, which lacks a hollow pulp cavity at any developmental state and preserves a layer of single crystallized enameloid capping an orthodentine layer. As in neoselachians, the outermost enameloid layer mineralizes first, and the inner portions of the tooth mineralize later in development. While in neoselachians the enameloid is triple layered. The Devonian teeth from Morocco show the primitive state.

New discoveries from the Middle Triassic locality La Mora, northeastern Spain.

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La Mora, an early−to−middle Anisian (early Middle Triassic) site in the Catalan Basin, northeastern Spain, has yielded an abundance of tetrapod fossils and is one of the most important localities from this time period on the Iberian Peninsula. The site was discovered in 1989 and has been excavated during four field seasons: 1990, 2008, 2010, and 2023. Stratigraphically, La Mora is situated within the upper Bundsandstein facies, which is comprised of interbedded sandstones and mudstones interpreted as channel and overbank deposits, respectively, of ephemeral, braided streams. Body fossils from the site are dominated by capitosaur temnospondyls, with procolophonids and archosauromorphs also present. Tetrapod ichnites recovered close to the site include the ichnogenera *Rhynchosauroides*, *Chirotherium*, and *Synaptichnium*. Here we present new discoveries stemming from the most recent excavations at La Mora. These include a new trackway attributed to *Capitosauroides* isp., and a tubular structure up to 28 cm long, 19 cm wide, and 7 cm high, which we interpret as a tunnel section from a tetrapod burrow based on its size, morphology, and the presence of scratch-marks on the ventral surface and side walls. This represents the first reported Triassic tetrapod burrow cast from the Iberian Peninsula. The burrow cast bears similarities with other burrow casts reported from similar aged deposits elsewhere in the world and potential tracemakers for the burrow include cynodont therapsids and procolophonid reptiles. The latter is preferred, however, since procolophonid body fossils of suitable size have also been recovered from La Mora.

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Paleontological data analysis with Past.

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Past is a user-friendly, free, and widely cited app suitable for all kinds of paleontological data analysis, including general statistics and plotting, morphometrics, paleoecology, biostratigraphy, and

systematics. In this workshop, the author of Past will demonstrate it with examples. Bring your laptop, if you have one! And if you have a data set that we can try, then contact me beforehand! There will be sweets served, and maybe some cheap Past merchandise!
https://www.nhm.uio.no/english/research/resources/past/

Discovery of an additional remain belonging to the holotype of *Micromysticetus tobieni* (Cetacea: Mysticeti) from the upper Oligocene of Germany.

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The posterior portion of the skull of *Micromysticetus tobieni*, initially decribed as "*Cetotheriopsis*" *tobieni* by Rothauen (1971), was once discovered in a commercial gravel pit in the neighbourhood of Düsseldorf in federal state North Rhine-Westphalia. For many years, another cranial fragment remained unidentified in a still unprepared nodule from this site. It turned out that the nodule contains another piece of the same cranium, namely the following anterior portion including the partially broken supraorbital processes. Still, *Micromysticetus tobieni* from the Chattian North Sea basin represents the earliest and northernmost occurrence of a very probable toothless mysticete so far.
Rothausen (1971) recognized close relationship to *Cetotheriopsis lintianus* from the Austrian Paratethys deposits and besides ancestral characters also derived characters such as the stage of telescoping process and the development of the air sinus system of the pterygoids in the otic region which lead to more modern mysticetes and less to the hitherto known toothed forms. In their evaluation of 2002, Sanders and Barnes considered *Micromysticetus tobieni* as belonging to the Cetotheriidae before Geisler and Sanders (2003) stated an affiliation with the Eomysticetoidea. Boessenecker and Fordyce (2014) in the following classified *Micromysticetus* as a possible eomysticetid, and in their comprehensive phylogeny of 2015 the American representative *Micromysticetus rothauseni* was grouped within the Eomysticetidae. In a new investigation, a membership of *Micromystictus* within the Eomysticetidae is confirmed. Comparisons with close relatives such as the North American (NW Atlantic) and New Zealand (SW Pacific) eomysticetids plus *Yamatocetus* from Japan (NW Pacific) reveals closest relationship with *Micromysticetus* and *Eomysticetus* from North Carolina and *Waharoa ruwhenua* from New Zealand.
Fossil cetaceans relatively remains are rare in the Oligocene. Only *Micromysticetus tobieni* and five primitive odontocetes are known from the North Sea basin and *Cetotheriopsis lintianus* and eight determinable odontocetes from the Paratethys, predominantly the Linz sands, of Chattian age. One reason for this situation may have been a generally low diversity and dispersal in the North Atlantic and adjacent oceanic basins or lie in the preservation biases. During the Chattian the Fish Canyon supervolcano eruption in North America, which is considered to be the second most energetic event to have occurred on Earth since the Cretaceous–Palaeogene extinction event likewise might have affected life and evolution of the marine mammals at that time.

Reconstructing energetically optimal walking speeds of Tendaguru sauropods: Is the tail natural frequency informative?

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Tails played an important role in the locomotion of non-avian dinosaurs. However, most biomechanical models have neglected the tail entirely or simplified it to a single rigid structure. Sauropods exhibit a wide variety of tail morphologies, ranging from shorter, more robust forms as in brachiosaurids to extremely elongated and whip-like tails as in diplodocids. However, how different tail morphologies affect the locomotion, locomotor energetics, and gait kinematics of sauropods is mostly unexplored. The Late Jurassic Tendaguru Formation in Tanzania, southeastern Africa, hosts

a rich sauropod fauna with diverse tail morphologies, making it a prime candidate for studying how tail morphology influences sauropod locomotion. One of the functions of the tail is to store elastic energy, which can be optimized by selecting gait kinematics tuned to its natural frequency. Recent work on *Tyrannosaurus rex* as shown that this principle can be used to estimate the energetically optimal step frequency of bipedal dinosaurs and infer their preferred walking speed in an approach termed the Natural Frequency Method. It is assumed that sauropods traveled long distances while foraging. Given their enormous body masses, the selection of the energetically optimal walking speed was presumably of particular importance. Here, we will apply the Natural Frequency Method to estimate energetically optimal step frequencies and walking speeds of Tendaguru sauropods. For that, we will construct spring-suspended biomechanical models, based on volumetric musculoskeletal and ligamentous reconstructions of sauropod tails. Tail function in bipedal dinosaurs has been well researched. This analysis may enable us to quantify the relative importance of tail elastic storage in quadrupedal dinosaurs, where its effects remain largely unknown. These may include new insights into how sauropods managed long-distance foraging migrations and how long these migrations lasted. In addition, it may reveal whether some tail morphologies are better adapted to long-distance travel.

Growth in alligators and caimans informed by osteohistology of the Eocene alligatoroid *Diplocynodon hantoniensis.*

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Among living crocodylians, alligatoroids exhibit a wide range of body sizes and a biogeographic distribution that spans tropical to temperate climates. The fossil record of alligatoroids shows even greater variation, with multiple examples of gigantism and a more extensive latitudinal distribution. Osteohistological studies on extant alligatoroids show that living alligators and caimans both exhibit seasonal growth, with roughly comparable growth rates. However, the dearth of studies on extinct alligatoroids makes it unclear if this shared condition indicates convergent responses to changing climate or represents 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. In addition to qualitative descriptions, we quantitatively reconstruct growth rates and allometry. The microanatomy of *D. hantoniensis* shows moderate bone compactness, with a well-defined medullary cavity, and histologic features that are consistent with those of extant alligatoroids. In all samples, the endosteal tissue is lamellar and periosteal tissue is dominated by parallel-fibered bone. However, samples vary greatly in the degree of remodeling and vascularity, as well as preserving features such as Sharpey's fibers, highlighting the importance of studies on intraspecific variation. Our ontogenetic assessment indicates our sample captures a range of skeletally immature to mature individuals roughly related to femur size. We find that body size estimates for *D. hantoniensis* fall within the typical range of living American alligators. Femoral circumference scales positively with femoral length in *D. hantoniensis* ($p = 0.02$), demonstrating similar allometry to *Alligator mississippiensis*. This differs from other extant Crocodylians (e.g., *Crocodylus*, *Caiman*), which suggests that *D. hantoniensis and A. mississippiensis* experienced similar terrestrial loading and, therefore, locomotor habits. 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 and matches what limited data is already available for extinct alligatoroids.

Mosasaur feeding ecology in the Bearpaw Formation, Alberta, Canada: The final chapter.

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The Campanian Bearpaw Fm. (~80–75 Ma) deposits of southern Alberta host a score of large marine predatory reptiles: mosasaurs (typically *Mosasaurus missouriensis*, *Tylosaurus* ?*proriger*, *Prognathodon overtoni*, and *Plioplatecarpus primaevus*), elasmosaurs, and turtles. Other vertebrate inhabitants confirmed from the Bearpaw Sea are sharks, sawfish, other predatory fish like *Enchodus*. Finally, invertebrates such as lobsters, ammonites, and bivalves have been recovered from the Bearpaw deposits, constituting a rich marine ecosystem. As such, with most material coming from two adjacent ammolite mines, and therefore most fossils originating from the same strata, it is the ideal case setting for palaeoecological reconstructions on feeding behaviour and foodweb reconstruction Previously, microwear, energy-dispersive X-ray spectroscopy analysis, and isotope pilot studies were used to demonstrate a clear case of niche partitioning amongst the large marine predators. In particular, the EDX based Sr/Ca Ba/Ca principal component analysis made a clear distinction between *Prognathodon* and durophagous, bottom-feeding sawfish on one end of the spectrum, and *Plioplatecarpus* with sharks and elasmosaurs on the other end, and *Mosasaurus* overlapping with all.
However, based on new isotope analysis, the $\delta^{18}O$ range (indicative of salinity and temperature of the seawater), and $^{87}Sr/^{86}Sr$ isotopes (indicative of different soil input, and therefore of nearshore and offshore conditions), habitat partitioning, and not necessarily niche partitioning emerges as the differentiating factor in the mosasaurs' diet. *Prognathodon* shows the largest range of all mosasaurs in both oxygen and strontium isotopes, indicating migration, followed by *Plioplatecarpus*. Lower-latitude platecarpines have been shown in other studies to migrate between fresh and saltwater environments, and this current study confirms this behaviour also in higher-latitude ones. However, this behaviour is now also proposed for *Prognathodon*. The $\delta^{18}O$ range of marine turtles seems equally wide. Interestingly, *Mosasaurus* shows a narrower range, and *Tylosaurus* shows an equally narrow, but decidedly offset range of values from all other mosasaurs. *Tylosaurus* is overlapping with ammonites and turtles, showing a possible preference for foraging in the upper water column. This study shows that perhaps mosasaurs minimized competition for resources by preferring different water depths for foraging and that others, like *Prognathodon*, foraged between offshore and nearshore. This latter conclusion is backed up by dental microwear texture analysis of type-Maastrichtian *Prognathodon*s, indicating feeding on soft invertebrates found in shallower, near-shore conditions.

Funding 20 years of Arctic excavations through outreach.

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Few topics in science are more dependent on chance discovery than paleontology.
Svalbard is a Norwegian Archipelago located in the high Arctic. In 2003, I received a report from students at the University Centre in Svalbard (UNiS) who had uncovered a neck and front paddle from a Jurassic plesiosaur. In 2004, paleontologists from the Natural History Museum in Oslo (NHMO) and volunteers excavated the specimen. This lucky find turned out to be just one of eleven skeletons scattered on the hillside, all found within three days. The media and public interest in this surprising discovery was enormous. However, obtaining "normal scientific" funding through the National Research Foundation was not an option, as marine reptiles do not cure cancer or save the climate. Despite this challenge, I was aware that everything we would find was likely new to science, but I needed many years of fieldwork to do so. This drew a comparison to Roy Chapman Andrews and his ability to attract sponsors using outreach from his Mongolian adventures. Fieldwork in a high Arctic barren landscape with polar bears, snow blizzards in the middle of summer and midnight sun is very exotic. In Norway the "polar hero" idea formed about 130 years ago is still cultivated. Public outreach with

personal stories from excavations + polar environment + skeletons of large marine reptiles were a recipe for funding.

So far, the outreach from the expeditions has funded the longest-lasting paleontological excavation program at Svalbard. The collection at NHMO is now the largest from the archipelago, with about 60 skeletons of marine reptiles from the Jurassic, thousands of invertebrates and sedimentary samples, and tons of bonebed material from the Triassic. The work has resulted in more than 60 peer-reviewed papers.

This talk offers insights into the 20 years of public outreach experience with the Spitsbergen Mesozoic Research Group, from a time before Facebook to a world with live feeds from close to the North Pole. Various strategies such as three international documentaries (NatGeo, BBC/History, ZDF), 200+ popular talks, children's books in multiple languages, blogging on the National Geographic Explorers blog, website development, 30+ popular science papers, hundreds of news articles, museum exhibits, science tourism to the excavation sites, live feeds, art shows, activity days and more have been used.

Engaging with the public during the discovery process is vastly different from the secrecy typically associated with scientific research. Most documentaries are produced retrospectively, featuring scientists as props re-enacting their discoveries. However, conducting outreach as the project unfolds serves as both a fun initiative and a strategic approach.

20 years of Arctic excavations and research – Spitsbergen Mesozoic Research Group (SMRG).

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A group of students and a teacher from the University Studies at Svalbard (UNIS) would often use the Janusfjellet hillside for excursions, and in 2001, they stumbled upon a partial skeleton. This find was showcased as an example in 2002 and 2003, but unfortunately, it began to deteriorate. JHH got a tip about the discovery in 2003 and the idea about excavations started to form. In the summary that follows, we will only focus on the main discoveries made each year and the main expeditions. Several expeditions were also undertaken in cooperation with other research groups.

In 2004, we celebrated the 10th anniversary of the Paleontological Friends of the museum (PalVenn) and decided to visit Svalbard to examine the site where the bones were found. A team of amateur collectors and paleontologists discovered not just the previously found skeleton, but also an additional ten skeletons on the same hillside. While a few specimens were collected, the majority were left in the ground due to limited supplies of plaster and burlap.

2006 – we understood that a mapping of the Jurassic hillsides was necessary and started the endeavor. The first pliosaur remains and methane seep carbonates was discovered.

2007 – the first pliosaur dig and another well preserved plesiosaur was excavated.

2008 - second pliosaur (Predator X) dig, several other smaller skeletons excavated.

2009 – back almost to the locality where we started in 2004, a nearly complete plesiosaur and complete ichthyosaur were excavated.

2010 – campsite at the locality found in 2004. Main finds: two ichthyosaurs and one plesiosaur.

2011 – same campsite, six skeletons excavated.

2012 – new campsite and last excavation in the Jurassic, six skeletons, and first skull of a plesiosaur.

2014 – Shift to the Triassic. The goal was to gain a stratigraphical control of the classical vertebrate bearing layers of the Early to Middle Triassic of Svalbard. Mapping of marine reptile localities around Flowerdalen.

2015 – First Triassic excavations, large ichthyopterygian, discovery of the Grippia bonebed.

2016 - Triassic excavations, focus on the Grippia bonebed.

2019 - Triassic depositional environment studies: Botneheia logging for isotopes and fossils.

2020 - Corona trip… Triassic. First three dimensional mixosaurskull.

2021 – A major skeletal find from 2019 of an early ichthyopterygian was excavated.

2022 – Early Triassic logging and discovery of classic localities at Roslagen.

SMRG have unearthed around 60 marine reptile skeletons from the Late Jurassic, about 20 marine reptile skeletons from the Triassic, and approximately 25,000 disarticulated bones and teeth from bonebeds in the Early Triassic. Additionally, our findings also include thousands of invertebrate fossils, microfossils, and rock samples. This comprehensive collection represents a valuable resource for future research and serves to rejuvenate old polar fossil collections at the Natural History Museum in Oslo. The research encompasses multidisciplinary studies of the Jurassic and Triassic deposits of Svalbard, which involve sedimentology, biostratigraphy, isotope-stratigraphy, micropaleontology, invertebrate paleontology, geochemistry, and vertebrate paleontology. Our international group includes members from Poland, Canada, Sweden, USA, Russia, England, France, Denmark, Germany, and Switzerland. Our collective efforts have resulted in over 60 peer-reviewed scientific papers, 6 completed PhDs, and 19 master's theses. To date, we have described approximately 30 new species, spanning from microfossils to large marine reptiles.

