PROGRESSIVE PALAEONTOLOGY 2010

PROGRAMME AND ABSTRACTS

University of BRISTOL

PROGRESSIVE PALAEONTOLOGY

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Welcome and Acknowledgments

Hello, and welcome to Department of Earth Sciences, University of Bristol and the 2010 edition of Progressive Palaeontology. We look forward to a stimulating conference, and particularly welcome our many delegates from outside the UK.

As ever, Progressive Palaeontology consists of plenty more than just presentations. The meeting will commence with an ice-breaker reception at the Eldon House, Cllifton, and the presentations will be followed by the much-anticipated annual dinner at the Severnshed Restaurant in Bristol's historical and scenic Harbourside. The conference will be rounded off with a fieldtrip to Triassic fissure fills of South Gloucestershire, including the site of the famous Bristol Dinosaur, Thecodontosaurus.

We would like to extend our thanks to the following for their invaluable help and support:
Cambridge University Press, Taylor & Francis and the Paleontological Association for funding the conference. The staff at the Department of Earth Sciences and University of Bristol for their advice and patience. All staff at the Eldon House and Severnshed Restaurant for hosting the social events. Everyone at Tytherington quarries and Cromhall Dive Centre who helped in allowing access to the quarries. Also to David Whiteside for providing so much information, Pam Gill for kindly agreeing to lead the fieldtrip, our minibus driver, Phillippa Thorne and Keith Nicholls for agreeing to drive. Mark Sutton for help in designing and maintaining the website. Phil Jardine (University of Birmingham) for advice on hosting ProgPal. Matt for assisting with design of the original logo.

And finally, we wish the organisers of next year's conference the best of luck!

Aude Caromel, Roger Close, Alex Dunhill, Jenny Greenwood, Duncan Murdock and Rachel Warnock
The Progressive Palaeontology 2010 organising committee

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Programme and timetable for presentations

WEDNESDAY 26TH MAY

19.30 – 21.00: Icebreaker at the Eldon House, Clifton, Bristol.

THURSDAY 27TH MAY

Talks will take place in lecture theatre G25, Dept. Earth Sciences, Wills Memorial Building.

08.30 – 09.00: Registration in G27, Dept. Earth Sciences, Wills Mem Bdg

09.00 – 09:15: Introduction and Welcome

09.15 – 11.00: Session one (chair, Jenny Greenwood)

09.15 – 09.30: Emily G Mitchell
Feeding Strategy Models of Ediacaran Communities

09.30 – 09.45: Janine Pendleton
Palaeontological investigation of a neglected coalfield: the Coalpit Heath Basin of the Bristol Coalfield

09.45 – 10.00: Linda Satour, Agnes Lauriat Rage, Lahcène Belkebir, Jean Paul Saint Martin, Didier Merle and Mustapha Bessedik
Shell beds of bivalves (Mollusca) from the Pliocene formation of Sidi Brahim (Base Chelif Basin, Algeria)

10.00 – 10.15: Soheir H. El-Shazly
Isotopic Composition of some Egyptian Pectinidae and their paleoenvironmental implications

10.15 – 10.30: Russell J. Garwood and Mark D. Sutton
Computer modeling of evolution over palaeontological timescales

10.30 – 10.45: Alexander M. Dunhill

Using remote sensing and a GIS to quantify rock exposure area in the United Kingdom: implications for palaeodiversity studies

10.45 – 11.00: James C. Lamsdell

A new genus of eurypterid from the Lower Silurian Pentland Hills of Scotland and its implications for the phylogeny of basal Eurypterina

11:00 – 11.30: Coffee and posters in G27

11.30 – 13.00: Session two (chair, Roger Close)

11.30 – 11.45: Colin Palmer

Using engineering techniques to reconstruct the flight of pterosaurs

11.45 – 12.00: Javier Ortega-Hernández and Nicholas J. Butterfield

Microfossil evidence for the miniaturization of (detritus-feeding) priapulid worms from macroscopic Cambrian ancestors

12.00 – 12.15: Anne O'Connor and Matthew A. Wills

Fossils and the tree of life

12.15 – 12.30: Laurent Darras, Mark A. Purnell, and Paul J. B Hart

Investigating the diet of extant and fossil fishes through microtextural analysis of teeth

12.30 – 12.45: Dave Marshall

The phylogeny of the Chasmataspids

12.45 – 13.00: Qi Zhao and Michael J. Benton

Diversity and Fossil record of the Ceratopsian dinosaurs

13.00 – 14.00: Lunch break (refreshments not provided)

14.00 – 15.30: Session three (chair, Rachel Warnock)

14.00 – 14.15: Stephen Mitchell

Macroevolutionary patterns through cynodont evolution

14.15 – 14.30: Benjamin Hyde

The stomach contents of Ichthyosaurs from the Lower Lias of Southern England, their taphonomic importance

14.30 – 14.45: Peter D. Heintzman, Ian Barnes and Scott A. Elias
Phylogeography of Ice Age Beringian Beetles: an Ancient DNA Approach

14.45 – 15.00: Leila Battison and Martin D. Brasier
Ecological Adaptation of Algal Communities in Billion-year-old Lake Basins

15.00 – 15.15: Joseph A. Bonsor, Simon J. Braddy and Jason A. Dunlop
A new enigmatic arachnid (?Trigonotarbida) from the Early Devonian of Arctic Canada, and the phylogeny of the Trigonotarbida

15.15 – 15.30: Martin Hughes, Sylvain Gerber and Matthew A. Wills
Morphological disparity through time

15:30 – 16.00: Coffee and posters in G27

16.00 – 17.30: Session four (chair, Alex Dunhill)

16.00 – 16.15: Andrew J. Smith, Emily Rayfield, Pamela Gill, Marcello Ruta and Jerry Hooker
The taxonomic diversity of the stem mammal Morganucodon (Morganucodonta: Morganucodontidae) from Late Triassic–Early Jurassic fissure deposits of Glamorganshire, south Wales

16.15 – 16.30: Emiliano Peralta-Medina and Howard Falcon-Lang
Patterns of vegetation diversity and productivity in the Cretaceous World: an analogue for future global warming

16.30 – 16.45: Nancy Simone Scott
Genome duplication and the onset of vertebrate morphological complexity: Dating whole genome duplication events in vertebrate evolutionary history.