Osedax bioerosion in Late Cretaceous marine reptiles: biogeography, diversity, and ecology.

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Today, the bone-eating worm *Osedax* is a member of the niche ecosystems surrounding whale carcasses on the ocean floor. It is also present in the fossil record in both whales and marine reptiles. *Osedax* is globally distributed in modern oceans, with 29 species currently described. The earliest fossil evidence is in plesiosaur and sea turtle bones from the mid-Cretaceous. These occurrences from the United Kingdom represent the only unequivocal evidence for *Osedax* colonizing marine reptile bone in the Mesozoic, prior to the origination and diversification of large marine cetaceans. We present new evidence here for *Osedax* borings in twelve additional marine reptile specimens, including the first instances in mosasaurs and an ichthyosaur. The geographic range of *Osedax* in the Late Cretaceous, previously limited to what is today the United Kingdom, is expanded to both sides of the Atlantic Ocean basin, expanding on the known biogeography of this clade in deep time. The diversity of *Osedax* borings in the chalk of the United Kingdom is also explored through borehole morphotype diversity. The presence of *Osedax* borings is confirmed here through CT-scanning. Distinct borehole morphotypes in modern-day whale bone are created by different species of worm, and the fossil bones presented here contain eight borehole morphotypes, likely created by different species of *Osedax*, showing a relatively high diversity by the Late Cretaceous. Additional examination of marine reptile bone from broader geographical localities and depositional environments will elucidate the time range, diversity through time, and ecological preferences of this unique clade.

Stepping Back in Time: Unveiling the origins of bipedalism in early terrestrial tetrapods through innovative biomechanical approaches.

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Bipedalism represents one of the most striking forms of locomotor convergence in the history of terrestrial tetrapods. However, it remains unclear how bipedalism first evolved, whether it conveyed an adaptive advantage over quadrupedal locomotion, or if it was the result of multiple factors. One of the oldest taxa hypothesized to have employed bipedalism is the bolosaurid *Eudibamus cursoris*, from the early Permian Bromacker locality in central Germany. Nonetheless, interpretations regarding the bipedal aptitude of *Eudibamus* have primarily relied on limited comparison of skeletal proportions, and currently lack robust biomechanical testing. Here, we employ a novel methodology combining synchrotron-based imaging, range of motion analysis, and musculoskeletal modeling to quantify the bipedal

capabilities of *Eudibamus*. A first phase of our project is to apply our methodology to extant lizards, including both facultative bipeds and obligate quadrupeds, through comparison with in vivo kinematics. We will then exploit this relationship to constrain reconstruction of a bipedal stride for *Eudibamus* with the aim to resolve whether this unique specimen was indeed capable to run bipedally (obligate or facultative, if at all). Our preliminary research aims to enhance our understanding of biomechanical and evolutionary adaptations in early terrestrial tetrapods, shedding light on the ecological pressures and morphological transformations that facilitated this unique locomotor transition.

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Investigating the patterns and mechanisms of skull simplification in Tetrapodomorphs.

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One of the best documented phenomena in tetrapod evolution is the repeated loss of bones in the skull. This trend is first seen in early tetrapodomorphs as the number of elements of the skull roof reduces from ~55 in the bony fish Eusthenopteron, to ~30 in Acanthostega. The loss in complexity is even more extreme in lissamphibians which have ~20 components to their skull roof. Within the skull roof the temporal series (i.e. intertemporal, supratemporal, and tabular) shows the greatest degree of variation in terms of presence/absence of elements in the tetrapodomorph phylogeny, whilst the median series (i.e. frontal, parietal, postparietal) shows the least variation. We used a combination of ancestral state reconstruction analyses and histological data to ask questions regarding the evolutionary and developmentary mechanisms behind skull simplification in tetrapodomorphs, namely: (1) is the loss of the temporal series convergent between the anamniote and amniote lineages, (2) were bones lost independently or in a modular pattern in the temporal series, and (3) is the loss of skull bones caused by fusion or loss of ossification centres. The first two questions were addressed by a maximum likelihood ancestral state reconstruction of the presence/absence of the temporal and median series using a large composite phylogeny of tetrapodomorphs under different hypotheses relating to the position of Lissamphibia and homology. The analyses reveal that the simplification of the temporal series follows an overall direction of loss in both the anamniote and amniote lineages in which the intertemporal disappears first, then the supratemporal, and then the tabular. However, there are some exceptions restricted to Eureptilia whereby the supratemporal either reappears, as in Squamata, or the supratemporal remains and the tabular is lost, as seen in Captorhinidae. This step-wise pattern of loss and regain indicates that the simplification of the temporal series evolved parallelly in anamniotes and amniotes, it also suggests that the temporal series did not form a tight developmental module. The third question was addressed with histological data collected from synchrotron scans of the temnospondyls *Sclerocephalus*, *Apateon*, and *Micromelerpeton*, and the lepospondyls *Brachydectes*, *Cardiocephalus*, and *Diplocaulus*. The specimens were at different ontogenetic stages and were scanned at 2.5µm along a transect running anteroposteriorly along the temporal series. The absence of evidence of fusions either indicates that fusions happened early in development, or that bone loss was the result of other developmental mechanisms such as the loss of ossification centres through heterochrony.

Timing the nearshore–offshore transition in earliest Triassic marine tetrapods,

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Tetrapods first radiated into oceanic environments after the cataclysmic end-Permian mass extinction (EPME), which marked the beginning of the Age of Dinosaurs, 251.9 million years ago (Ma). However, the precise timing and context of this landmark evolutionary transition are controversial. Popular hypotheses have favoured a step-wise

ecological succession of euryhaline temnospondyl amphibians invading oceanic predator niches during the earliest Triassic (~251 Ma), but being replaced by ichthyopterygian marine reptiles after the late Smithian crisis (LSC), ~249.6 Ma. Yet, the anomalous discovery of ichthyopterygian remains in strata that pre-date the LSC (~250 Ma) implies a more ancient emergence of Mesozoic marine tetrapod communities, perhaps even preceding the EPME. Here, we integrate new field data from the Scandinavian Arctic with phylogeny-based ancestral area estimations for the dominant marine temnospondyl clade Trematosauridae. This group was globally distributed throughout paralic to distal shelf environments during the Early Triassic, and therefore tracks the nearshore–offshore transition in the first oceanic tetrapods. Some of the geologically oldest Induan (Griesbachian–lower Dienerian) marine trematosaurids have been reported from East Greenland, but occur in a tidally-influenced depositional setting. Unequivocal pelagic trematosaurids otherwise only manifest in lower Olenekian (middle-to-upper Smithian) deep water deposits on Svalbard. Similar time-coincident habitat differentiations typify trematosaurids found elsewhere around the world. Indeed, our ancestral area analyses pinpoint an initial fluviatile–nearshore marine cosmopolitan dispersal from northern Pangaea during the Induan. Opportunistic offshore excursions by regionally disparate trematosaurid lineages subsequently took place during the early Olenekian, concurrent with the proliferation of sea-going reptiles. Finally, Tethyan littoral trematosaurids persisted into the Middle Triassic (early Anisian), thus clearly post-dating the LSC and demonstrating a parallel rather than step-wise evolution of the earliest oceanic tetrapods.

Using 3D geometric morphometrics and discrete analysis on the teeth of Late Triassic Archosauriformes exhibiting the plesiomorphic condition: tools for distinguishing the isolated and undistinguishable.

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The Late Triassic is a fantastic case study in expansive diversification of life after a catastrophic mass extinction. Archosaurs exemplified this and rose to fill an exceptionally wide range of terrestrial ecological niches. The plesiomorphic tooth condition of archosaurs is hypothesised as being recurved, serrated, and laterally compressed, indicating carnivory, and despite forays into other morphotypes (e.g., suited to herbivory in aetosaurs, omnivory in silesaurids), a great number of archosaurs retained (or possibly reverted) to this ancestral condition. This similarity can complicate narrowing down the clade of isolated archosaur teeth, hampering studies of ecology, diversification, and changing faunas. Here we compare the teeth of individuals from across archosaurian clades (Dinosauria, Erpetosuchidae, Erythrosuchidae, Poposauridae, Gracilisuchidae, "Sphenosuchia", Ornithosuchidae, Loricata, Aetosauria, and non-archosaurian archosauriform outgroups) using 3D geometric morphometrics (3D GM) and non-metric multidimensional scaling (NMDS), allowing us to quantify shape and compare discrete characters, respectively. A range of carnivores from across Archosauriformes were surface or μCT scanned to create 3D models, with *Euparkeria* acting as an outgroup and representative of the ancestral condition. We quantified tooth types by location in the mouth (premaxilla, maxilla, and dentary), where possible, to test the full spectrum of tooth shape and identify trends in these mouth regions. Models were landmarked and run through 3D GM code in R. To complement this quantitative approach, NMDS was performed to visualize differences between discrete characters and provide further separation between taxa and tooth type. As expected, many taxa plot closely together, with teeth from each individual tending to plot in clusters. There does not, however, seem to be any noticeable separation or pattern between how the different regions of the mouth plot in any taxon. *Euparkeria* in both analyses plots centrally, or at least within the majority of teeth – acting as our ancestral tooth that others diversified from, this is exactly where we'd expect to see it plot. The same two taxa, *Coahomasuchus* and *Parringtonia*, plot away from the main clusters in both quantitative and discrete analyses, suggesting that these may be the most derived teeth in the study, given their distance

from *Euparkeria* and more plesiomorphic taxa. The distance between the dinosaur and pseudosuchian teeth tested is promising that these methods could be used to narrow down the clade of isolated teeth. This work is easily transferrable to other animal clades, and we hope that it will become a useful tool, particularly in the study of microsites.

The largest Triassic Neotheropod.

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Triassic neotheropods, once all grouped within Coelophysoidea, have recently been shown to encompass a broader phylogenetic diversity, with several species now regarded as being stem-line representatives of Averostra. However, the placement of several species is still uncertain, and so is the possible increase in body size towards the Jurassic. New neotheropod remains from the Trossingen Formation (late Norian) of Bavaria, Germany, consist of numerous isolated elements found in a bonebed of mostly *Plateosaurus* material. The bones show extensive taphonomic alteration due to carbonate infilling and clay welling. The preserved theropod material includes a maxilla, quadrate, partial dentary, vertebrae, humeri, ilia, femora, an ischium, and elements of the manus and pes of several individuals of different sizes. The maxilla lacks additional pneumatic recesses. It has a single unerupted tooth preserved, with a denticle pattern like that of *Liliensternus*. The cervical vertebrae are elongate and have anterior and posterior pleurocoels. The latter become deeper distally in the series and are elongated and bound by ridges similar to those of *Liliensternus,* which, however, lacks depressions. The ilium is robust and the pelvic elements remain unfused. The ischium is anteroposteriorly broad, with a prominent pubic peduncle. The femur has a prominent trochanteric shelf and low fourth trochanter. Preliminary phylogenetic analyses recover the specimen as a sister-taxon to *Liliensternus*, sometimes in a broader clade with *Zupaysaurus,* on the stem-line of Averostra. The presence of a trochanteric shelf, closed neurocentral sutures, and the body size of the elements indicate that they are derived from more ontogenetically mature individuals when compared to the *Liliensternus* syntype, long known to be subadult. The similarities with the latter taxon, including the ridges and keeling on cervical centra and the pattern of denticles in the maxillary teeth, might suggest that the material represents ontogenetically more adult individuals of *Liliensternus.* This could indicate ontogenetic changes e.g. in the cervical pleurocoels and ischial width, but further preparation and more detailed study are necessary. The largest specimens represent a large animal, with an estimated body length of 7-9m – larger than any known Triassic neotheropod. The specimen adds to the Triassic diversity of averostran-line dinosaurs and might provide information on early theropod ontogeny. Moreover, it demonstrates the presence of large-bodied theropods in the Late Triassic, suggesting that even the small increase in theropod size across the Triassic – Jurassic boundary might be an artefact of our knowledge of the fossil record of the time.

Contrasting macroevolutionary patterns in pelagic tetrapods across the end-Triassic bottleneck.

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Ichthyosauria and Eosauropterygia were the two of the most successful lineages of marine raptorial predators, co-existing in the same ecosystems throughout most of the Mesozoic. As such, these animals were affected by similar environmental, ecological, and evolutionary pressures, making them a good example in comparing macroevolutionary trajectories among contemporaneous clades of aquatic tetrapods. The very end of the Triassic represents a key period in their evolution as both groups seemingly went through a massive bottleneck that strongly reduced their morphological diversity, with pelagic lineages (*e.g.* Parvipelvia and Plesiosauria) as the only survivors. However, previous research analysing their evolution across the Triassic-Jurassic (T/J) transition are rare and usually focussed on coarse morphological and

temporal data. In the present study, we comprehensively compare the evolution of ichthyosaurian and sauropterygian size and morphology across the Middle Triassic to Early Jurassic interval. We reveal distinct patterns in the craniodental diversification of these two lineages. The ecomorphospace of eosauropterygians is predominantly shaped by a strong phylogenetic signal, resulting in the clustering of three clades: Pachypleurosauroidea, Nothosauroidea and Pistosauroidea, with clearly distinct craniodental phenotypes, suggesting rapid 'leaps' towards novel feeding ecologies. Ichthyosaurian diversification lacks a discernible evolutionary trend, as we find evidence for a wide overlap of craniodental morphologies between Triassic forms and Early Jurassic parvipelvians, suggesting a weak effect of the T/J extinction in terms of ecological breadth. Temporal evolution of ecomorphological disparity, body size, and fin shape of ichthyosaurians and eosauropterygians during the Late Triassic does not support the hypothesis of an abrupt macroevolutionary bottleneck at or near the T/J transition. Instead, our findings suggest that a profound turnover event should be sought earlier, within the Carnian to middle Norian interval, during times of abrupt sea-level changes leading to the extinction of coastal waters species.

A virtual cranial endocast of the Miocene primate *Mioeuoticus shipmani* (Lorisidae, Primates) from Kenya.

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Mioeuoticus shipmani is an extinct primate of the family Lorisidae, the group that includes modern lorises and pottos. This species comes from the early Miocene of Kenya and has been argued to be a stem lorisid. *Mioeuoticus shipmani* is known only from its holotype (KNM-RU 2052), represented by a relatively complete partial cranium. We present the first virtual cranial endocast of a fossil lorisid and perform comparative analyses with extant lorisoids (i.e., lorises and galagos). The segmented endocranial space resembles today's Galagidae despite the fossil being ascribed to its sister family, Lorisidae. Such shared features include the relative size and overall shape of the olfactory bulb and the neocortex, as well as an encephalization quotient (0.74-0.82), overlapping with the bottom range of galagids. *Mioeuoticus* differs from its extant Asian relatives of the subfamily Lorisinae, specifically in having a significantly smaller neocortex, and an especially reduced prefrontal cortex. Additionally, the olfactory bulb volume ratio and the encephalization quotient of *Mioeuoticus* do not overlap with the respective ratios in lorisines. This suggests that the galagid brain might have retained plesiomorphic features (similar to *Mioeuoticus*), whereas the brain of modern lorisids may have acquired derived endocranial traits. Despite the apparent similarities between the endocasts of the primitive lorisid, *Mioeuoticus,* and galagos, members of Galagidae have relatively larger petrosal lobules than *Mioeuoticus*; the relative size of these structures in *Mioeuoticus* is more consistent with the small petrosal lobules typical of modern lorises. However, *Mioeuoticus* stands out for having even smaller petrosal lobules than extant lorisids, which suggests even less capacity for visual tracking of moving insects. Our study reveals critical aspects of brain evolution in Lorisidae to fill an important gap in their poorly known evolutionary history.

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Reversing the Pachycormid Polarity?: Secondarily-derived feeding behaviours, Polar finds and extensive palaeolatitudinal ranges.