16.45 – 17.00: Michael Pittman, Paul Upchurch and John Hutchinson
The evolution of tail variation in sauropod dinosaurs

PROGRAMME

17.00 – 17.15: Marco Brandalise de Andrade
A new sebecian crocodylomorph from the Early Cretaceous of Araripe Plateau, Brazil

17.15 – 17.30: Rachel C. M. Warnock, James E. Tarver, Ziheng Yang and Philip C. J. Donoghue
Integrating molecular and palaeontological approaches to telling evolutionary time

19:00 - Annual dinner at Severnshed Restaurant, Bristol Harbourside

FRIDAY 29TH MAY

Fieldtrip to the Triassic fissure fill deposits of South Gloucestershire.

Those who have registered for the field trip will leave from Woodland Road at 9 am, and aim to spend the morning at the first quarry before a pub lunch followed by a visit to the second quarry. We will be back in Bristol by 5 pm at the latest. Field trip registrants please refer to the field guide in your registration packs for further details.

Abstracts of oral presentations (A-Z)

A new sebecian crocodylomorph from the Early Cretaceous of Araripe Plateau, Brazil

Marco Brandalise de Andrade
Department of Earth Sciences, Faculty of Sciences, University of Bristol, BS8 1RJ, Bristol, England, UK (marcobranda.br)

The diversity of known fossil crocodylomorphs widely surpasses that of extant crocodylian taxa. Among crocodylomorphs, the non-eusuchian mesoeucrocodylians (formerly known as 'mesosuchians') were particularly abundant in the Cretaceous of Brazil, currently encompassing 15–20 species. The Araripe Basin alone, located in northeastern Brazil, has four species and one undescribed taxon. In addition to these, a new mandible (SMNS-81977) deposited in Stuttgart (Germany), comes from the Araripe Plateau, (Santana Formation, Araripe Basin) and represents an additional new taxon. The specimen was originally classified as a 'cf. *Araripesuchus'*, a genus already present in the same Basin (*Araripesuchus gomesii* Price, 1959; Santana Formation, Romualdo Member). However, SMNS-81977 shares none of the typical characters for this genus (i.e., specialized dentition, trough-shaped symphysis). A new phylogenetic analysis (104 taxa, 486 characters) places SMNS-81977 as the basalmost branch of the sebecian lineage. The most derived sebecians (e.g., *Sebecus*, *Lomasuchus*, *Caririsuchus*) share a ziphodont dentition (teeth with true serrations), and festooned mandibles, therefore were well adapted to hypercarnivory. However, the new mandible lacks serrated teeth and its general morphology resembles the poorly known *Itasuchus jesuinoi* Price, 1955 (Upper Cretaceous, Bauru Basin, Southeastern Brazil). The absence of serrations and moderate crown compression suggest that these forms were also carnivores, but adapted towards different (and perhaps proportionally smaller) prey than other sebecians. These were important crocodylomorphs from the Early Cretaceous to Paleogene, and they combine a mixture of primitive and advanced crocodylomorph features. Nonetheless, the diversity and evolution of these high-walking terrestrial

hypercarnivores is still poorly known. MBA financial support was provided by CNPq, Brazil (Proc. N° 200381/2006–10).

Ecological Adaptation of Algal Communities in Billion-year-old Lake Basins

Leila Battison and Martin D. Brasier
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Phosphatic nodules in the 1000Myr old Torridonian rocks of northwest Scotland preserve, in exceptional three dimensional detail, a diverse community of cellular fossils. The assemblage includes both prokaryotic and eukaryotic cells; the oldest known terrestrial body fossils.

The depositional environment of the Proterozoic lake basins varied considerably over space and time. Lacustrine shales belonging to the Diabaig Formation are in some places black and finely laminated, in others rippled and bearing frequent desiccation cracks. A slightly younger lake system, forming the Cailleach Head Formation, has a distinctive cyclothem pattern, indicating periodic lake level fluctuations and associated progradation of fluvial fans.

Occurrence of phosphatic nodules throughout the shaley facies of the Torridonian has allowed analysis of the fossil assemblages characteristic of each lithology and depositional environment. Data show marked ecological adaptation of the algal communities to the varying conditions at that time, including dominance of simple, more resistant forms in areas where stress levels would have been high. Further, the existence of the same fossil morphologies in lake basins separated in time by almost 20Ma, suggests that these algae were adapted to cope with longer term desiccation and basin migration, and that evolution at this time was slow.

Preservation in phosphatic nodules offers a unique opportunity to conduct such ecological studies. The remarkable fidelity of preservation allows even the most delicate cellular cluster to be preserved almost as in life. As such, meaningful estimations of diversity and ecological dominance can be made under the assumption that the preserved assemblages are unbiased by taphonomy.

A new enigmatic arachnid (?Trigonotarbida) from the Early Devonian of Arctic Canada, and the phylogeny of the Trigonotarbida

Joseph A. Bonsor[1], Simon J. Braddy[1] and Jason A. Dunlop[2]
[1]Department of Earth Sciences, University of Bristol, Wills Memorial Building, Queen's Road, BRISTOL BS8 1RJ (jb9696@bris.ac.uk, S.J.Braddy@bris.ac.uk). [2] Museum für Naturkunde, Leibniz Institute for Research on Evolution and Biodiversity at the Humboldt University Berlin, D-10115 Berlin, Germany (jason.dunlop@mfn-berlin.de)

A new enigmatic arachnid, possibly a trigonotarbid, is described from the Early Devonian (Lochkovian) Peel Sound Formation of Prince of Wales Island, Arctic Canada. Trigonotarbids are basal members of the Tetrapulmonata, characterised by two pairs of book lungs, and resemble modern spiders but lack silk-producing spinnerets and venom glands. Although imperfectly preserved, this fossil is remarkable because at ca. 6 cm long, it would be the largest trigonotarbid yet recorded, although familial assignment is problematic. Recent work has reduced the total number of valid trigonotarbid species to around 50, yet little is known on their intra-relationships as a phylogeny of Trigonotarbida is lacking. Representatives of the main trigonotarbid genera were coded from the literature, with other tetrapulmonate arachnids, such as the ricinuleids and the recently recognised Uraraneida added to help resolve their inter-relationships. This study will form the basis for future phylogenetic analyses and macro-evolutionary studies.

Investigating the diet of extant and fossil fishes through microtextural analysis of teeth

Laurent Darras[1], Mark A. Purnell[1], and Paul J. B Hart[2]
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Hypotheses regarding diet and feeding in fossil fishes rely heavily on anatomical comparison and mechanical modelling. However, recent evidence indicates that in some fishes species level dietary specialisations in feeding structures correlate poorly with diet, and that diet can differ between morphologically similar populations within a species. These observations undermine the assumptions of the functional morphology approach. New techniques such as dental microtexture analysis allow us to test these hypotheses.

It allows for rapid and automated acquisition of data from the textures developed on molariform teeth of extant herbivorous, durophagous and specialised shell-crushing populations of fishes (*Archosargus probatocephalus* and *Anarhichas lupus,* Teleostei) This data provides a model to compare teeth from fossil and modern fishes.
Analysis of extant taxa reveals that dental microtextures reflect differences in diet both within and between species, even when functional morphology fails to detect it. The reliability of the model was validated through blind testing of data from pharyngeal jaw teeth of cichlids (*Astatoreochromis alluaudi*) with known diets.

The widely accepted hypothesis of diet in fossil Pycnodontidae assumes, on the basis of functional morphology, that they were specialised shell-crushers. Application of microtextural analysis to molariform teeth from fossil pycnodontid fishes suggests a more varied range of diets for the Pycnodontiformes.

Using remote sensing and a GIS to quantify rock exposure area in the United Kingdom: implications for palaeodiversity studies

Alexander M. Dunhill
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Rock exposure area is a better proxy for the amount of sedimentary rock available for study than the widely used measures of outcrop area (= map area) or number of formations. With the use of remote sensing and GIS it is possible to quantify rock exposure area accurately on a regional scale. Rock exposure area, at least in the UK, does not correlate well with either outcrop area or number of sedimentary formations and the proportion of rock exposed in different areas can vary considerably with proximity to the coast, bedrock age, land use and elevation. Rock outcrop area and number of sedimentary formations have been widely used as sampling proxies in paleodiversity studies, but it is not clear that these are independent sampling measures, as has been claimed. GIS methods offer an efficient and accurate method of quantifying regional sedimentary rock exposure and this may provide a helpful approach to assessing rock record bias on patterns in the fossil record.

Isotopic Composition of some Egyptian Pectinidae and their paleoenvironmental implications

Soheir H. El-Shazly
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Eight Pectinid shells were collected and subjected to quantitative study using $\delta^{18}O$ and $\delta^{13}C$ isotopic analysis, to study the paleoenvironment prevailed during their calcification. Four shells from the Early Miocene in Agrud area, northeastern Desert, two from the Early Pliocene and one from the Early-Middle Pleistocene of Abu

Hamera area, Red Sea coast and one from the Recent Mediterranean coast, were selected for this study. The scalerochronological variations in $\delta^{18}O$ and $\delta^{13}C$ values, along these shells, are also discussed. The Early Miocene pectinid shells display highly depleted $\delta^{18}O$ and $\delta^{13}C$ signature, as a result of paleo-meteoric water with heavy rainfall produced by Tropical Cyclones, when the Tethys Sea was open. The Early Pliocene pectinid shells reveal depleted $\delta^{18}O$ values, related to influx of fresh water influenced by monsoonal activity following the formation of the Tibetan Plateau, while their enrichment in the $\delta^{13}C$ isotopic excursion is referred to high productivity of the Indian Ocean, which was the main source of the Red Sea water. The Pleistocene pectinid shell shows highly depleted $\delta^{18}O$ and $\delta^{13}C$ signature with obvious diagenetic shell structure, indicating wetter humid climate prevailed during the Early – Middle Pleistocene and long sub-arial exposure of the shell. The Recent Mediterranean pectinid shell displays slight enrichment in $\delta^{18}O$ and $\delta^{13}C$ values referring to deeper inhabitation of this species, with low temperature and high salinity environment. The scalerochronological variations in both $\delta^{18}O$ and $\delta^{13}C$ values, along these shells is referred to seasonal variations or kinetic effects.

Phylogeography of Ice Age Beringian Beetles: an Ancient DNA Approach

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The Beringian region consists of northeast Asia, northwest North America and the now inundated land bridge between the two. During ice ages, much of this region remained ice free and, together with its variety of habitats and large size, provided a refuge for populations of animals that were escaping the advancing ice sheets. At the end of an ice age, these populations could then recolonise the newly ice free continents. Beetles, which are important for ice age climatic reconstruction, were one

such group that took refuge in Beringia and subsequently recolonised Asia and North America, although the exact mode of this recolonisation is unknown. Additionally, at the end of the last ice age, there was widespread extinction of the large mammalian fauna; beetles seem to have passed through this extinction event unscathed, although the effects of this event are not known at the population level. A phylogeographic approach, using both ancient and modern DNA of beetles from the Eastern Beringian region, is proposed here in order to address these two important questions. Initial work is focusing on two ground beetle species (*Amara alpina* and *Pterostichus brevicornis*) and a preliminary phylogeny reveals that *A. alpina* displays some phylogeographic patterning, although much work still needs to be done.