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In addition to being actinopterygians that are critical to understanding the development and emergence of teleosts, pachycormids are also among a very select group of taxa to be found in Antarctic deposits. As well as their importance as

contemporary discoveries in challenging polar environments, suspension-feeding pachycormids have particular significance for their role as Mesozoic 'oceanic health' indicators, showing the viability of plankton-feeding and hence primary productivity at extreme palaeolatitudes. The unusually large (greater than 1 metre in standard length, ranging up to 16.5m) size of suspension-feeding pachycormids indicates that they pioneered the 'large vertebrate suspension-feeder' niche that is today principally occupied by baleen whales and chondrichthyans such as the whale shark and basking shark. Within this niche, pachycormids exhibit a variety of specialisations for different grades of plankton. Pachycormid specialisations were not all within the area of suspension-feeding, however. Recent discoveries have indicated not only that suspension-feeding pachycormids held a sophisticated monopolisation of the diverse vertebrate suspension-feeding niche throughout the Mesozoic, but that they also secondarily diversified into carnivory in the Late Cretaceous, in the form of *Protosphyraena* and closely-related taxa. In doing so, pachycormids effectively pioneered another niche, that of the pursuit predator, occupied by today's billfish.

Justifying the means: The ethics and limitations of social media use for specimen restitution.

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Questions of repatriation of illegally-removed vertebrate fossils have existed for almost exactly as long as the science of vertebrate palaeontology itself. In point of fact, the specimen often cited as the 'first vertebrate fossil', the Meuse River mosasaur type specimen skull of *Mosasaurus hoffmanni*, was taken by Napoleonic armies from the Netherlands to George Cuvier in Paris in 1795 and as such is now the subject of a restitution claim by authorities in Maastricht, The Netherlands. But the most high profile claims for restitution in the modern age have concerned dinosaur material, primarily from China, Mongolia and Brazil. The most recent and most public of these have been campaigns primarily conducted on social media for the restitution of Brazilian theropod dinosaurs, which have featured the targetting of administrative and secretarial staff, as well as the public museums themselves. These activities in turn have raised their own ethical questions, that run parallel to the issues of where a particular specimen should be housed. This presentation looks at some of the issues raised by these online campaigns, examining the degree to which academics can become involved or lead such campaigns, and where both their involvement and the range of the campaign should be circumscribed, through the following questions: what actions are legitimate in the pursuit of raising awareness and bringing pressure to bear on an organisation? To what degree can academics participate in such a campaign, without their involvement or leadership becoming academic bullying of other researchers? The extent to which activities encompassed by a given campaign are viewed as legitimate or otherwise will inevitably reflect on the academics that participate in those campaigns, as well as those that do not, with long-term consequences.

Clade-specific patterns of brain size allometry in Euarchontoglires and their effect on encephalization quotients.

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Primates have received much attention regarding how their brain size scales relative to body size. The broader phylogenetic context of this relationship, which has been less extensively studied, is fundamental for understanding evolutionary shifts in relative brain size. Equations describing these scaling relationships are also employed in calculation of Encephalization Quotients (EQ) for comparisons of relative brain size, which are essential for interpreting fossil data. Here we developed metrics that are more targeted than existing general mammalian equations to particular questions in euarchontogliran brain evolution.

Ordinary (OLS) and phylogenetic generalized least squares (PGLS) regressions were fitted to the largest euarchontogliran dataset of brain and body size, comprising 715 species of Primates, Scandentia, Dermoptera, Lagomorpha, and Rodentia. Contrary to previous inferences, based on slopes the lagomorph brain (PGLS = 0.465; OLS = 0.593) scales relative to body mass similarly to rodents (PGLS = 0.526; OLS = 0.638), and differently than primates (PGLS = 0.607; OLS = 0.794). A shift in the pattern of the scaling of the primate brain occurs, with Strepsirrhini occupying an intermediate stage, being more similar to Scandentia but different from Rodentia and Lagomorpha. The unique brain-body scaling relationship of Primates among Euarchontoglires illustrates the need for clade-specific EQs for more restricted taxonomic entities than Mammalia. We created clade-specific regular and phylogenetically -accounted EQ equations at superordinal, ordinal, and subordinal levels. When using fossils as test cases, our results show that generalized mammalian equations underestimate the encephalization of the stem lagomorph *Megalagus turgidus* in the context of lagomorphs but overestimate the encephalization of the stem primate *Microsyops annectens* and the early euprimate *Necrolemur antiquus* in the context of primates. Conversely, generalized mammalian equations provide similar EQ values to our new strepsirrhine-specific EQ when applied to the early euprimate *Adapis parisiensis*. These results highlight the importance of understanding patterns of brain-body scaling in interpreting fossils in an evolutionary context.

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First therapsid fossil from the Permian of the Mediterranean.

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Non-mammalian therapsids, the forerunners of mammals, were an important group of Permian terrestrial vertebrates. They are thought to have diversified explosively in the middle Permian, with several subclades originating that include dominant components of the ecosystems they inhabited. Most skeletal remains of Permian therapsids have been documented from the northern and southern temperate latitudes of Pangaea (primarily in Russia and South Africa), whereas their record from the palaeotropics is extremely poor. Palaeotropical ichnoassemblages suggest the presence of therapsids, but this record is still far from suitable for understanding the first stages of therapsid evolution, given the difficulties in conclusively associating Permian tracks with particular synapsid clades. Here we report the first definitive therapsid body fossil from the palaeotropics of Permian Pangaea, found in the modern Mediterranean. We discuss its anatomy along with the phylogenetic and palaeobiogeographic implications for the origin of therapsids. We provide information on a new locality with great potential towards resolving the outstanding questions on the evolution of the Therapsida and timing of latitudinal shifts in the distribution of this major clade.

Wildlife in the Late Jurassic of Northern Switzerland - a key to faunal exchange between the Boreal and Tethyan Realms.

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Late Jurassic Swiss fossil-bearing sites, from the Northwestern corner of the Swiss Jura Mountains, now well-constrained by biostratigraphy, offer a revised understanding of the vertebrate fauna

inhabiting the Jura carbonate platform. These findings corroborate the evidence of periodically emergent land areas for faunal exchange with isolated larger landmasses (i.e., Rhenish Massif to the north or the Iberian Massif to the south).

Several Swiss Jura dinosaur tracksites are known from the Reuchenette Formation and are located at the Kim 3 discontinuity which is dated into the *acanthicum*/*mutabilis* ammonite biochrons (Early Kimmeridgian). Currently, six localities are known that have yielded both terrestrial vertebrate body and trace fossils, with notable findings include the small eusauropod *Amanzia*, a Ceratosaurus tooth, unidentified theropod vertebra and teeth, the partial femur of a stegosaur, and pterosaur remains (rhamphorinchyoids). The track record consists of sauropods and small-, medium- and large-sized theropods traces. The latter represented by *Jurabrontes*, the tracks of large apex predator(s) which are now also known from Germany, France and the Iberian Meseta. Moreover, the sauropod tracks can be largely ascribed to *Parabrontopodus*, a Late Jurassic North American ichnogenus. Lagoonal or shallow water vertebrate fauna, such as thalattosuchians, pycnodontid fish, chondrichthyans as well as turtles, are also associated with the terrestrial records. In these stratigraphic levels, the reduced number of stenohaline neoselachians and the dominance of rays, hybodonts and chimaeroids indicate reduced salinity or brackish conditions. Finally, the presence of abundant cheirolepidiaceaen conifer fragments (*Protocupressinoxylon*) found largely within the lagoonal facies are further evidence of emergent areas.

The Late Jurassic of Northwestern Switzerland can no longer be considered a fully marine sequence. The occurrence of a megatracksite at the Kim 3 discontinuity (and those from Kim 4) corroborates the idea of large emergent areas between the Oxfordian/Kimmeridgian and the Berriasian. In a wider palinspastic context, they lie above reactivated reliefs which resulted in these emergent areas bordered by brackish lagoons connected to open waters. It is possible that these terrestrial environments formed an isthmus orientated in an ESE–NNW direction that connected the southwestern corner of the London Brabant massif with Massif Central in the Southwest. The retrodeformation of the Jura thrust and fold belt by approximately 30 km resulted in a Late Jurassic corridor that was at least 80 km wide, providing ample space for faunal exchange between the Boreal and Tethyan realms, potentially extending even further south to Gondwana.

The Early Jurassic ichthyosaur fauna of northern Bavaria.

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There are many Early Jurassic localities across Germany that contain ichthyosaur fossils. The most well-known and studied is undoubtedly the Holzmaden area. Quarries in Holzmaden, Ohmden and Dotternhausen have yielded countless specimens of at least five different genera (*Temnodontosaurus*, *Eurhinosaurus*, *Stenopterygius*, *Hauffiopteryx* and *Suevoleviathan*) and a plethora of biological information including pregnant females, skin imprints and fossilised blubber. The shear wealth of material has overshadowed specimen analyses from contemporaneous localities elsewhere in Germany. Here we review Lower Jurassic ichthyosaur material found in localities in Franconia (northern Bavaria), mainly specimens housed in Bamberg, Nürnberg, Mistelgau, and Kloster Banz. The latter is home to the holotype of *Temnodontosaurus trigonodon*, which is the largest skull of the species found to date. We find that, similar to Holzmaden, most of the material can be attributed to *Stenopterygius quadriscissus*. The originally proposed species of *Ichthyosaurus bambergensis* is based on a single specimen housed at the Natural History Museum Bamberg and the genus designation was related to coracoid shape. Reanalysis of *I. bambergensis* revealed that the coracoid of the holotype is broken and that its morphology is virtually identical to *Stenopterygius quadriscissus*. We therefore deem *Ichthyosaurus bambergensis* to be a junior synonym of this species. Even though species composition of the Franconian fauna seems to be relatively similar to the Holzmaden area, the material deserves more attention. In terms of preservation, the Franconian localities have a much higher potential of 3D preservation than those in Baden-Wuerttemberg. While in the classic Holzmaden localities, vertebrate fossils are compacted during diagenesis,

in many Franconian localities they are preserved in early-diagenetic carbonate nodules. An excellent example of this nodule preservation is a *Stenopterygius* specimen from Altdorf, which consists of a 3D-preserved skull and trunk displaying the original position of the ribs and pectoral girdle in relation to the vertebral column. Together with several other finds, this material has high potential in terms of accurate muscle reconstruction and volumetric assessment.

Using of the C and O stable isotopes for reconstruction of the Lower Permian limnic ecosystems: Case study from Boskovice basin, Czech Republic.

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The Boskovice basin, located in the eastern part of the Czech Republic, is well known for its lagerstätten-type localities with amazingly preserved Lower Permian limnic ecosystems. An analysed material comes from the northern part of the Boskovice Basin – from the Lower Permian Letovice Formation (Lower and Middle Letovice Member). We analysed the scales (paleoniscid and acanthodian fish), fin spines (acanthodian fish) and cranial and postcranial bones (discosauriscid and temnospondyl amphibians) with different taphonomic conditions (phosphatised, partly carbonized and carbonized specimens). These skeletal material (bioapatite) without diagenetic impurities was analysed for the C and O isotope composition of the carbonate ($\delta^{18}O_{APCO3}$, $\delta^{13}C_{APCO3}$) and phosphate ($\delta^{18}O_{APPO4}$) components. We supplemented these analyses with stable isotope analysis of an organic C ($\delta^{13}C_{ORG}$) from carbonised organic matter (plants, animals, bitumen from rocks, and in some cases from bioapatites) and C and O isotopes of carbonates ($\delta^{18}O_{CARB}$, $\delta^{13}C_{CARB}$) from the fossiliferous layers. The signatures of the $\delta^{18}O_{APCO3}$, $\delta^{13}C_{APCO3}$ and $\delta^{18}O_{APPO4}$ from bioapatite we consider to be diagenetically unaltered. This is supported by remarkably well-preserved paleohistological conditions of the fossil bones and fractionation factor of $\delta^{18}O_{APCO3}$ and $\delta^{18}O_{APPO4}$ ($\Delta^{18}O_{AP}$) with values between 6,96‰ and 12,69‰, which correspond to recent animals. Based on the $\delta^{18}O_{APPO4}$ signatures and with the support of the $\delta^{18}O_{CARB}$ and $\delta^{13}C_{CARB}$ signatures from the fossiliferous carbonates we observed different demands on hydrological lake regimes between studied taxa from the Lower and Middle Letovice Member. A slight shift to positive $\delta^{18}O_{APPO4}$ values in partly carbonized and carbonized specimens was apparently caused by a change of the redox conditions or by increased microbial activity. The $\delta^{13}C_{APCO3}$ signatures indicate the presence of both carnivorous and herbivorous vertebrates and confirm previous hypotheses regarding the feeding preferences of the studied taxa. In contrast, $\delta^{13}C_{ORG}$ signatures from carbonized specimens are probably diagenetically or microbially altered and are therefore likely not suitable for interpretations of trophic relationships.

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Are extinct islanders more predisposed to illness? New evidences of pathological conditions in Plio-Holocene fossil bones from Balearic Islands (Menorca, Spain).

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The research on ancient diseases or injuries (paleopathologies) in bones and teeth of extinct organisms (protozoans, plants, invertebrates and vertebrates) can reveal meaningful biological features of these past species (e.g., about their lifestyle, life history, behavior, ecological relationships, physiology, immunology, etc.) and their environments, which are impossible to achieve with other approaches. Currently, hundreds of abnormal conditions have been reported in extinct non-human vertebrates, including injuries, joint diseases, toxic-metabolic pathologies, infections, or neoplastic disorders with congenital malformations. The objective of the present study is to

provide an accurate description of several pathological remains recovered from Menorcan fossil sites (Balearic Islands, Spain), showing light about the behavior and life history of insular extinct species. The studied material consists of 5 limb bones of *Latonia* sp. (Alytidae, Lissamphibia; Pliocene Punta Nati-6 locality), 2 dentaries of *Podarcis lilfordi* (Lacertidae, Squamata; Pleistocene Punta Esquitxador-17 locality) and 1 rib, 1 incisive and 1 tibia of *Myotragus balearicus* (Bovidae, Mammalia; Pleistocene Sa Cigonya and Holocene Es Pas d'en Revull localities). Bones and teeth were examined grossly and with non-invasive cross-sectional imaging techniques (micro-CT), letting to view their inner microstructure. Results primary reveal the presence of healed fractures with mineralized calluses, infection and neoplastic conditions. Pathologies (fractures, infections, etc.) impact on the normal organism life (e.g., abnormal positions, swelling, pain), becoming them an easy target for predators. However, such disorders were healed meaning that these individuals were able to survive at least months after the wound. The general absence of terrestrial predators in small-to-medium islands (like Menorca) can be the main factor for healed pathological conditions in ancient insular species, agreeing with previous occurrences and observations (e.g., *Prolagus sardus*).

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The first reported megaraptoran theropod dinosaur from Europe and the implications for megaraptoran origins.

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Theropod remains from the Lower Cretaceous Wessex Formation of the Isle of Wight, U.K., are rare and often fragmentary, making the phylogenetic placement of several species questionable. Based on first-hand observations and micro-CT scan data, we present a previously undescribed braincase from the Wessex Formation (NHMUK PV R6775). It represents the first braincase referrable to a non-avian coelurosaur from the U.K., and a phylogenetic analysis that included 88 taxa and 1760 characters recovered it as a megaraptoran. This makes it among the oldest known megaraptorans, and new megaraptoran synapomorphies found by this analysis, and present in this specimen, include a rounded, sub-rectangular occipital condyle, prominent sub-condylar recesses and a unique foramen magnum to occipital condyle ratio (FOR).