Morphological disparity through time

Martin Hughes, Sylvain Gerber and Matthew A. Wills
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Morphological diversity (disparity) refers to a type of analysis that describes the range or spread of anatomical design displayed by a sample of organisms. It is distinct from the taxonomic diversity of clades which is a direct function of the number of species sampled. From the fossil record we can infer that since some time prior to the Cambrian, there has been a prevalent trend of increasing taxonomic diversity up the recent. It could be assumed that the diversity of organismal form would mirror this trend. However many modern phyla have body plans with a fossil record extending back to the Cambrian: a time when diversity was low. Disparity and diversity therefore appear to be decoupled.

From the limited literature available, it appears that some clades (i.e., blastozoan echinoderms, crinoids, and carnivorous mammals) explore morphospacial extremes prior to a peak in diversity early in the clade's history. Others groups show the opposite trend, with early high diversity accompanied by low disparity (i.e., trilobites,

pterosaurs). Still others show diversity and disparity increasing in tandem (i.e., acritarchs, acanthomorph fish).

Which pattern (if any) predominates? Do different signatures pertain at different times, in different clades or in different habitats? And what effect do mass extinctions have on disparity curves? To date, I have collated discrete morphological data and stratigraphic ranges for many terrestrial and marine animal groups, and I will present preliminary findings utilising published indices of disparity.

The stomach contents of Ichthyosaurs from the Lower Lias of Southern England, their taphonomic importance

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This research will be looking in to the stomach contents of Ichthyosaurs from the South coast of England, which is Lower Lias Lower Jurassic in age. Despite the hundreds of specimens found from this region including scores with stomach content preservation there has been relatively little work done. This research aims to uncover the taphonomy processes resulting in the preservation of the cephalopod hooklet found within the stomach contents and to a limited extent to explain evidence for the digestive processes. It shows that hooklets from the *Phragmoteuthis* genus were subjected to acid and enzyme attack within the stomach, which pitted their surfaces and were then preserved due to calcite replacement, with minor amounts of organic carbon preserved. This digestion together with possible transfer to the lower digestive tract resulted in the complete digestion of the hooklets.

Computer modelling of evolution over palaeontological timescales

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Computer modelling of evolution through self-replicating computer programs ('digital organisms') allows the study of evolutionary processes in a system that shares no ancestry with carbon life forms. This offers the possibility of experimental study of evolution, with the added advantages of short generation times and high accuracy. Current software (e.g. Avida, Tierra) provides an excellent tool for studying evolution in a system analogous to a microbial population in a chemostat. However, even the most extensive studies are typically conducted with maximum population sizes of 10,000 individuals, over 15,000 generations, and are thus limited in their ability to inform palaeontological considerations.

This presentation reports initial work on an alternative approach to the computer investigation of evolution that allows experiments to be conducted on palaeontological population sizes (in excess of one million individuals) and over geological timescales (millions of generations). An environment is modelled using a highly customisable RGB ‘playing board’, which allows both spatial and temporal variation, and accordingly permits the co-existence of isolated, evolving populations/species of digital organisms. These are modelled with a 64-bit genome, half of which is used to assess their fitness in relation to the environment, the other to dictate breeding behaviour. The fittest individuals can breed with their neighbours and combine genomes, and their offspring can settle within a predefined distance. Mutation rate, as with all other variables in the program, is user-defined, allowing a wide range of experiments to be conducted. The system can demonstrate speciation; experiments are likely to inform speculation on long-term evolutionary processes and patterns, including punctuated equilibrium and plus ça change models, in addition to allowing knock-out studies and investigation of environmental impact on evolution. Further, the software will allow random sampling to create a range of digital fossil records which vary in completeness. Comparison between cladistically recovered phylogenies based on these and the ‘true’ lines of descent

should inform debates regarding the impact of the incompleteness of the fossil record.

A new genus of eurypterid from the Lower Silurian Pentland Hills of Scotland and its implications for the phylogeny of basal Eurypterina

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Restudy of the Silurian Pentland Hills eurypterid fauna helps to resolve the poorly understood early phase of eurypterid evolution. '*Drepanopterus*' *bembycoides* and '*D*'*. lobatus* are not stylonurines, but identified as synonyms of '*Nanahughmilleria' conica*, representing a distinct new genus with an intriguing set of characters; an epistoma, appendages II-IV with poorly-expressed paired spines, and a pediform appendage VI with a modified podomere 7a (as in Eurypterina; swimming forms). It is assigned to the superfamily Moselopteroidea, along with *Moselopterus* and *Vinetopterus*, that share an oval metastoma with anterior notch, anterior 'ears' on the coxa of appendage VI, a pediform appendage VI with a podomere 7a, and serrate posterior margins of the postabdominal segments. This new genus is the most primitive Eurypterina known, and shows that both basal Eurypterina and Stylonurina possess a three-segmented genital operculum and a pediform appendage VI. Eurypterina are distinguished by the presence of a podomere 7a and the lack of transverse sutures on the prosoma. The new genus shows some adaptation towards a sediment-grubbing mode of life which suggests that the 'swimming paddle' of Eurypterina initially developed for digging in sediment much as in modern *Limulus*. Furthermore, some 'derived' characters, such as genital spatulae and epistomal sutures are now found in the most basal Eurypterina, which comprises Moselopteroidea, Eurypteroidea and an unnamed clade consisting of *Onychopterella* and *Tylopterella*. *Megalograptus*, previously considered to be a basal taxon, resolves as a member of the Mixopteroidea, suggesting a rapid diversification event early in eurypterid evolution, probably during the late Ordovician.