Theropod braincases are often described as morphologically and phylogenetically conservative, but the new braincase characters identified here potentially provide useful data that might help refine theropod phylogeny. For example, these features differ from those of other theropod groups, in which the occipital condyle is dorsoventrally depressed and kidney-shaped (early-branching theropods), sub-spherical (Abelisauroidea), spherical (Spinosauridae) or elliptical (Carcharodontosauridae and Maniraptora). The occipital condyle of the new specimen is slightly larger than the foramen magnum, differing from Abelisauroidea and Carcharodontosauridae (in which the occipital condyle is significantly smaller than the foramen magnum) and maniraptorans (in which it is significantly larger), but it is similar to those of the megaraptorans *Murusraptor* and *Megaraptor*. The specimen differs from tyrannosaurids, such as *Daspletosaurus*, due to a significantly different FOR and from other non-tyrannosaurid tyrannosauroids, such as *Guanlong*, due to the shape of the foramen magnum. The FOR has distinctive trends across different theropod clades. The new specimen can be distinguished from the two other known megaraptoran braincases (those of *Megaraptor* and *Murusraptor*) by its possession of the following autapomorphies: a small basipterygoid recess is present anterior to the -asisphenoid recess on each side of the parabasisphenoid, a slightly compressed hourglass shaped sagittal nuchal crest in posterior view and the presence of two large,

deep, dorsoventrally elongate paracondylar recesses on the ventrolateral sides of the basioccipital.
Globally, three-dimensionally preserved braincases of early-diverging coelurosaurs are rare and often incomplete, so this new specimen provides important information for understanding their evolution, and also supports the nesting of Megaraptora within Coelurosauria. This new specimen increases our knowledge of Early Cretaceous European tyrannosauroids, hints at a Laurasian origin of Megaraptora and might indicate a greater diversity of these taxa than previously suspected.

A Jurassic early bird: Integrative taphonomy and identity of *Ostromia crassipes*.

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The origin and interrelationships of the earliest birds remain controversial and are only sparsely documented in the fossil record. The Solnhofen Limestone (Late Jurassic, ca. 149-145 Ma) from southeastern Germany are crucial for reconstructing bird origins. Three endemic avialan taxa have been described from these deposits. These are Archaeopteryx, Alcmonavis, and a new taxon of Anchiornithidae; Ostromia crassipes. Ostromia is defined by longitudinal furrows on the manual non-ungual phalanges, a strongly flexed pubic shaft, and a sub-triangular pubic foot. The holotype of Ostromia crassipes (TM6929 - TM6928, two counterparts) exhibits taphonomic collapse typical of fossils from the Solnhofen Limestone. Furthermore, significant 2portions of the skeleton remain obscured by the matrix. This prevents direct assessment of functional and phylogenetically-informative anatomical characters, and identification of taphonomic artefacts. We used propagation phase-contrast synchrotron radiation microcomputed tomography (PPC-SRμCT) at BM05 of the European Synchrotron Radiation Facility (ESRF) for complete non-destructive 3D visualisation of the preserved elements. This enabled us to evaluate the taphonomy, functional anatomy, and identity of this specimen. Additionally, we used laser-stimulated fluorescence (LSF) and white-light microscopy (WLM) imaging to analyse exposed skeletal elements. Detailed 3D description of the elements, aided by LSF and WLM visualisation, revealed that none of the characters in the formal diagnosis of Ostromia could be confirmed. Several of these are explained by taphonomy, whereas some appear to be derived from an imperfectly coloured cast. Phylogenetic analysis confirmed that TM6929 - TM6928 is virtually indistinguishable from Archaeopteryx and differs markedly from anchiornithines. The 'Haarlem specimen' is recovered within the expected variation of Archaeopteryx and should therefore be considered a representative of the genus. Furthermore, the 3D data provided novel insights in the skeletal anatomy of the specimen. These pertain to the wrist, unguals, and gastralia. Our improved understanding of this specimen also has implications for the anatomical reconstructions of basal Avialae.

Upper Carboniferous, Permian and Triassic conodonts of Svalbard.

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Research on Ordovician, Carboniferous, Permian and Triassic conodonts from Svalbard has been done since the mid 1970s. The current account is synthesizing already published data as well as own research in recent years, based on samples collected from the approximately 1 km thick Upper Carboniferous – Middle Triassic succession of Svalbard. Conodont elements have been recovered from all lithological units, however in small numbers. Species composition and dating of respective units will be presented. Faunas are here discussed from oldest to youngest units.
The lowest sampled unit, the Minkinfjellet Formation contains species of *Idiognathodus*, *Streptognathodus, Neognathodus* and *Hindeodus* sp. The specific composition places the investigated interval in the uppermost Moscovian. Late Carboniferous species, *Diplognathodus coloradoensis*, *Idiognathodus incurvus* and *I. magnificus* are present in the overlying Cadellfjellet Member. The lowermost part of the

Tyrrellfjellet Member contains conodonts of ? Gzhelian - Asselian age, whereas the upper part is ?late Sakmarian with presence of *Sweetognathus inornatus*. The upper part of the Gipshuken Formation with *Neostreptognathodus pequopensis* is ?late Artinskian. A more diverse condodont fauna is present in the Vøringen Member (*Neostreptognathodus pequopensis, N. pnevi, N. svalbardensis* and *Sweetognathus whitei*) dating this unit as late Artinskian - early Kungurian. *Mesogondolella idahoensis* was recorded in the middle-upper part of the Kapp Starostin Formation dating this part of the succession as early Guadalupian ("middle" Permian).

The lowermost part of the Vikinghøgda Formation contains *Neogondolella* cf. *meishanensis*, and *Neogondolella hauschkei*. The presence of these species supports other biostratigraphic and chemo-stratigraphic evidences that the basal metres of this unit are of latest Permian age. The base-Triassic defining species, *Hindeodus parvus*, has been reported from apprx. 2.5 m above the base of this unit. Further up, 18 conodont species are recorded throughout the Vikinghøgda Fm, 6 in the overlying Botneheia Fm. and three in the lowermost Carnian Tschermakfjellet Fm. Conodonts have not been recorded from younger Triassic units.

A notable character of the Upper Carboniferous - Lower Permian conodont faunas is the lack of "gondolellid" (segminiplanate) species, whereas "gondolellids" are dominating in the middle Permian and all Triassic units. This is considered due to gross depositional environment change from predominantly shallow water carbonates to deeper and colder water siliciclastic dominance.

Regionally, the studied conodont faunas are similar to those of other Arctic regions. Correlations with sections in the Canadian Arctic (Sverdrup Basin), Greenland, Novaya Zemlya, and other Russian areas will be discussed in the presentation.

Cretaceous enantiornithine bird from Brazil fills fundamental knowledge gap in the early evolution of the avian skull and brain.

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A dearth of Mesozoic three-dimensional fossils hinders understanding of the origin of the distinctive skull and brain of crown birds. We report an exquisitely preserved new fossil cranium from the Late Cretaceous of Brazil (Campanian age - 83.6-72.1 million years ago) from the Adamantina Formation (Bauru Basin). The skull is toothless and large-eyed, with a vaulted cranium closely resembling the condition in crown birds; but clearly belongs within the Enantiornithes, a highly diverse clade of Mesozoic stem birds. Despite an overall geometry quantitatively indistinguishable from crown birds, the skull of the new specimen retains numerous plesiomorphies. Altogether, its emergent cranial geometry reveals an unprecedented degree of similarity between crown birds and enantiornithines, groups last sharing a common ancestor over 130 million years ago. It provides long-sought insight into the detailed cranial and endocranial morphology of stem birds phylogenetically crownward of *Archaeopteryx*, clarifying the pattern and timing by which the distinctive neuroanatomy of living birds was assembled.

A new notosuchian crocodyliform phylogeny resolves long-standing debates about the placement of sebecids.

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Notosuchia encompasses a taxonomically diverse clade of predominantly Gondwanan crocodyliforms. Although the group has its highest apparent diversity in the late Early–Late Cretaceous (120–66 Ma), putative notosuchians are known from the Middle Jurassic to Middle Miocene (~168.3–11.6 Ma). Many members of the group possess highly derived crocodylomorph traits such as duck-like snouts, dentition convergent with that of mammals, and erect, elongate limbs. 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 that comprises Baurusuchidae + Sebecidae, sebecids have alternatively been recovered as the sister group to Peirosauridae and closely related taxa. Some of the uncertainty surrounding relationships within the group likely derives from the fact that Sebecosuchia, and especially Sebecidae, includes several highly fragmentary remains such as those from the Paleogene of Africa and Europe. Despite a large number of notosuchian-focused phylogenetic analyses, few have critically examined the underlying characters, particularly in terms of their construction. In order to re-evaluate the systematics of the group, we compiled the largest and most comprehensive notosuchian dataset to date, comprising 586 morphological characters scored for 120 species. All existing characters were critically reviewed, and many were extensively modified. 113 novel characters were constructed, many of which focus on previously undersampled regions of the skeleton (postcrania and the endocranium). Continuous characters were utilised for the first time in the context of Notosuchia, and taxon sampling was increased, in part via inclusion of seven notosuchians that have not previously been assessed in a phylogenetic context. Under multiple scenarios, including utilisation of different character weighting schemes and varying character combinations, the broad tree topology remains similar, recovering a monophyletic Sebecosuchia that is supported by several newly recognised morphological similarities of baurusuchids and sebecids. These include a dorsoventrally broad premaxilla anterior to the nares, an elongate non-dentigerous process of the maxilla on the ventral skull surface, and a highly inclined dorsal margin of the anterior jugal bar. Inclusion of multiple fragmentary remains from Africa and Europe that are often neglected 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.

The tooth, the whole tooth, and nothing but the tooth – the fascinating dental morphology of arctic mixosaurids.

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The Triassic deposits of Svalbard offer a great variety of ichthyosaur fossils. The Middle Triassic Botneheia Formation preserves a large number of fragmented mixosaurid ichthyosaur specimens, a clade of smaller-sized marine reptiles containing several species with a long and complex taxonomic history. The seven currently recognized species, across the two genera *Phalarodon* and *Mixosaurus*, are to a large part differentiated by their heterodont dentition of posterior pointed, blunt or shearing teeth. Different authors have claimed the representation of three *Phalarodon* species at Svalbard, with presumably two species being preserved a few meters from each other. One of these specimens (PMO 250.490) possesses detailed information on dental morphology, triggering a new study on mixosaurid teeth. This study looks at tooth placement, count, shape and differentiation, as well as root morphology and ontogenetic differences. One of the most unexpected discoveries when analysing the specimen was the repeated every other placement of crushing/shearing teeth and piercing teeth in the posterior region of the jaw, this was also observed in a juvenile individual (PMO 251.390). This feature is similar to *Mixosaurus kuhnschnyderi*, but the taxon only possesses one piercing tooth placed in between the first and second posterior crushing teeth. Luckily, the PMO specimens are both detailed, and possess good x-ray and µCT contrast. This enables us to learn more about their similarities and differences from the already established species of *Phalarodon*, and may open up for further research on already assigned specimens as well. New questions arise regarding the dietary uses, evolution and viability of diagnoses of such teeth.

Paleoecology of the Middle Pleistocene Java as inferred from the endemic pig species *S. brachygnathus* and *S. macrognathus*.

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Paleoenvironmental context is a crucial factor in understanding human evolution. Mammal fossils from hominid-bearing deposits are often used as a proxy for revealing hominin palaeoecology. Especially suids are good environmental indicators because their physiology and ecology are similar to that of hominids. Research on extinct suid species from hominin fossil beds in Africa has shown promising results. Although Java (Indonesia) also represents a key stage in hominin evolution, fossil suids have not been studied in relation to paleoecology. Here, we address the paleoecology of two endemic fossil pig species from Middle Pleistocene sites on Java that were contemporaneous with *Homo erectus: Sus brachygnathus* (Trinil H.K; 0.9 Ma) and *S. macrognathus* (Kedung Brubus and Ngandong; 0.7-0.1 Ma) by reconstructing their body mass and analyzing their feeding adaptations in comparison with extant and fossil suids. Body mass was estimated using multiple logarithmic regression functions based on craniodental measurements as developed for extant ungulates in Rstudio. We estimated a body mass of around 40-70 kg for *S. brachygnathus* and ~ 70-150 kg for *S. macrognathus*. Concerning feeding adaptations, both species have a bunodont and brachydont dentition, but with considerable morphological differences, suggesting that their ecological niches did not overlap. *S. brachygnathus* shows a morphotype more similar to omnivorous suine species that include a high amount of fruit in their diet, such as the Sunda bearded pig (*S. barbatus*). Conversely, *S. macrognathus* shows a trend to develop transversal ridges (lophed type) typical of grazing species in open environments, such as the Common Warthog (*Phacochoerus africanus*). Taking all evidence together, the ecomorphotype of *S. brachygnathus* indicates a closed and wooded habitat in a wet or riparian environment with nearby water sources, while that of *S. macrognathus* fits with an open woodland habitat and drier environment. These scenarios are in line with previous research on the environment in Java during this time period, which indicated a progressive aridification of the environment due to glacial stages. Lastly, the phylogenetic relationship between the two species is unresolved. We suggest two possible scenarios: 1) *S. macrognathus* evolved from *S. brachygnathus* following a trend of insular gigantism, 2) the two species represent independent dispersals to Java at successive time periods. To test these hypotheses, more complete remains of *S. macrognathus* as well as a revision of phylogenetically valid traits in suids are necessary. Our research shows that suid remains can be used to validate paleoenvironmental reconstructions of hominid sites.

A hard life for *Ophthalmosaurus*: survey of osteopathologies in ichthyosaurs from the Middle Jurassic Oxford Clay of England.

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Palaeopathologies evidence mainly skeletal anomalies in the fossil record. Recent studies of palaeopathologies in ichthyosaurs have revealed how trauma-related bone modifications in different areas of the skeleton have changed over time, possibly in response to body-plan evolution. In this study, we surveyed 138 ichthyosaur specimens from the Middle Jurassic (Callovian) Oxford Clay of England that are housed in various European museum collections. Importantly, the Oxford Clay ichthyosaur assemblage is monotaxic, including only the single ophthalmosaurian species *Ophthalmosaurus icenicus*. In addition, *O. icenicus* bones from the Oxford Clay tend to be three-dimensionally (3D) preserved and are often found disarticulated, thus permitting a comprehensive inspection of all exposed surfaces for any signs of injury and/or disease. Given these parameters, we assessed: (1) how preservation affected the detection frequency of skeletal pathologies between samples; (2) whether the types of skeletal pathologies were similar or different to those reported in stratigraphically older ichthyosaur assemblages. Data was collected via an initial macroscopic survey by one observer to standardize occurrence scoring. Selected pathological bones were then subjected to more detailed examination using computed tomography (CT). Our assessment shows that the most common osteopathology in *O. icenicus* was trauma with healing in the upper and lower jaws (12/138 specimens = 9% of the total sample), followed by articular disease, including

avascular necrosis (7/138 = 5%) and ankylosis (5/138 = 4%) in the phalanges of the fore- and hind fins. An isolated femur with extensive tissue overgrowth might represent a tumor. In most cases, the osteopathologies observed in *O. icenicus* affected multiple surfaces of a single element, suggesting that 3D preservation does not overtly increase instances of detection in the fossil record. However, in contrast with other stratigraphically/ taxonomically constrained ichthyosaur assemblages, the proportional number of Middle Jurassic Oxford Clay *O. icenicus* specimens suffering observable osteopathologies (24/138 = 17%) was comparably higher than similar survey counts of Lower Jurassic (Toarcian) Posidonia Shale *Stenopterygius* spp. (12/104 = 12%), and Middle Triassic (Anisian–Ladinian) Besano Formation *Mixosaurus* spp. (9/190 = 5%). Nonetheless, the osteopathology types and affected skeletal regions were more compatible between *O. icenicus* and *Stenopterygius* spp. than *Mixosaurus* spp.; being predominantly distributed throughout the cranial and anterior appendicular versus axial skeletons. These results are consistent with our previous finding of body-plan linked osteopathologies in ichthyosaurs, and highlight an important field for future research into the broad temporal patterns of injury and disease in the evolutionary history of marine reptiles.

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Myobradypterygius hauthali (Reptilia: Ichthyosauria) from the Hauterivian of the Chilean subantarctic region including a gravid specimen.