The phylogeny of the Chasmataspids

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Chasmataspids are a rare and unusual group of Palaeozoic arthropods with an irresolute phylogenetic positioning within Chelicerata. Possessing synapomorphies with both Xiphosura and Eurypterida their ordinal status is also ambiguous, having previously been considered paraphyletic and even polyphyletic. A Cambrian trace fossil, likely produced by a chasmataspid, represents the earliest evidence of all Euchelicerata and, as such, the resolution of this group is critical for the understanding of the evolution of one of the most diverse and abundant clades on the planet. A phylogenetic analysis of all chasmataspid taxa, as well as dubiously described Siberian 'eurypterids', bracketed by xiphosuran and eurypterid representatives, shows that the chasmataspids are indeed a legitimate order. Tagmation of the opisthosoma is identified as the most reliable character to differentiate between these three orders. The paddle shaped 6th prosomal appendages of the eurypterids and diploaspid chasmataspids are considered convergent, whereas the presence of a genital appendage and metastoma provide close links between these two groups to the exclusion of Xiphosura. '*Eurypterus*' *stoermeri* and '*Stylonurus*' *menneri* are identified as chasmataspids constituent of a rich and diverse assemblage from Siberia, Russia, further contributing specimens to this poorly represented group.

Feeding Strategy Models of Ediacaran Communities

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The Ediacara biota are the first documented complex, macroscopic organisms on Earth. They have few similarities with modern organisms, making the ecology very difficult to assess. In order to investigate possible feeding strategies, nutrient requirements and autecologies for these organisms, I present an ecological network model for a middle Ediacaran (575-560 Ma) Avalon-type biota.

The model consists of the 12 most dominant Ediacaran species from the Avalon assemblage, microbial mats, planktonic microbes and nutrients. Fossil abundance, body size data and life history data for planktonic microbes was input into Lotka–Volterra type differential equations to describe the ecosystem dynamics. Stability of the ecosystem was derived using eigenvalues of the Jacobian community matrix and analysed in terms of feedback loops.

Osmotrophy, suspension feeding, chemosynthetic and photosynthetic strategies for the 12 Ediacaran species were considered, with each strategy having different life history traits and interspecies interactions. The ecological feasibility of different affinities of Aspidella and other problematica were investigated along with the amount of nutrients required for the 12 species. An alternative model, with species grouped by different morphologies, was used to investigate different autecologies. It was found that the majority of non-microbe biomass must feed osmotrophically, because there is not enough energy in the system to support a large biomass of suspension feeders. Metazoans have never exhibited large scale multicellular osmotrophy, supporting the theory that Ediacaran organisms were not the precursors to modern life.

Macroevolutionary patterns through cynodont evolution

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The cynodont evolutionary radiation began in the latest Permian, and spanned a number of major events, including the end-Permian mass extinction and the origin of the dinosaurs. This study examines various different macroevolutionary factors (evolutionary rates, disparity, diversity) through the period of cynodont evolution ranging from the latest Permian through to the end of the Triassic. Rates of change in morphological characters are at their highest in the Lower Triassic following the end-Permian mass extinction. This indicates that the vacating of ecospace caused by the extinction event facilitated increased rates of character change. Diversity and disparity were decoupled, with disparity reaching its peak in the Lower Triassic, whilst diversity remained low following the mass extinction, only starting to increase in the Middle and Upper Triassic. Once the cynodont disparity peak was reached in the Lower Traissic, disparity remained fairly constant throughout the rest of the Triassic. This included as you pass into the Upper Triassic, the time of the origin of dinosaurs. However disparity was substantially lower in the Norian than the Carnian. This suggests that the rise of the dinosaurs did not adversely affect cynodonts, but, as seen in other terrestrial tetrapods, cynodonts were affected by the end-Carnian extinction event.

Fossils and the tree of life.

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Research into major evolutionary trends and molecular clocks both require accurate temporal and phylogenetic data from fossils. We know the fossil record is incomplete, but where are the biggest gaps (ghost ranges) and do some groups of organisms have more gaps than others? If phylogeny and the stratigraphic record are strongly congruent, we can have confidence that both reflect the evolutionary

history with accuracy. Using statistical modelling methods, a large dataset of published cladograms is being used to investigate the performance of published indices of congruence, and to better understand the influence of conflating factors such as cladogram balance and size. New indices will be developed to control for such biases and incorporated into open source code.

Microfossil evidence for the miniaturization of (detritus-feeding) priapulid worms from macroscopic Cambrian ancestors

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The Phylum Priapulida consists of 17 living species of benthic worm-like invertebrates, some of which are almost negligible components of modern marine benthic ecosystems. Most priapulid species are macroscopic and possess well-developed cuspate pharyngeal teeth for capturing live prey; a small number of representatives, however, are meiobenthic and characterized by pectinate teeth and a detrivore diet. The discovery of pectinate priapulid teeth preserved as carbonaceous compression microfossils on the Middle Cambrian Pika Formation, Canada, suggests that detritus-feeding priapulids were initially a component of the macrofauna and later acquired a meiobenthic mode of life through miniaturization. Some of the fossil priapulid teeth are almost an order of magnitude larger than those found in the morphologically similar Family Tubiluchidae (*Tubiluchus* + *Meiopriapulus*), while others are more similar in size and shape to *Priapulopsis* (Family Priapulidae) and *Maccabeus* (Family Maccabeidae), indicating that miniaturization occurred within more than one lineage and in different degrees. Additional support to these observations comes from the pharyngeal armature and gut contents of the Burgess Shale priapulid *Ottoia prolifica*, both of which indicate that this taxon was not a voracious predator as previously considered, but rather relied mainly on a detritus-feeding and opportunistic carnivory. The significance of

these observations is discussed in terms of the ecology, phylogeny, disparity and development of Cambrian and Recent priapulid worms.

Using engineering techniques to reconstruct the flight of pterosaurs

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The flight apparatus of pterosaurs is unique - a thin membrane supported by a single structural spar of articulated bones. This combination resulted in requirements for bending stiffness and wing morphology unlike those of any extant animals and without any direct mechanical analogue.

Various engineering analyses have been used to investigate the structural and aerodynamic performance of these unique fliers. A beam theory approach was developed to analyse the distribution and orientation of the wing spar stiffness, revealing hitherto unreported variation in the orientation of the principle axis along the length of the wing spar. This variation implies that the proximal wing bones were adapted to minimizing the overall deflection of the wing under aerodynamic loads (which are predominantly dorsoventral) but the more distal wing phalanxes to reacting mediolateral tension in the distal regions of the wing membrane. These adaptations allow control of the wing section shape and delay the onset of membrane flutter.

The maintenance of membrane tension requires a planform with a concave posterior margin and a finely pointed wing tip - a shape with potentially very poor aerodynamic characteristics. The potential to mitigate this limitation by anteroposterior bending of the wing spar was examined using a vortex lattice aerodynamic model, demonstrating a marked superiority for a 'lunate' shape.

Palaeontological investigation of a neglected coalfield: the Coalpit Heath Basin of the Bristol Coalfield

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At the Late Carboniferous (Westphalian-Stephanian) boundary a dramatic turnover event is evident in the floral record of the tropical Euramerica peat mires. Lycopsid diversity and abundance is severely reduced, and the more tolerant tree ferns became dominant. This is believed to coincide with the mires contracting to nearly half their pre-Stephanian size. The causes of this floral event are uncertain, but probably relate to substrates drying out due to tectonic uplift, that possibly also coincided with a period of global climate change.

This study focuses on the palynology and palaeobotany of the much overlooked Upper Coal Measures of the Bristol coal field. The Bristol coal measures have so far yielded well preserved examples of some very rare and unusual palynomorphs, some of which have never before been recorded in Britain. Abundant tree fern spores and rarer well preserved conifer pollen in the Westphalian coal seams indicate that the coal swamps of Bristol were dominated by a more xerophytic flora than the surrounding coal fields. The thin and sporadic nature of most of the coal seams and rare associated Lycopsid megafossils are also strong indicators that this relatively small area of the Westphalian aged Euramerica forest may have been drier than previously thought.

Patterns of vegetation diversity and productivity in the Cretaceous World: an analogue for future global warming

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The Cretaceous Period was a time of extreme Greenhouse warmth with high atmospheric carbon dioxide levels of ~1000 ppm. Global mean temperature was elevated by >10^{o}C, high sea-levels and there were probably no polar ice-caps. Extrapolation of current trends in atmosphere carbon dioxide suggest that future concentrations will exceed Cretaceous levels within ~300 years. Consequently, the Cretaceous represents an excellent analogue for the medium-term impact of future global warming on terrestrial ecosystems. In this project, we (1) create a database of megaflora and palynoflora based on literature review to investigate vegetation patterns and (2) study tree-rings in fossil woods from different palaeobotanical collections to evaluate terrestrial productivity. This will help answer the following important questions: Was diversity and productivity equator-centered, pole-centered, or did it have other pattern? Was productivity elevated compared to the present? How did the rise of angiosperms influence conifer biogeography? What vegetation patterns existed along climatic and latitudinal gradients? The present work will improve knowledge of Cretaceous vegetation biomes, help test computer climate models, and give insights into the effects of medium-term global warming.

The evolution of tail variation in sauropod dinosaurs

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Sauropod dinosaurs are famous for their giant size and their long tail and neck. Their tails are particularly interesting because of differences in length, centrum face type and the acquisition of ‘whip-lash’ and tail club specializations in some taxa. To improve our understanding of the form, function, and evolution of sauropods tails, we

examined factors associated with dorsoventral and mediolateral vertebral joint flexibility in 17 taxa.

We expect dorsoventral and mediolateral vertebral joint stiffness to be lowest in 'whip-lash' and opisthocoelous and procoelous tails since this facilitates higher degrees of tail flexibility. We also expect higher vertebral joint stiffness in clubbed tails since this would make the club easily to wield.

Using a dataset of approximately 6500 size normalized vertebral measurements principal components analyses (PCA) determined the principal vertebral parameters responsible for data variations. These were plotted on an up-to-date phylogeny to reconstruct ancestral states using square-changed parsimony. Changes along the line of descent and on side branches were then determined making use of discrete biomechanically informative phylogenetic data too.

In the dorsoventral plane, factors associated with vertebral joint stiffness, particularly neural spine, centrum, chevron and transverse process height, indicate that stiffness decreases along the line of descent for the proximal tail.

In the mediolateral plane, vertebral width which is associated with vertebral joint stiffness indicates that stiffness decreases along the line of descent for the proximal tail. Data for centrum length does not show clear a clear trend but its affect on vertebral joint stiffness is still poorly constrained. Middle and distal tail data is too sporadic to draw statistically meaningful trends at present. However, more detailed statistical work is underway to tease a signal from this data.

Sauropods show a clear trend towards increased dorsoventral and mediolateral flexibility along the line of descent. As a result 'whip-lash' and clubbed tails are side branch specializations that adopted much of the ancestral tail flexibility found along the line of descent.