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Ichthyosaurs were marine reptiles that inhabited the oceans during the Mesozoic Era and have been considered to be the best-adapted marine tetrapods during that time. Most of the fossil record of ichthyosaurs comes from the northern hemisphere, but a few localities from the southern hemisphere show the presence of the group. From the South American margin of Gondwana, ichthyosaurs are known in Colombia, Argentina, and Chile. Chilean ichthyosaurs have been reported in different regions of the country, of these, the most abundant are from the Early Cretaceous of the Magallanes region and include over eighty individuals, most of them complete and articulated. From these, the species *Myobradypterygius hauthali* von Huene, 1927 has been reported to be present in this deposit preserving exposed entire articulated skeletons but without a formal description. The holotype of *M. hauthali* was described almost a century ago based on fragmentary material from the Barremian of Argentina, including only an incomplete forefin. An excavation performed between March and April of 2022 on the border of the Tyndall glacier in the Torres del Paine National Park, allowed us to extract a complete and articulated 3.50 m skeleton of a gravid ichthyosaur. The specimen includes the skull, axial skeleton, pectoral girdle/ forefins, and pelvic girdle. A 150 mm long section of a fetus is preserved within the body cavity with 15 articulated vertebrae in lateral exposure. Another almost completely exposed specimen preserving cranial and postcranial elements has been reported. Additional skeletons were studied in situ. These specimens share with *M. hauthali* a unique combination of features (i.e., a hexagonal intermedium, a humerus with three distal facets for the radius, ulna, and anterior extrazeugopodial element, and rectangular tightly packed phalanges). The Chilean *M. hauthali* adds previously unknown anatomical information regarding the skull and postcranial skeleton (i. e., plicidentine in the tooth roots, a subdivided narial opening, and a strap-like scapular shaft) which greatly expands what is known regarding the anatomy of this species. The Southern Chilean Patagonia records of *Myobradypterygius hauthali* also extends both the geographical and the chronostratigraphic distribution of the species to the Hauterivian (131.07 +/- 0.07 Ma) of southernmost Gondwana, opening new avenues for further research on the paleobiology as well in the distribution and evolution of

platypterygiine ichthyosaurs in the southern hemisphere.

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The fossil mammal assemblage of Promano (Città di Castello, Italy): taxonomy and biochronology.

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Umbria is a region in the center of Italy with a small surface (ca. 8400 km^2) but a rich paleontological heritage, especially regarding Quaternary terrestrial vertebrates. Most paleontological sites are concentrated in the central and southern areas of the region (e.g., Pietrafitta, Pantalla, Villa San Faustino, Torre Picchio, etc.), whereas very few information is available on the northern part. Scanty remains of mammals are reported from Fighille, at the northern end of the region, near the border with Tuscany. Some kilometers south, around the city of Città di Castello, the presence of mammal fossils has been known since the 1970s, but so far only few of these have been preliminarily examined in some theses of those years. All these remains were retrieved by collectors in a sand quarry near Promano and are now part of the Città di Castello's municipal collections. In 2004, the Promano fossils were reported in a paper by P. Argenti as belonging to three different assemblages of latest Early Pleistocene, mid Middle Pleistocene, and Holocene age, respectively, but without providing any support to this chronological division. However, the information in our possession by the fossil collectors, points towards a homogeneous origin of the collection, although it cannot be ruled out that some specimens may come from different layers of the Promano sequence of fluvial sand.

Fossils from Promano are about 250. Our preliminary analyses indicate the presence of at least 13 large mammal taxa, namely, *Ursus* sp., *Canis* sp., *Meles* sp., *Pachycrocuta brevirostris*, *Castor fiber*, *Mammuthus* cf. *meridionalis*, *Stephanorhinus* sp., *Equus* sp., *Hippopotamus antiquus*, *Sus strozzii*, *Praemegaceros* sp., *Pseudodama* gr. *farnetensis-vallonnetensis*, and *Bison* cf. *schoetensacki*, alongside numerous coprolites. Some specimens such as nearly complete skulls of rhino, hippo, pig, and megacerine deer, stand out for their remarkable completeness. With the exception of a few fossils showing traces of abrasion (i.e., river transport) and/or weathering (i.e., prolonged subaerial exposure), most are in excellent state of preservation, indicating rapid burial in low-energy river context, compatible with the sedimentological evidence that can be recovered on the site. Although the systematic analysis of the assemblage is still in progress, the co-occurrence of some mammalian taxa suggests a latest Villafranchian or, most likely, Epivillafranchian age for the Promano fauna. If confirmed, this would make it one of the few assemblages of this chronology in Italy and certainly one of those with the best preserved fossils.

Evolutionarily-informative ancient proteins persist across geological timescales in polar regions.

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Ancient biomolecules are known to be favourably preserved in cold, dry environments as low temperatures arrest many degradation processes. Unlike for ancient DNA, which has not been identified beyond the Early Pleistocene, phylogenetically informative ancient proteomes have been recovered even from the Pliocene of a high-latitude permafrost site, and well-validated peptide sequences have been identified at high-elevation sites from the Late Miocene. While these applications illustrate the extended survival of ancient proteins over ancient DNA, it remains unclear if proteins may persist for extensive geological time scales, making it difficult to assess

claims of ancient protein preservation from beyond the last 5-10 million years.

Here, we use established protocols for the extraction of ancient protein sequences from highly -biomineralized remains to assess the likelihood of ancient protein survival across time and space. We sample broadly across various geographic localities and geological time ranges, focussing on latitudes and altitudes favourable to biomolecular preservation. Specifically, we attempt to push back the date for the oldest verifiable evidence for ancient protein survival by sampling dental enamel from high latitude sites in the Miocene, Oligocene, and Eocene of Antarctica and Canada's High Arctic. We also explore the potential for high altitude regions in preserving ancient proteins from deep-time, including some of the highest-elevation fossil sites yet discovered.

Our temporal sampling across progressively older deposits allows for the recognition of markers of proteomic degradation, which are necessary in identifying criteria for establishing the authenticity of ancient proteins. Ultimately, in tropical and subtropical regions, ancient peptides from highly-biomineralized sources do not appear to preserve beyond the Late Miocene, and phylogenetically-informative peptide sequences do not persist beyond the Pliocene. On the other hand, we were successful in extracting phylogenetically-informative peptide sequences from dental enamel from the Early Miocene (>20Ma) of Canada's High Arctic. However, this proteome displays significant degradation, and appears to approach the limit for sufficient proteomic preservation permitting phylogenetic reconstruction. Beyond this timeframe, we identify only limited evidence for protein preservation in older deposits from high latitudes. These results suggest thermal age correlates better with protein preservation than geological age.

While methodological development may allow for improvements in peptide extraction and identification, it appears unlikely evolutionarily-informative ancient proteins may persist beyond the Oligocene, even under favourable geological conditions. In tropical and subtropical environments, peptides likely cannot survive beyond the Late Miocene.

The thermal metabolism in Metriorhynchidae: a histological quantitative approach.

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The metriorhynchids were crocodylomorphs that adopted pelagic lifestyle within the seas that covered the earth from the Middle Jurassic (-167.7 Ma) to the Lower Cretaceous (-113 Ma). This unique ecological transition in the history of crocodylomorphs has long aroused the interest of paleontologists, namely since it raises questions about potential adaptive changes in biological properties such as thermal metabolism. In order to shed light on this matter, we inferred metabolic parameters of a metriorhynchid species, *Thalattosuchus superciliosus.* We used the histological data of femora as a proxy for endothermy probability, resting metabolic rate and nutrient foramina measured on ct-scans as a proxy for maximum metabolic rate, combined with phylogenetic comparative methods, among a sample of both extant and extinct crocodylomorph species. Thanks to a Phylogenetics Linear Regression (PLR) we computed the probability of endothermy while the Phylogenetics Eigenvectors Maps (PEM) allowed to infer both the resting and the maximal metabolic rates of *T. superciliosus*. The parallel interpretation of these analyses suggests that *T. superciliosus* both possessed an ectothermic metabolism and a low maximal metabolic rate like the extant crocodylian species. In other words, we hypothesize that *T. superciliosus* most likely shared a sit-and-wait opportunistic feeding strategy that is similar to the extant species' rather than it developed an active predator lifestyle that would potentially resemble that of the other Jurassic marine "reptiles" such as ichthyosaurs and plesiosaurs. Our study seems robust enough to assess the ecology of *T. superciliosus* but future investigations based on interspecific sampling are needed to draw any further conclusion over metriorhynchids paleobiology.

Identification of titanosaur sauropod dinosaurs from the Early Cretaceous of the UK.

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Titanosauriformes represents the most diverse and globally distributed clade of sauropod dinosaurs. Titanosaurs make up approximately half of known titanosauriform diversity, extending from the late Early Cretaceous to their last appearance as the only surviving sauropods in the latest Cretaceous. Most titanosaurs are found on southern continents, with a disproportionately small number of taxa known from northern continents, leading to most authors viewing titanosaurs as a primarily Gondwanan radiation. However, several recently described species from the Early Cretaceous of Eurasia appear to represent early members of Titanosauria that are contemporaneous with or predate many early Gondwanan occurrences. The age and affinities of these Eurasian species potentially challenge the traditional biogeographic model of titanosaurian evolution. Here, we describe several specimens of caudal vertebrae from the Barremian (Lower Cretaceous) Wessex Formation of the UK that appear to represent titanosaurs. One problem with comparing with other taxa when dealing with fragmentary specimens pertains to serial variation, i.e. anatomical differences might result from genuine taxonomic distinction, or could reflect anatomical changes along the vertebral column. To overcome this, we compiled quantitative data on shape and elongation from complete or relatively complete caudal vertebral series from twelve sauropod taxa, representing several clades, including Titanosauria (*Alamosaurus, Apatosaurus*, *Barosaurus, Baurutitan, Camarasaurus*, *Dreadnoughtus*, *Epachthosaurus*, *Giraffatitan*, *Mamenchisaurus, Omeisaurus*, *Tastavinsaurus*, *Wamweracaudia*). For each species, we determined where there are clear boundaries between regions of the tail. The boundary ranges of the taxa had substantial overlaps, with the posterior caudal boundaries differing the most and the anterior caudal boundaries being the most constrained. The upper boundary for anterior caudal vertebrae is placed between Cd8 and Cd18, most commonly at Cd14 as seen in four taxa. The upper boundary for middle caudal vertebrae ranged from Cd15 to Cd23 but most commonly at Cd15 and Cd18, seen in three taxa each. The upper boundary for posterior caudal vertebrae ranges between Cd24 and Cd47, but most commonly at Cd30 as seen in three taxa, with distal caudal vertebrae beyond this. These splits closely match previously proposed qualitative schemes based on the sequential loss of ribs, distinct postzygapophyses and neural spines, and entire neural arches. Based on these findings, the serial placement of the UK caudal vertebrae specimens can be estimated. We demonstrate that there are at least two distinct morphologies for the same region of the tail, indicating that there are at least two titanosaurian lineages present in the Early Cretaceous of the UK.

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 which comprise more than half of all living vertebrate species. 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 of concatenated genealignments, that the 3R WGD event occurred in the early-middle Permian (286.18-267.20 Million years ago; Ma), 52.02-12.84 million years (Myr) before the divergence of crown-teleosts in the latest-Permian-earliest Late Triassic (254.36-234.16 Ma) and long before the major pulses of teleost diversification in Ostariophysi and Percomorpha (56.37-100.17 Myr and at least 139.24-

183.29 Myr 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.

A new metriacanthosaurid theropod from the Middle Jurassic Balabansai Formation of Kyrgyzstan.

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Metriacanthosaurid allosauroids are an early branching clade of tetanuran theropod dinosaurs with a predominantly Asian distribution, with only a single taxon known from outside that continent, from the Late Jurassic of England. The oldest known representative, *Shidaisaurus*, comes from the early Middle Jurassic of south-eastern China, but most other taxa are known from the Late Jurassic and Early Cretaceous of southern and eastern Asia. Recent fieldwork in the late Middle Jurassic Balabansai Formation of Kyrgyzstan, central Asia, has yielded a partial skeleton of a large theropod dinosaur. The material includes a few bones of the skull (postorbital, quadratojugal), dorsal and sacral vertebrae, fragments of the pectoral girdle and forelimbs, and almost complete pelvic girdle and hindlimbs. It represents a new taxon, which can be diagnosed by an extremely developed orbital brow on the postorbital, a pneumatic opening leading into cavities in the neural arch from the centroprezygodiapophyseal fossa in posterior dorsal vertebrae, an enclosed ventral sulcus in manual phalanx II-1, a narrow and deep intercondylar groove on the anterior side of the distal femur, and an epicondylar crest on the distal femur that is offset from the distal end. A second, more fragmentary and smaller specimen from the same site, including partial pubes and ischium and a tibia, represents the same taxon. Based on long bone histology, the large individual represents a late subadult individual, whereas the smaller specimen is a juvenile, possibly indicating gregarious behaviour. Phylogenetic analysis places the new taxon in the Metriacanthosauridae, underlining the diversity and wide distribution of this clade in the Jurassic of Asia. A biogeographic analysis indicates the origin or at least early radiation of tetanurans and several of its subclades, including metriacanthosaurids, in south-eastern Asia, with a subsequent dispersal via central Asia and Europe into other continents.

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Evolutionary insights into the loss of ossified Meckel's cartilage from the development of the short-beaked echidna.

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Modern mammals possess a transient Meckel's cartilage that breaks down during the development of the unique mammalian middle ear. However, an increasingly diverse fossil record suggests that a persistent ossified Meckel's cartilage is plesiomorphic for the clade, and that the detached mammalian middle ear was acquired independently in the three extant lineages of crown mammals (eutherians, metatherians, monotremes) and in numerous extinct clades. Developmental evidence has proven invaluable in understanding the timing, mechanisms and triggers of Meckel's cartilage breakdown. For example, disruption of chondroclast cells in mice and opossums leads to a persistent Meckel's cartilage that morphologically resembles that of fossil mammals, suggesting that a heterochronic shift towards early clast cell recruitment is vital to break down Meckel's cartilage and form a detached mammalian middle ear. However, it is unclear as to whether this mechanism of middle ear detachment is present in non-therian crown mammals, including fossil groups that lost a persistent Meckel's. Monotremes are known to retain a robust Meckel's cartilage for a long period

after hatching, and so may provide better analogues for the persistent Meckel's of fossil mammals than embryonic or juvenile therians. In this study we used use micro-CT scanning, histological staining and immunofluorescence to map Meckel's cartilage breakdown and middle ear and jaw musculature development in neonatal *Tachyglossus*, the short-beaked echidna, to examine how monotremes can inform our understanding of mammal middle ear evolution. We show that Meckel's cartilage is the main structural component of the lower jaw for several days post-hatching, and that its 3D morphology changes dramatically during further development before it breaks down after >50 days. We find that early clast cell recruitment is responsible for Meckel's cartilage breakdown in echidnas as in therian mammals, strongly suggesting conservation of this mechanism among the living crown mammal lineages and, likely, fossil mammals with detached middle ears. Additionally, we find that the medial pterygoideus muscle and several intermandibular muscles are attached to Meckel's cartilage at birth, providing insights into possible triggers for Meckel's cartilage breakdown and muscle placement in extinct crown mammals. This study highlights the need for integration of developmental data in our efforts to understand morphological evolution in deep time and provides a window into the mechanisms by which mammals evolved one of their most diagnostic features.

A regurgitalite from the Early Permian Bromacker locality (Thuringia, Germany).

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Bromalites, i.e., fossilised gastric remains, can be preserved within (e.g., oralite, gastrolite, cololite) or outside (e.g., coprolite, regurgitalite) the body remains. In all cases, they represent digested elements that provide unique information regarding the behavioral ecology and physiology of extinct animals, such as direct evidence of predator-prey interactions. Regurgitalites are the fossilized remains of stomach contents that have been regurgitated. Here, we present a new specimen from the early Permian continental Bromacker locality (Tambach Formation, Thuringia, Germany), using computer-tomographic 3D-imaging technologies, as well as chemical and taphonomical analyses. The specimen exhibits a relatively compact cluster of at least 45 small bones, an unusual taphonomic disposition suggesting that it represents a regurgitalite. The bones preserved within this cluster are disarticulated and partially aligned along their long axis and include mostly long bones and a maxilla. The majority of elements most likely belong to a single taxon, the small captorhinomorph reptile *Thuringothyris mahlendorffae*. Furthermore, the regurgitalite contains at least two additional long bones that do not belong to *Thuringothyris*, instead representing two other distinct taxa, likely an anamniote and another small reptile. The size and composition of this specimen suggests that this regurgitalite was produced by a terrestrial apex predator, such as the sphenacodontid *Dimetrodon teutonis* or the varanopid *Tambacarnifex unguifalcatus*, already known from Bromacker. This study constitutes the first description of an early Permian regurgitalite from a terrestrial ecosystem and provides novel insights into the behavioral ecology of the trophic network that would have been present at the Bromacker locality.