Shell beds of bivalves (Mollusca) from the Pliocene formation of Sidi Brahim (Base Chelif Basin, Algeria)

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The Pliocene Formation of Sidi Brahim (south western edge of Dahra, north of Algeria) shows unusually rich deposits in mollusc bivalves. According to the descriptive method established by Kidwell (1991) and well illustrated by Videt (2007), the taphonomic analysis of these fossiliferous levels allows identifying different types of assemblages and understanding the bio sedimentary dynamics implied in the implantation of these shell concentrations. However, the eustatic oscillations phases of the Pliocene sea are represented by the occurrence of a transgressive system tract, including "*3D allochthonous*" and "*3D census assemblages*, while the high-level system tract is marked by alternating deposits of "*3D multi habitat time averaged assemblage*" and "*3D allochthonous assemblage".*

Genome duplication and the onset of vertebrate morphological complexity: Dating whole genome duplication events in vertebrate evolutionary history.

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Whole genome duplication events (WGDEs) have long been implicated as a driving force in vertebrate evolution, frequently cited as responsible for the onset of an increase in morphological and genomic complexity that defines the vertebrates as a whole. Three 'rounds' of duplication are thought to have shaped vertebrate evolution, the first associated with the origin of the clade itself (1R), the second (2R) at the origin of gnathostomes from the cyclostomes in the early Devonian, and the third (3R) with the origin of teleost fish later in the Devonian. Here, the endeavour is to demonstrate the significance or non-significance of whole genome duplication in the onset of vertebrate morphological and genomic complexity, the aim of this research being to establish a timescale for each WGDE to determine if the shift in complexity seen at each 'round' was in place prior to whole genome duplication (as the fossil record suggests), indicating that whole genome duplication is more an artefact of genomic evolution. To obtain well-constrained dates of WGDEs, gene family splits will be calculated using estimates of divergence of different animal groups to bracket the timing of genome duplication events. Paralogous gene families that span the tree of life pre and post duplication have been rigorously selected, and used to derive molecular clock dated 'species trees' for each gene family. This study will form the basis for future studies into the mechanisms behind shifts in complexity, and will shed light on the nature of the evolution of the distinctive vertebrate morphological and genomic complexity.

The taxonomic diversity of the stem mammal *Morganucodon* (Morganucodonta: Morganucodontidae) from Late Triassic– Early Jurassic fissure deposits of Glamorganshire, south Wales

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Morganucodon is a basal mammal found in Triassic-Jurassic fissure fills from several sites in south Wales. The abundant fossil vertebrates from these localities have recently yielded isolated molariforms that were assigned to two new morganucodontan genera, and we hypothesize that *Morganucodon* taxonomic diversity may extend further when intraspecific variation is fully investigated. Interestingly, a previous study into the associated mammal *Kuehneotherium* revealed a taxonomic diversity, with different species occurring in each individual fissure. *Morganucodon* molar material was analysed morphometrically and statistically from two quarry fissures, Pontalun 3 and Pant 2, to investigate whether a similar pattern was present. Data was assessed using Principle Component Analysis and Principle Coordinate Analysis of the morphometric and disparity data respectively. All molars cluster in morphospace with minimal overlap, in respect to their relative localities. Morphological separation is most distinct in second molars with a similar pattern revealed in third molars, although clustering is less distinct. This result is in direct contrast to dental measurement scatter-plot data, which shows a greater size distinction between third molars compared to second molars. This is possibly because third molar dimensions are highly variable but are not morphologically distinct. The observed differences in size and morphology between these quarries have led us to infer that *Morganucodon* possesses a true taxonomic diversity, similar to that of *Kuehneotherium*. A Principle Component Analysis will reveal the significance of these data and further explain patterns resulting from this taxonomic diversity.

Integrating molecular and palaeontological approaches to telling evolutionary time

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Molecular clocks have usurped the traditional role of the fossil record in providing a timescale for evolutionary history. However, the choice of fossil calibration points and their associated prior probabilities have one of the greatest impacts on any molecular clock study. It is therefore of critical importance that fossil data are correctly represented. No protocols have yet been established for implementing prior probability distributions that reflect the degree to which fossil minima approximate the time of divergence. Instead, clock analyses have adopted expeditious solutions such as normal, log-normal and uniform probability distributions that assume some general relation between fossil minima and divergence dates, but are not informed by any palaeontological or geological data. We intend to explore the implementation of a variety of palaeontological and geological data as prior probabilities on fossil calibrations within a Bayesian molecular clock analysis of metazoan diversification. These include using subjective data such as phylogenetic bracketing and, more objectively, temporal variation in rock outcrop area. These priors could potentially better constrain posterior probabilities, yielding divergence estimates that show appreciable concordance with raw palaeontological estimates.

Diversity and Fossil record of the Ceratopsian dinosaurs

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The Ceratopsia, dinosaurs such as Triceratops with horns on their faces and neck frills, originated in the Late Jurassic, and became dominant herbivores in the Late Cretaceous. Meanwhile, the angiosperms, flowering plants, originated in the Early Cretaceous (approximately 100 million years ago), and attained a great radiation from the mid-Cretaceous. By the Late Cretaceous, angiosperms dominated

environments formerly occupied by ferns and cycadophytes. In order to test whether there is any correlation between the evolution of Ceratopsia and angiosperms, we built a new species-level dataset of all Ceratopsia. Ceratopsian diversity is low in the Late Jurassic and the early Early Cretaceous, and shows a marked increase during the late Early Cretaceous. During this time, ceratopsian evolution does not seem to have been influenced by the angiosperm radiation. However, a steep drop in ceratopsian diversity followed in the early Later Cretaceous. Ceratopsian diversity reached a peak in the late Campanian, and then dropped slightly in the Maastrichtian. The empirical pattern of ceratopsian diversification is matched to various proxies for sampling (e.g. number of formations with ceratopsians, number of formations with dinosaurs, number of terrestrial formations, number of publications, number of workers) to determine whether the record could be influenced in a coarse way by any sampling bias. Matching of ceratopsian and angiosperm records is assessed to determine whether there could be any inter-relationship between herbivore and plant group.