A new macronarian (Dinosauria, Sauropoda) from the Late Jurassic Cañadón Calcáreo Formation of Argentina and the systematic incongruences of recent phylogenetic studies.

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Terrestrial sediments from the Late Jurassic are abundant in the continents that conformed Laurasia, but few terrestrial Late Jurassic units are known from the Gondwanan continents. The Cañadón Calcáreo Formation of Argentina, together with the Tendaguru Formation of Tanzania, are the only units that have yielded several articulated or closely associated sauropods

from the southern hemisphere. Here we present a new non titanosaur macronarian sauropod (MPEF-PV 1730), composed of a semi-articulated cervical to sacral vertebral series with additional closely associated ribs and caudal vertebrae. The new specimen shares the reversal to dorsal neural spines that are longer anteroposteriorly than wider mediolaterally with the other macronarian from the same formation, *Tehuelchesaurus benitezii*. However, several other characters suggest that these two specimens belong to separate genera: the hyposphene in middle to posterior dorsals is ventrally supported by paired CPOL in the new specimen and the sTPOL in *Tehuelchesaurus*; the pleurocoel is triangular and enlarged in the new specimen while it is oval and rather small in *Tehuelchesaurus*; posterior dorsal vertebrae of MPEF-PV 1730 are only slightly ophistocoelous when compared to those of *Tehuelchesaurus*. The phylogenetic position of the new specimen was tested using two of the most recent matrices with a wide variety of non-neosauropod eusauropods and neosauropods, both macronarian and diplodocoids. Depending on the matrix, the new specimen can take different positions within the tree in our preliminary results: as a non-titanosauriform macronarian, together with *Tehuelchesaurus* (supported by dorsal neural spines with subparallel lateral margins without triangular aliform process and dorsal margin of the pleurocoels in middle to posterior dorsal vertebrae at the level of the neurocentral junction), or within Brachiosauridae (supported by the absence of pre-epipophyses in cervical vertebrae and a high aEI in anterior caudals). Between these analyses there are additional phylogenetic incongruences: *Tehuelchesaurus* is recovered within Macronaria or Turiasauria; *Europasaurus holgeri* is recovered outside or within Brachiosauridae; *Camarasaurus, Lourinhasaurus alenquerensis* and *Bellusaurus sui* as non-titanosauriform macronarians or outside Neosauropoda; *Euhelopus zdanskyi* is recovered within Somphospondyli or as a non-titanosauriform macronarian. The underlying causes for topological incongruence are difficult to identify and remain ambiguous. In sauropod phylogeny, taxon choice has long been discussed to influence tree topology, but its effect has been rarely tested. Using comparative cladistic methods we recognise taxon and character choice as the main causes for incongruence.

Triassic Treasures: New Insights into Svalbard's Marine Reptile Heritage.

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The recovery from the end-Permian mass extinction marked the emergence of new groups of secondarily aquatic top predators, including ichthyopterygians, thalattosaurs, and sauropterygians. Among these, sauropterygians were one of the most diverse groups in the Mesozoic, originating in the Early Triassic and playing a significant role in marine ecosystems until their extinction at the end of the Cretaceous. Eosauropterygians, a subset of sauropterygians, encompass all sauropterygians excluding the placodonts. During the Triassic, eosauropterygians included pachypleurosaurs, nothosaurs, and pistosaurs, were found primarily in the Panthalassa and Tethyan provinces, with limited specimens reported from the northern border of Pangea.

In this study, we present isolated material from the Late Triassic De Geerdalen and Tschermakfjellet Formations of Svalbard (Norway) and compare it with previously described specimens. The material includes both historical and recent collections. We utilized Micro-CT to examine the internal structure of the vertebrae, focusing on the presence, absence, and positioning of penetrating foramina. The different vertebrae are clearly distinguished into two morphotypes, and are assigned to Nothosauridae and Pistosauridae. The described material includes multiple isolated cervical and dorsal centra. Morphotype 1 (Nothosauridae) comprises of platycoelous vertebrae with highly wrinkled and rugose articular surfaces. This morphotype features a laterally expanded centrum-neural arch contact, with the characteristic eosauropterygian 'butterfly'-shaped or cruciform neural arch facet. The lateral surface is slightly constricted, with no visible external nutritive foramina and a lack of pachyostotic internal bone structure. The cervical vertebrae of this morphotype bear single-headed rib facets, consistent with some members of Nothosauridae. Morphotype 2 (Pistosauridae) includes a platycoelous cervical and pectoral and two flat- to platycoelous dorsal vertebrae with smooth articular surfaces. The lateral surface is

significantly more constricted than in Morphotype 1 and in addition is constricted ventrally in dorsal centra. External nutritive foramina are visible and can be followed internally using radiographs. The cervical vertebra (PMO 210.642) exhibits a clear keel, separating the nutritive foramina. This morphotype closely resembles previously described material from the Late Triassic of Svalbard. Notably, the vertebrae assigned to Nothosauridae represent the first members of this clade described from Svalbard, demonstrating the presence of both Nothosauridae and Pistosauridae in the region during the Late Triassic.

Lessons learned on repatriating fossils.

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Until recently, repatriating fossils was mainly an administrative and curatorial activity that was only occasionally mentioned in publications. However, the topic has received more attention in the last few years, notably after high-profile auctions of theropod dinosaurs, with the recent repatriation of Brazilian fossils also seeing growing academic and public interest.

Since 1942, Brazilian legislation has determined that all fossils found within its frontiers belong to the state, regardless of whether they are found on private or public lands. Any type of export—taking a fossil out of the country—should be subject to formal analysis and approval. As many famous paleontological deposits in the country only began to be systematically excavated after 1942, most Brazilian fossils currently overseas left the country after that date, potentially having done so without the proper export authorization and, thus, illegally. This is especially concerning with the vertebrate fossils of the Santana Group, which recently sparked ethical concerns that resulted in some of them being repatriated. There are some interesting lessons to be learned from these cases.

Repatriating vertebrate fossils that are in the hands of vendors is bureaucratic. A recent case of Santana fossils being sold in a shop in France involved authorities from both countries. It required a years-long justice court case that analyzed and ruled on the situation. This process is very time-consuming, and legal costs can be high for the parties involved. However, for fossils in scientific collections, repatriations can be treated as donations, a much more straightforward process. Fossils in public collections can (and preferably should) be donated in a friendly manner. Negotiations should include administrators, directors, and curators. After deaccessioning, the repatriation requires a letter of donation from the donor collection and a letter of acceptance from the recipient institution. In the case of private collectors, it is important to be mindful that fossils can be lost if the family does not share the same interests or does not have the means to maintain them. In this case, donations or their arrangements can be made in life to avoid inheritance-related bureaucratic problems.

If small enough, donated fossils could be transported by hand or through a courier. For large collections, transportation needs to be done using a specialized company whose costs can be negotiated with the receiving institution. There are good recent examples of vertebrate fossils that have been donated and repatriated to Brazil from public and private collections.

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A new record of a marine reptile from the Agua Nueva Formation in Vallecillo, Nuevo Leon, Mexico.

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Outcrops of laminated marlstones from the Upper Cretaceous (Turonian) Agua Nueva Formation around Vallecillo, Nuevo León, Mexico, have produced several new species of fossil marine vertebrates, and continue to be a source of important fossil material. Coming from this locality, a fragmented specimen has been detected in various slabs that presents skeletal elements of a sauropsid-type organism. A large part of the vertebrae can be seen, as well as a flat femur that is wider than it is long, similar to that of the polycotylid *Mauriciosaurus fernandenzi*. We can also visualize the pubis on the same slab as the ilium, this due to its

large size, in addition to being relatively close. According to other fossil evidence of extinct sauropsids, particularly leptocleidid pliosauroids share a characteristic like those we see in thin ribs. We also have evidence of possibly half of the cervical vertebrae. We can also highlight several complete plate-shaped bones that may come from the pubis, ischium and coracoid. We have concluded that this specimen did not reach great length and was more similar to the leptocleidid pliosauroids, due to the dimensions of the skeletal elements that, as far as can be seen, were not large in size, taking as a reference the dimensions of different specimens of marine reptiles discovered in the same region.

3D Range of motion analysis of the forelimb of the Permian recumbirostran 'microsaur' *Batropetes palatinus* and its implications for fossoriality.

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Recumbirostran 'microsaurs' represent a diverse group of terrestrially-adapted Permo-Carboniferous tetrapods, which show a wide range of morphological adaptations associated with a fossorial lifestyle. These adaptations include specializations for head-first burrowing as well as forelimb-based scratch-digging. Traditionally, recumbirostrans have been placed within anamniote lepospondyls but have more recently been suggested to represent reptilian amniotes. Independent of their phylogenetic placement, investigating the paleobiology of recumbirostran 'microsaurs' represents an opportunity to better understand the origin and evolutionary history of burrowing behaviors among early tetrapods. However, the morpho-functional abilities of the group currently lack robust biomechanical testing. The exceptionally complete and well preserved brachystelechid *Batropetes palatinus* represents an ideal specimen to undertake biomechanical analyses. Here, we employ computational range of motion (ROM) analyses to assess the potential fossorial capabilities of its forelimb. In parallel we apply our methodology to two extant phylogenetic bracketing and known fossorial taxa, *Ambystoma tigrinum* (Amphibia) and *Heloderma suspectum* (Reptilia). Preliminary ROM results in *Batropetes* reveal an overall similar forelimb joint mobility to that of both *Ambystoma* and *Heloderma*. However, *Batropetes* records more restricted mobility in the shoulder and elbow joints than both taxa. We hypothesize that restricted motion in the elbow joint may help in the stabilization against dislocation and strengthen the elbow during digging motions. However, the forelimb also records limited anterior reach at the shoulder joint, questioning the aptitude for forelimb-based digging. Although lateral undulation of the body could potentially counterbalance this constraint, the overall advantage of this combination of movements is unknown at present. This study emphasizes our limited knowledge on fossoriality in extant amphibians and reptiles and highlights the necessity for more suitable comparative material. Our findings offer new biomechanical perspectives on evolutionary adaptations associated with a fossorial lifestyle and help to improve our understanding of forelimb-function in recumbirostran 'microsaurs'.

A new styracosternan dinosaur specimen (Ornithischia: Iguanodontia) from the Lower Cretaceous Wessex Formation of the Isle of Wight, southern England.

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Wealden Group exposures in southern England form some of the most fossiliferous non-marine strata found in Western Europe. Their rich faunal assemblages are dated to the Lower Cretaceous and have generated a two-hundred-year history of palaeontological research. The Wealden Group is represented on the Isle of Wight by the largely Barremian Wessex Formation, representing deposition in a fluviolacustrine meander-plain environment, overlain by the Aptian Vectis Formation,

representing a shallow lagoon. The Wessex Formation is rich in large iguanodontian remains, which historically have been referred to *Iguanodon bernissartensis* or *Mantellisaurus atherfieldensis*, although the recent description of *Brighstoneus simmondsi* suggests that diversity in this group may have been underestimated. This contribution describes a novel iguanodontian specimen excavated from the oldest exposed rocks of the Wessex succession at Hanover Point, on the Hauterivian-Barremian boundary. The specimen (OUMNH PAL-K.40631) housed in the Oxford Museum of Natural History is represented by axial and pelvic elements. This specimen is older than the holotypes of *Mantellisaurus* and *Brighstoneus* and can be distinguished from these taxa by a combination of characters: The neural spines of the dorsal vertebrae are relatively much shorter than in *Brighstoneus*; the first sacral rib facet of the ilium is visible in lateral view as in *Barilium dawsoni*; the robusticity and angles of the ischiadic and pubic peduncles differ from *Brighstoneus* and the prepubic blade is more broadly expanded dorsoventrally than in *Mantellisaurus*. This new specimen gives further support to a wider iguanodontian diversity on the Isle of Wight.

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Preservation patterns of vertebrate remains from the Lower Triassic (Spathian) Grippia bonebed from Svalbard, Norway.

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The Lower Triassic Grippia bonebed from the Vikinghøgda Formation on the Svalbard archipelago in the Scandinavian Arctic yields a surprisingly rich assemblage composed of chondrichthyans, actinopterygians, coelacanths, dipnoans, temnospondyls, and diverse ichthyosauriform marine reptiles. The amassed collection, surpassing 20,000 specimens, incorporates isolated scales, teeth, and bones recovered from an area of only ~33 m². The bonebed contains skeletal elements with a distinctly broad range of preservation patterns and degrees of post-mortem alterations. Here, we present observations on taphonomical features of the Grippia bonebed material.

Most of the specimens exhibit very good 3D preservation with a relatively limited number of distinctly compressed specimens. The latter are predominantly represented by ichthyosauriform vertebrae tentatively assigned to *Omphalosaurus*. Moreover, ichthyosauriform caudal vertebrae tend to be much more commonly compressed compared to specimens derived from other portions of the vertebral column. The good 3D preservation is attributed to the strong phosphatization of the outer bone layer revealed through histological analysis. Moreover, the investigation of pore mineral infillings suggests extensive (likely early) precipitation of calcite in the bone pores, enhancing the structural preservation of specimens.

On the other hand, specimens exhibiting strong compression more frequently show sediment infill of bone pores petrographically equivalent to the silty shale matrix of the bonebed. Signs of late diagenetic alterations are also observed by sulfur phases permineralization, including sphalerite (ZnS) and baryte (BaSO4), most likely related to Cretaceous HALIP and circulation of sulfur-rich fluids. Skeletal elements also exhibit a range of abrasion features, ranging from non-abraded to slightly and moderately abraded specimens. Surface polishing can pertain to the entire specimen as well as to localized parts of it. The outermost bone layer also shows variability among specimens, ranging from well-preserved to cracked and flaking portions. These observations indicate a highly varied degree of transportation and/or exposure of elements on the sea floor. However, an overall uniform pattern of fossil phosphatization and similar likely early diagenetic bone infilling indicates that at least most specimens underwent permineralization of skeletal elements within the bonebed, and the inclusion of reworked elements fossilized in other settings is restricted or absent.

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Extensive internal modifications of cervical vertebrae in Triassic long-necked archosauromorphs.

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The Triassic period saw the emergence and diversification of a plethora of successful lineages of reptiles, some of which are still extant (e.g. turtles, squamates, rhynchocephalians, crocodylians). Among the evolutionarily successful groups of the early Mesozoic, tanysaurians (Tanysauria, Archosauromorpha) exhibited especially disparate lifestyles and habitats (terrestrial, semiaquatic, aquatic, and possibly gliding forms). One of the key features that might have allowed them to flourish, was their highly specialised neck anatomy. Some tanysaurians (tanystropheids) had extremely elongate cervicals, while others (trachelosaurids) increased the cervical vertebrae count instead. While the external morphology of these bones is generally well known, their internal structure has never been comparatively studied in detail, although some researchers have already noticed that their "hollow" centra are unique among vertebrates. We investigated the histology and microanatomy of tanysaurian vertebrae, to provide the first comprehensive description of their internal anatomy.

We sampled representatives of two tanysaurian genera (*Tanystropheus* spp. and "*Protanystropheus*" *antiquus*), using traditional thin sections, polished sections, and computed tomography. Nearly 40 vertebrae, including both historic and newly excavated specimens, were analysed. In both studied taxa an internal cavity occupies most of the volume of the centrum. In "*P.*" *antiquus*, symmetrical slanted trabeculae cross the middle portion of its cavity, ventrally propping the floor of the neural canal. In *Tanystropheus* spp., the middle portion of middle cervicals is nearly devoid of trabecular bone - there is even no remnant of the neural canal floor. Thus, in both genera, the vertebrae are cylindrical and built mostly of dense cortex, which provided durability while contributing less to the weight of the neck. Whereas some similarities to avemetatarsalian bones exist, there is no evidence for pneumatisation in tanysaurians. However, *Tanystropheus* spp. have a pair of foramina that connect the internal cavity with the ventral surface of the centrum, which we interpret as being of vascular origin. Posterior cervicals show that the canals originating from these foramina run straight to the neural canal, showing that intersegmental arteries were present in *Tanystropheus* spp. In the absence of pneumatisation, the internal cavity was most likely filled with bone marrow.

Our results are relevant for better understanding of a unique and extreme anatomy among tetrapods, which evolved as a result of very strict selection for some particular function. Moreover, extreme modifications of the internal anatomy of vertebrae were not unique to derived avemetatarsalians (pterosaurs and dinosaurs), but more widespread among archosauromorphs.

Acknowledgement: We thank everyone involved in the excavations in Miedary, all technicians responsible for specimen preparation and data acquisition, as well as the museal collections managers who allowed us to study their material.

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A newly described neoselachian fauna from the Grippia Bonebed (early but not earliest Spathian, Early Triassic) of Spitsbergen.

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Despite the 150 years that chondrichthyans (cartilag-inous fish) from the Triassic of Spitsbergen have been studied, it includes only one previous

description of a neoselachian (modern shark) species. This study focuses exclusively on the neoselachian dental material in the Grippia Bonebed. Of the thousands of chondrichthyan teeth retrieved from the bonebed by the Spitsbergen Mesozoic Research Group in 2016, 56 have been assigned to the subcohort Neoselachii. Herein, dental material from four species of neoselachians from the Early Triassic of Spitsbergen are described in detail. The newly discovered material leads to the establishment of two new monotypic genera (*gen 1* and *gen 2*), introduces a new species of *Synechodus* (*Synechodus sp 1*), and reaffirms the classification of *Synechodus incrementum* within the order Synechodontiformes and the *Synechodus* genus. A detailed histological approach was applied with scanning electron microscopy (SEM) imaging of etched sections through multiple axes and positions in the teeth. Our study revealed that advanced enameloid microstructures were present already in the Early Triassic. The newly described neo-selachian fauna from the Grippia Bonebed shows a wide range of enameloid microstructures. These range from an outer single crystallite layer paired with an indistinct bundled crystallite layer underneath, as observed in *gen2*, to a complete triple-layered enameloid including radial bundled enameloid in *Synechodus sp 1*; indicative of a highly derived enameloid. *Gen 1,* stands out among its contemporaries, with its monocuspid, serrated teeth and relatively large size. These characteristics resemble those of younger relatives and are reported for the first time in a neoselachian from the early but not earliest Spathian (Early Triassic).

A fossil is not just a fossil - fostering transparency, accessibility and preservation of excavation documentation in a colonial vertebrate palaeontology collection.

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In the past, the collection history for colonial vertebrate palaeontological collection suites was often considered important mostly because it provided additional scientific documentation and this history was viewed from the perspective of the colonisers. In recent years however, ongoing debates about and the generally increasing awareness for the colonial heritage have encouraged other ways of looking at the collections we manage. Justified demands are being made to open up colonial collections, specifically to increase their transparency and accessibility. Colonial scientific objects are simultaneously scientific and cultural objects, and multiple new perspectives lead to very different demands regarding these objects. As scientific curators, we need to take up these developments and become aware of our responsibility for these colonial palaeontology collections, including acknowledging and incorporating other perspectives in our daily collection-based work, for example by actively seeking feedback from people in the countries of origin of the specimens. Providing as much transparency and information about the collections as possible is always the first step to get into a proper and factual dialogue. Possible ways to achieve this are outlined here using the example of the colonial Late Jurassic dinosaur collection from Tanzania housed at the Museum für Naturkunde Berlin.

To increase transparency and availability of object data, we are currently developing a comprehensive digitisation strategy for the dinosaur fossils that in addition to 3D digitisation also includes metadata and paradata assessment, documentation, and low-barrier accessibility of the data. This strategy will be oriented on the FAIR principles and very importantly, contextualising the data in terms of their colonial background and making them available on the virtual level. Scientific practices of describing specimens are being overhauled, as visible for example in naming practices of new taxa (e.g., *Wamweracaudia keranjei*, named in 2019) or acknowledging labour of the people working on the historical site explicitly in scientific publications. Using non-destructive approaches of researching specimens, e.g., CT scans of unprepared materials, helps to preserve unique documentation of colonial field practices as well as the expertise of local people that the Tendaguru expedition harvested from. Finally, when active preservation and documentation (e.g., 3D surface digitisation, photo documentation of unprepared specimens) of historical field practices

becomes part of the collection management strategies, we can preserve colonial collection specimens as life documents of palaeontological excavations under colonial conditions and increase awareness of fellow scientists for the multiple perspectives one can have on a dinosaur bone.

Digitizing and sharing of the JURASSICA Museum's extensive Late Jurassic Dinosaur Ichnological Collection.

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In the realm of natural history preservation, digitization currently stands as a cornerstone for improving and democratizing accessibility and assisting with research advancement. Recognising this, the JURASSICA Museum in Porrentruy (Switzerland) was granted funding from the SwissCollNet initiative of the Swiss Academy of Sciences to launch the digital curation of its vast ichnological collection.

JURASSICA houses and manages one of the world's most extensive repositories of Late Jurassic dinosaur tracks and trackways previously collected under the "Paléontologie A16" (PAL A16) project. Systematic excavations, during the construction of the A16 "Transjurane" highway (1987–2017), allowed for 14,000 dinosaur tracks to be documented, with more than 650 track-bearing slabs of limestone and over 190 casts of trackways, entering what is now the JURASSICA Ichnological Collection (JIC). Crucially, the significance of the JIC is accentuated by the meticulous field metadata gathered by the PAL A16 team, corresponding to the documentation of almost every track (i.e., by photos, maps, measurements, etc).

This invaluable collection stands as an unparalleled global resource for paleontological research and education. Over the past two years, we have produced high-resolution 3D models of all track-bearing slabs of limestone and casts of trackways in collection, sorted and reorganized the PAL A16 field metadata, and designed richly illustrated educational materials explaining track formation, faunal diversity, etc. All of these will now be hosted in an open digital platform to facilitate research on this collection, foster collaboration, and data sharing among researchers. Additionally, this initiative aims to disseminate educational materials, nurturing public interest in ichnology and broadening our educational outreach efforts. Altogether, the digital curation of the JIC also ensures the long-term accessibility and preservation of this unique collection and aims to encourage virtual curation in ichnology collections.

Late Miocene fauna around a shrinking sea: ichnofossils from the Zhyghylghan Escarpment, Kazakhstan.

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The Zhyghylghan site, situated within the Zhyghylghan escarpment near Fort-Shevchenko, Kazakhstan, offers a remarkable window into the late Miocene (Khersonian age: 9.85-7.65 Ma). This site is perched on what was once the shoulders of a large inland sea (Eastern Paratethys). Traditionally, the deposits which make up the sedimentary succession of Zhyghylghan escarpment are considered marine, with a range of marine vertebrate (e.g., whale) and invertebrate fossils (e.g., *Chersonimactra* sp.). However, several discrete bedding planes also preserve evidence for terrestrial vertebrates living on the sea's margins. Our study represents the first comprehensive analysis of the ichnofossils found at this location, shedding light on animal life in this region, during this period.

Through examination of fallen boulders and careful logging of exposed sections, we have identified three distinct and successive layers containing tracks at Zhyghylghan. The track-bearing package, along with their sedimentary structures and facies associations, suggests deposition in coastal floodplain settings and reveals a complex interplay between fluctuating water levels, invertebrate burrowers, and a diverse vertebrate ichnofauna. Notably, vertebrate tracks include those of small and larger-sized equids (*Hippipeda* isp.; several with posterior lateral digit impressions [hipparions]), felids (*Felipeda* isp.), canids (*Bestiopeda* isp.), and large birds (cf. *Fuscinapeda* isp.).

Tridactyl equid trackways and *Felipeda* isp. are present on all bedding planes. More enigmatic traces are preserved as a trackway series of 4 thin (mm-scale), roughly parallel, and arcuate grooves, and likely representing swimming behaviours. Tracks belonging to fauna commonly noted between Europe and Asia at this time, such as cervids, artiodactyls (*Pecoripeda*), and rhinos (*Rhinoceripeda*) are notably absent. Similarly, bird tracks are rare, limited in diversity, lacking smaller forms, and show no indication of shoreline or milling behaviours.

Morphological preservation of the tracks varies significantly across a track-bearing bedding surface and is controlled by substrate saturation, that ranged from damp sands, where tracks show higher morphological fidelity, to semi-firm muds, where tracks show expulsion rims and digit distortion. Retreat of the shoreline during evaporative cycles likely aided in track preservation.

Our provisional work suggests a complex relationship between fauna and environment, with animals repeatedly visiting water-margin settings. Paleoenvironmental changes during the Khersonian ('Khersonian drying') resulted in significant changes in water level and salinity in the Eastern Paratethys and lead to the formation of freshwater coastal plain environments. This phenomenon hints at the possibility of larger vertebrates frequenting the plain as the water there became fresher, although a more thorough investigation of track abundance and associated body fossils is necessary. By situating the Zhyghylghan site discoveries within the broader geological and climatic context of the late Miocene, our study contributes to a deeper understanding of ecosystem dynamics during this transformative period.

In the belly of the beast: *Temnodontosaurus* bromalites from the Lower Jurassic elucidate trophic ecology and prey preference of a macropredatory ichthyosaur.

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Temnodontosaurus trigonodon is the most iconic apex predator found in the Posidonienschiefer Lagerstätte, and one of the largest parvipelvian ichthyosaur from the Lower Jurassic. Fossilized food items found in or passed through the digestive tract of an animal (bromalites) offer a precious window into the dietary habits and ecological role of the producer taxon, but bromalites attributed to *T.trigonodon* received little attention in the past. Two specimens interpreted as (or containing) bromalites were identified in the collections of the Staatliches Museum für Naturkunde Stuttgart. The first, represented by an almost complete coiled-up juvenile *Stenopterygius* skeleton, has historically been interpreted as a regurgitalite. The peculiar taphonomy of the specimen supports this interpretation, since no abiotical processes could have feasibly clustered the skeletal elements in its current state; moreover, *T.trigonodon* is the only known taxon in the Posidonienschiefer Fm. with a sufficient mouth gape to ingest and egest the size class of the studied specimen whole. The second specimen is represented by a complete *T.trigonodon* skeleton, preserving a large area of stomach contents in the former epigastrium and abdomen, composed of coleoid remains and neonatal ichthyosaur bones. Position, preservation and degree of ossification of the consumulite bones readily excludes the possibility that these represent fetal temnodontosaurs. 248 centra were counted in situ inside the consumulite, implying that the specimen ingested at least 4 postnatal ichthyosaurs, most likely *Stenopterygius* based on comparisons of centrum size to neonatal specimens of this genus. ESEM microstructural analysis of bone fragments extracted from the gastric mass revealed a roughened texture of the cortical tissue, together with the removal of mineralized cartilage on articular surfaces attributed to acid etching. Chemical characterization of the samples revealed a paucity of phosphorous, consistent with early stages of digestion for the gastric content. The two surveyed bromalites further confirm the role of apex predator of *T.trigonodon* in the Posidonienschiefer Fm., but also highlight a specific targeting of neonatal to juvenile *Stenopterygius* individuals as prey items.

mysterious billfish-like rostrum fragment from the Lower Cretaceous of Italy: preliminary results on rostral anatomy and dentition.

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The Ligurian Complex from the Northern Apennines (Italy) represents several marine Cretaceous formations deposited in deep-water settings. Extremely rare and fragmentary fossils of pelagic vertebrates have been described from the Albian-Cenomanian interval, including lamniform sharks and platypterygiine ichthyosaurs. Here we describe the occurrence of a large actinopterygian from the Ligurian Complex based on a rostrum fragment from the collection of the University of Modena and Reggio Emilia. Preliminary nannoplankton analysis confirms the fossil to be from the Lower Cretaceous. The specimen is represented by a posterior portion of upper and lower jaws in occlusion, both bearing paired bones. The lower jaw is much reduced relative to the robust upper jaw, indicating a billfish-like cranial morphology. The upper jaw is characterized by a peculiar reticular (net-like) ornamentation pattern on the dorsal surface, while the ventral and lateral portions of the premaxillae are draped by small and densely-spaced alveoli. A CT scan of the rostrum highlights a large tripartite longitudinal vacuity in the upper jaw. Numerous millimetric villiform teeth are found closely associated with the dental plates and dispersed within the matrix between the two jaws. These denticles show two different morphotypes, smooth and stout or thin and crossed by fine apicobasal ridges, both capped by a translucent acrodine tip. The presence of paired bones in the rostrum readily excludes its assignment to *Protosphyraena*. The specimen overall exhibits features found in modern and fossil Xiphioidea, which most likely represent convergently developed characteristics shared by other Cretaceous longirostrine taxa (e.g., tselfatiifom plethodids).

A preliminary report on new, and re-evaluated sauropodomorph dinosaur specimens from Southeast Asia.

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Southeast Asia (SEA) has experienced a significant rise in sauropodomorph dinosaur research, with 27 publications appearing mainly in smaller journals and sometimes written in local languages over the past two decades. The increasing volume of publications and the challenge of accessing information highlight the necessity for a detailed and comprehensive review of SEA sauropodomorph taxa, encompassing both unnamed and currently taxonomically indeterminate specimens. Previous studies have suggested the presence of various sauropodomorph groups in SEA, including non-sauropod sauropodomorphs, 'basal' sauropods, vulcanodontids, mamenchisaurids, diplodocoids, brachiosaurids, and somphospondylan titanosauriforms, in addition to the three established taxa: the 'basal' sauropod *Isanosaurus*, and the somphospondylans *Phuwiangosaurus* and *Tangvayosaurus*. Our preliminary study of the available specimens has confirmed some of these identifications, whereas others are yet to be substantiated. Presently, we can confirm the presence of a well-preserved non-sauropod sauropodomorph, a basal sauropod species distinct from *Isanosaurus* based on morphological differences in the femur, and the first Early–Middle Jurassic eusauropod from the region, previously reported in the local language. Furthermore, recent analysis of the first sauropod remains from the Aptian–Albian Khok Kruat Formation in the Chaiyaphum province of northeastern Thailand, has identified a large somphospondylan that is distinct from *Phuwiangosaurus* of the older Valanginian–Hauterivian Sao Khua Formation based on morphological disparities in the dorsal vertebrae and humerus. New data resulting from fieldwork and observations of existing specimens is essential in the revision of character scores and in turn will be used to produce an updated phylogeny for sauropods that will form the basis for testing macro evolutionary hypotheses such as biogeography.

Digesting an ancient ecosystem: coprolites from the Lower Triassic Grippia bonebed in Svalbard

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Five coprolite morphotypes were identified and described from the Grippia Bonebed, Vikinghøgda Formation, Lower Triassic, Svalbard. The bonebed consists of disarticulated skeletal material, teeth, and coprolites. 97 coprolites were studied and sorted based on shape and inclusions. Inclusions were studied using thin sections, SEM and micro CT-scanning that gave remarkable results. The analyses revealed inclusions such as bone material, fish scales and the first documented evidence of invertebrates in the Grippia bonebed. Invertebrates include sponge spicules, a cephalopod shell fragment and a high abundance of cephalopod hooks. Possible coprolite producers are discussed and includes fish, chondrichthyians, temnospondyls, ichthyopterygians and archosauriforms. This study introduces a new method for finding cephalopod hooks in CT-scans and provides a more complete picture of the marine paleoecosystem in the Grippia bonebed, Early Triassic, Svalbard.

The mysterious theropod dinosaur *Bagaraatan ostromi* is a chimaera.

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In 1996 remains of a small carnivorous dinosaur of unknown systematic position from the Nemegt Formation in Mongolia were described. The specimen was named *Bagaraatan ostromi* Osmólska, 1996 and later it was proposed to be related with the bird-like maniraptorans or tyrannosaurids. The reanalysis of all the material found in the assemblage revealed that *B. ostromi* is a chimaera of two theropod taxa. The leg and most of the bones undescribed in Osmólska's paper are identified as Caenagnathidae indet. The mandible, cervical vertebrae, pelvis, tail, and one pedal phalanx, show tyrannosaurid affinities. The latter is considered as the holotype of *B. ostromi* showing two potentially diagnostic features: double surangular foramina and a horizontal ridge on the lateral surface of the postacetabular process of the ilium. Given the small size of the holotype and the presence of numerus features characterizing young *Tyrannosaurus rex*, *B. ostromi* appears to be one of the smallest juvenile tyrannosaurid currently known. Thus, the potentially diagnostic features may fit within the individual or ontogenetic tyrannosaurid variability. Thus, while the validity of *B. ostromi* is provisionally upheld, it will require confirmation when the available sample of juvenile tyrannosaurids increases in the future.

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A three-dimensional comparative atlas of the post-cranial skeleton in extant Crocodylia.

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Unlike the semi-aquatic carnivorous crocodiles, alligators, caimans, gharials and false gharials of extant Crocodylia, the more inclusive clade Crocodyliformes – to which Crocodylia belongs – once composed a much greater variety of organisms in terms of shape, size and ecologies, dating back to the Late Triassic. These forms spanned from completely terrestrial to the completely marine, with locomotion styles ranging from swimming to sprawling gait to fully upright running; some species being as small as a house cat while others reached toward ten meters in length. Their trophic guilds included not only carnivores, but likely insectivores, malacophages, omnivores and herbivores as well. While research has deepened our understanding of crocodyliform evolution and paleoecology, the shape of post-cranial material remains undervalued and under-represented in phylogenetic matrices, especially in Eusuchia. Additional attention is required here, since paleoenvironmental adaptation and loco-

motion likely also diverged in this clade. To facilitate further paleobiological interpretations, there is a need for easily accessible post-cranial comparative material of extant species. To this end, the external morphology of a few extant crocodylian species' skeletal elements, judged to be both representative of similar elements within each species' Bauplan, and of phylogenetic as well as (paleo)ecological importance, were captured through surface digitization methods for 3D modelling purposes and subsequent morphological description. The complete post-cranium was digitized by structured light scanning. Moreover, we emphasized the most relevant appendicular elements (scapula, coracoid, humerus, ulna, radius, ilium, femur, tibia, fibula, astragalus, calcaneum), axis, last cervical, sacral and first caudal vertebrae with higher resolution models made by photogrammetry.

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Severe droughts did not restrict the distribution of large herbivorous dinosaurs in the Triassic – evidence from the lungfish aestivation burrows from Greenland.

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The Fleming Fjord Group in eastern Greenland is a sedimentary succession that documents environmental and faunistic changes in the Late Triassic continental ecosystems of the Jameson Land Basin. It was a time of expansion of dinosaurs across the globe and the Greenland basin is important because it was located further north than most dinosaur-bearing localities from the northern Pangea (Europe and North America). Recently it was suggested that Greenland was in a humid temperate climatic zone during the Late Triassic, which enabled large herbivorous dinosaurs to inhabit this area. We present here long, vertical to inclined, unbranched, cylindrical vertebrate burrows with a terminal chamber, and a diameter between 5 and 10 cm. These burrows were found in the Ørsted Dal Formation (upper part of the Fleming Fjord Group). We interpret them as aestivation burrows of lungfish, the skeletal remains of which are known from this formation. We base this interpretation on their morphology, size, and internal structure. The presence of lungfish burrows indicates seasonally dry climate that reached this paleolatitude, contrary to recent hypothesis but in accord with older geological literature. It seems that large herbivores were present in that area despite the dry seasons and perhaps their distribution was controlled by factors other than aridity.

Elucidating bear eco-evolutionary dynamics using ecological and morphological evolutionary landscapes.

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Bears (Ursidae, Carnivora) are considered keystone species in several ecosystems, besides their potential impact on early human migrations and habitat use. Fitness variations linked to phenotypic and/or ecological adaptations might be rendered using evolutionary landscapes meant to show differences in selective advantage of specific traits. Bears, thanks to their phenotypic, dietary, and behavioral adaptations, represent an ideal case study for elucidating existing eco-evolutionary optima and potential trade-offs in large-sized mammals. Here we investigate the conformation of morphological and ecological evolutionary landscapes within this clade. To do so, three

dimensional geometric morphometrics was applied to a total of 69 bear crania belonging to 23 living and extinct species to collect shape data. Furthermore, ecological variable scores were obtained relying on species occurrences from online databases (PaleobioDB, GBIF) and pre-existing literature, combined with paleoclimatic data (PALEO-PGEM). Our results suggest that strongest morphological and ecological adaptive peaks are mainly occupied by extinct derived morphotypes (i.e., short-faced bears). Both morphological and ecological landscapes show that many living species (e.g., genus *Ursus*) occupy a weakest selective optimum, whereas extant specialists (e.g., polar bears, pandas) are far from the strongest peaks. These evidences suggest that most of living bears are characterized by non-extreme morphologies and ecological niches that probably give them higher ecomorphological flexibility than their fossil counterparts, which occupied stronger selective peaks at the expenses of an increased extinction risk (e.g., potential occurrence of ratchet-like mechanisms in short-faced bear evolution).

The Phenotypic Evolution Time Series (PETS) database: facilitating research on phenotypic change within lineages.

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Understanding phenotypic evolution within lineages across time is fundamental to addressing numerous outstanding questions in both paleontology and evolutionary biology. Are lineages mostly not changing at all (stasis) or do they show substantial evolution? Do we observe similar evolutionary dynamics in lineages from different time periods? To what extent is the abiotic environment affecting phenotypic evolution within species? Are phenotypic changes within a population across a few generations comparable to changes at a larger timescale? Time-series of phenotypic change are needed to better understand how species survive, adapt, or disappear.

The Phenotypic Evolution Time Series (PETS) database has been developed to encourage further investigations into phenotypic changes within lineages. This publicly accessible repository (hosted by the Natural History Museum in Oslo) contains time-series on phenotypic changes in ancestor-descendant populations. PETS provides researchers with an interactive web application offering easy and open access to a comprehensive collection of time-series, complemented with vetted metadata. The user-friendly interface allows data filtering based on a variety of options. Indeed, PETS gathers a great diversity of time-series collected from all the geological periods, with a time span ranging from a few years to millions of years. Researchers can conveniently download data in various formats, including R objects, which can be directly analyzed using statistical tools tailored to study evolutionary trait dynamics. Our database facilitates the studies of traits at different time-scales, within or across lineages and geological periods.

By offering a centralized and user-friendly platform, we hope the PETS database can act as a leading repository for data on phenotypic changes both from the fossil record and contemporary observations. Users are welcome to contribute to the growth of PETS, by submitting evolutionary time-series. This team effort aims to facilitate and encourage research on phenotypic evolution, using time-series from the fossil record.

Tracking mobility of ruminants hunted by Late Pleistocene hunter-gatherers using enamel strontium isotope analysis of teeth from Melitzia Cave, Mani Peninsula (Greece).

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The Mani peninsula in the southern part of Peloponnese is an area with numerus archaeological sites yielding Palaeolithic artifacts and skeletal remains of animals as well as hominins. The Upper Pleistocene sediments of Melitzia Cave comprise Gravettian and Epigravettian cultural layers containing skeletal remains of three ruminant taxa (*Capra ibex*, *Cervus elaphus* and *Dama dama*) that

were hunted and butchered by humans, as indicated by frequent butchery marks. To assess the provenance and seasonal changes in the habitat use of these ruminants we analysed the strontium isotope composition ($^{87}Sr/^{86}Sr$) of their teeth.
To assign the diet-related $^{87}Sr/^{86}Sr$ of the ruminant teeth to a geographic provenance, a strontium isoscape of the biologically available $^{87}Sr/^{86}Sr$ was created for Mani Peninsula by analysing leaves from both herbaceous plants and trees growing on the different geological bedrock units in the cave surroundings, up to a maximum distance of 40 km. The area has a complex geology and is characterised by different lithologies such as marine limestones (in which the cave is situated), shallow marine clastic sediments, and metasedimentary rocks spanning from the Early Palaeozoic to the Pliocene. The spatial strontium distribution map was created by the Inverse Distance Weight (IDW) method in ArcGIS.
Enamel $^{87}Sr/^{86}Sr$ values of ruminant teeth from the cave deposits range from 0.70852 to 0.71014 and nearly all of them fall within the range of the Upper Cretaceous to upper Eocene marine limestones (in which Melitzia cave formed) and modern seawater (i.e., sea spray effects). The average $^{87}Sr/^{86}Sr$ of the enamel samples vary for *C. ibex* between 0.70852 and 0.70861 (mean: 0.70871, 0.000006 SD), for *C. elaphus* between 0.70860 and 0.70911 (mean: 0.70878, 0.0001 SD) and for *D. dama* between 0.70856 and 0.71014 (mean: 0.70894, 0.0005 SD). The lowest ratio occurs in *C. ibex* and the highest in *D. dama* although most of the enamel ratios lie within the narrow $^{87}Sr/^{86}Sr$ range of the cave limestone, except one *D. dama* individual (0.71014) that lies outside of this range. This suggests that most of these animals likely spent their early lives in the vicinity of the cave. The identification of one individual with a higher $^{87}Sr/^{86}Sr$ value, indicating a short-term migration may have occurred, suggesting that the individual possibly moved across different geological formations during its lifetime. Altogether, the enamel $^{87}Sr/^{86}Sr$ range indicates that humans hunted mainly in the surroundings of the Melitzia Cave and does not show any spatial niche partitioning.

What big teeth you have: disparity and convergence in the carnassial tooth shape in in carnivoramorphans and ‘creodonts’.

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Carnivoran species exhibit remarkable diversity in their feeding habits, behavior, and morphology. A defining feature shared by carnivorans and their stem groups (Carnivoramorpha) is the presence of a highly specialized dental complex- the carnassial complex - comprising the 4th upper premolar and the 1st lower molar. Initially evolved for efficient meat slicing, carnassials have diversified in size, shape, and use, allowing carnivorans to fill varied ecological roles from herbivorous giant pandas to molluscivore sea otters and hypercarnivorous lions. However, carnivorans represent only a fraction of the diversity of carnivorous mammals that once inhabited the Earth. Other placental clades also convergently evolved a carnassial complex, albeit with differences in the number of teeth and their arrangement; they are often collectively referred to as ‘creodonts’: Hyaenodonta and Oxyaenodonta.
Whereas the evolution of carnassial teeth in mammals has been the focus of a series of morphometric studies, the conventional wisdom for carnassial function assumes a relatively restricted use for these specialized teeth for slicing vs. crushing. However, the variety of morphologies observed among carnivoramorphans and ‘creodonts’ suggests the possibility of a higher degree of functional differentiation. In this study we use high-density 3D geometric morphometrics to quantify morphological disparity in the lower carnassial by covering each tooth in 1500 semi landmarks using a semi-automated protocol. Our dataset comprises nearly 300 species, spanning 26 families, and encompassing both extant and fossil taxa. Our analyses reveal a discernible dietary signal in carnassial tooth shape of extant forms, with the most pronounced differences observed between herbivorous and carnivorous taxa, while there is less strong dietary signal in the carnassial shape of omnivorous taxa. Some dietary categories (e.g. piscivore) exhibit notably high disparity, which could be an example of many-to-one function.

There are marked variations between feliformia and caniformia, even between taxa with a similar diet. Although displaying distinctive carnassial shapes, 'creodonts' demonstrate similarities with hypercarnivorous feliforms in the development of highly specialized cutting blades. However, unlike feliforms that exhibit diverse carnassial shapes, 'creodonts' likely remained restricted to a specialized hypercarnivorous niche throughout their evolution. These preliminary findings support the long-standing hypothesis that the greater dental plasticity of Carnivoramorpha conferred a competitive advantage, enabling them to occupy more diverse niches during the Eocene, while the morphologically constrained 'creodonts' went extinct.

Reimagining *Archaeopteryx*: Unlocking the 3D anatomy of incipient dinosaur flight.

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Archaeopteryx from the Late Jurassic of Germany remains pivotal in resolving the emergence of feathered flight among theropods. However, our understanding of the anatomical diversity of *Archaeopteryx* and its kin is hampered by the relative rarity, variable taphonomic collapse, and incomplete excavation of their skeletal fossils. This lack of consistent 3D insight prevents reliable reconstruction of the important phylogenetic, morphofunctional, and kinematic context underlying incipient dinosaurian flight.

We used synchrotron microtomography at the European Synchrotron to visualise and interpret the 3D anatomy of the ninth specimen of *Archaeopteryx*. This fossil comprises a partially disarticulated right wing skeleton of comparatively large size that experienced only limited compressional deformation. Virtual extraction revealed four previously undescribed elements that render the complete wing skeleton accounted for. These are the rounded tetrahedral radiale and reniform third distal carpal, as well as the wafer thin first claw sheath preserved in proximity to the robust first ungual.

The recovered association, maintaining even lighter distal elements in close proximity, asserts the absence of an 'ulnare' in *Archaeopteryx*. Contrary to previous assumptions of its conclusive recognition in various specimens, literature re-examination disclosed that 'ulnares' in *Archaeopteryx* actually represent misidentified third distal carpals. Our carpal solution aligns with embryological evidence that the cuneiform of birds is not homologous to the primitive 'dinosaurian' ulnare but rather a neomorphic pisiform that only emerged in Cretaceous flying dinosaurs. Such would imply that the ulna in *Archaeopteryx*-grade avialans distally articulated with the semilunate carpal, the co-ossification of two distal carpals, rather than with a conventional proximal carpal element.

The first examination of the ventral humerus in this specimen revealed a well-defined muscle insertion facet along the distal one-thirds of the deltopectoral crest, a pronounced internal tuberosity posterolateral to the humeral head, and a deeply excavated embayment proximal to elaborately developed ulnar and radial condyles. Although the ventral humeral anatomy is unavailable in most *Archaeopteryx* specimen, the observed features nevertheless mirror those employed to argue that *Alcmonavis* – a sympatric sister taxon to *Archaeopteryx* – exhibits increased adaptation for active flapping flight. Several additional characteristics proposed to discern *Alcmonavis* from *Archaeopteryx* appear to be (partially) taphonomic in origin.

Our aggregated observations thus cast doubt on the current phylogenetic hypothesis of Solnhofen Avialae and demonstrate that *Archaeopteryx* itself exhibited more sophisticated flight adaptations than previously assumed. The complete intra-wing mobility and newly reconstructed carpal organisation are tested in a kinematic model to explore the wing motion of *Archaeopteryx*.

Hanosaurus from the Early Triassic of China and the Early Evolution of Sauropterygiformes.

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Marine reptiles are important in amniote evolution because of their astonishing secondarily aquatic adaptations with both convergences and divergences. Sauropterygia is one of the most important

marine reptile groups with evident diversity and long existence. However, because of the scarce fossil remains from the Lower Triassic, the origin, ancestral morphology, and early history of sauropterygians are largely unclear. Fortunately, Triassic marine fossil assemblages in China provide rare glimpses of the origin and early evolution of sauropterygians and other related marine reptiles. Here we report recently studied material referred to *Hanosaurus hupehensis* from the Early Triassic in China, which represents the oldest known complete skeleton related to a sauropterygian ever discovered. This new specimen shows an unexpected mosaic morphology that combines the characters of multiple sub-lineages of sauropterygians and enigmatic saurosphargids. Our updated data matrix on Triassic marine reptiles resolved *Hanosaurus* as the basal-most member of a clade including all saurosphargids, placodonts, and eosauropterygians, which is termed as Sauropterygiformes. Moreover, *Hanosaurus* reflects a possible ancestral body plan of sauropterygiforms with an elongate trunk but short limbs and a neck of moderate length. This unexpected "long-trunk" body plan is obviously different from some subgroups of sauropterygians such as placodonts and plesiosaurs but similar to the early members of other marine reptilian clades including ichthyosauromorphs and mosasaurs, which hypothetically indicates a convergence as anguilliform swimmers in multiple lineages of marine reptiles at their early adapting stage to an aquatic way of life. After this convergence, different members of the sauropterygiforms achieved morphological divergence during the Early Triassic, not long after the end-Permian mass extinction, and occupied varied sea niches. Based on an array of analyses with the new data added, adaptive radiation for different subgroups of sauropterygiforms is confirmed with higher rates and disparity than previously documented.