Abstracts of poster presentations (A-Z)

Modelling the mechanical behaviour of the avian furcula

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Fusion of clavicles into a furcula, long considered to be unique to Aves, is now documented throughout Theropoda. However, the derived, hypertrophied furcula of modern birds appears to be important for flapping flight, with suspected roles in bracing the pectoral girdle, providing attachments for the flight muscles, and acting as a well-damped spring that either assists inflation and deflation of air sacs in the secondary-respiratory system or, in some taxa, perhaps stores kinetic energy to assist the upstroke. Considerable morphological diversity exists in the furculae of modern and pre-modern birds. In order to quantify any biomechanical differences that exist between the broad classes of furcular morphology, and thus functional-evolutionary trends, a series of idealised models were analysed using finite-element analysis (FEA). Preliminary results show that furculae with broad interclavicular angles are significantly less compliant than those with tighter angles, regardless of the angle in which the articular shoulder ends (omal tips) are loaded. Additionally, and perhaps counterintuitively, strongly V-shaped furculae are less compliant than strongly U-shaped elements of the same interclavicular angle. Further work will contrast the mechanical responses of different cross-sectional morphologies. Ultimately, FEA will be used to model scans of furculae from representative taxa of both extant and Mesozoic forms.

The holes of moles: implications for the resolution of implied trigeminal sensitivity of small mammals in the fossil record

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The Eulipotyphla family Talpidae consists of the moles, shrew moles and desmans, are found throughout Europe, Asia and North America and express a range of behavioural, environmental and dietary preferences. This current research aims to ascertain the resolution to which the Talpid skull records variation in somatosensation between species. This is being achieved via an investigation of the infraorbital foramina (IOF) caliber. This foramina is known to scale isometrically with the cross sectional area of the 2nd partition of the trigeminal nerve and is being validated through nerve area data collection from histological samples of available species.

All members of the Talpidae rely on a highly developed somatosensation system facilitated by Eimer's organs: complex sensory organs found exclusively in the nasal epidermis of Talpids. The variation in density of Eimer's organs between species has been utilized in this study as an index of somatosensory sensitivity. It is hypothesized a comparative analysis of IOF size recorded between a large sample of 29 species of Talpids (n=205) will indicate that foramina size correlates with Eimer's organ quantity on the rhinarium. Furthermore, I aim to investigate whether this correlation is related to behavioural and environmental preferences independent of phylogenetic relatedness.
Osteological cranial morphology has been extensively used as evidence for the development of nervous tissue and, by proxy, sensory adaptation in both living and fossil mammals and this new research hopes to indicate whether fine scale differences in the sensitivity of closely related, fossorial/semiaquatic mammals are detectable within the bony anatomy.

A biomechanical assessment of gaviolid rostral convergence in *Crocodylus cataphractus* and a reassessment of spinosaurid piscivory

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The extant slender-snouted crocodile (*Crocodylus cataphractus*) and extinct spinosaurid dinosaurs appear to have convergent rostral morphology with that of the modern gharial (*Gavialis gangeticus*). A lack of studies on the biomechanics of *C. cataphractus* and a debate on whether spinosaurid rostral morphology is linked to feeding ecology required reassessment. *C. cataphractus* was compared to two extant, but morphologically extreme, crocodilians (*Alligator mississippiensis* and *G. gangeticus*). Using 2nd moments of area and moments of inertia, the resistance to bending and torsion in the *C. cataphractus* rostrum with respect to the extreme morphologies of the gharial and American alligator was tested using computed tomography (CT) data. The raw results were standardised against a circle of equivalent cortical area to test the relative morphological benefits of material distribution within the rostra. The two spinosaurs' (*Baryonyx walkeri*, and an undescribed specimen - *Spinosaurus indet.*) rostra were both digitally reconstructed from CT data and then tested against all three crocodilians, in an attempt to add insight into the biomechanical properties of piscivorous archosaurs. Results show that *C. cataphractus* upper and lower jaws are more resistant to bending than an equivalent sized gharial. The spinosaurs are similar to each other despite their disparate morphologies, but are different from the gharial, contradicting previous studies. The study also suggests that extreme size may be a requirement of spinosaurs due to their highly inefficient rostra only being functional at large sizes. The biomechanics combined with known feeding ecology suggest that both *C. cataphractus* and the spinosaurs are not obligate piscivores and diet is likely determined by individual animal size.

Remarkable diversity of the earliest Ediacaran assemblages, Pigeon Cove, Newfoundland

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Understanding the evolutionary history of the earliest Ediacara biota is of critical importance to the study of both its biological affinities, and relationships to the Cambrian biota which followed. Detailed mapping of the oldest reliably dated fossil-bearing bed from Newfoundland ~579Ma has yielded a previously undocumented assemblage of small (< 3cm) frondose and filamentous fossils, on a surface which until now has only been known for its large ivesheadiomorph 'pizza discs'.

Not only does this new assemblage substantially extend the stratigraphic range of several characteristic Ediacaran organisms, but it provides insights into both the ontogenetic development of rangeomorph organisms, and the taphonomic processes operating on these bedding planes. The discovery implies that the earliest known Ediacaran fossil communities were remarkably diverse just 3 Myrs after the end of the Gaskiers Snowball Earth event, hinting at a 'missing evolutionary history' for the earliest Ediacara biota.

Our efforts to map the bed can also be applied to monitoring the effects of wave-induced erosion on this highly vulnerable site. Hopefully, this will allow the development of protocols for protecting fossil-bearing sites in the Mistaken Point Ecological Reserve.

Trace Fossil Classification – Fit for purpose?

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The fundamentals of trace fossil classification have remained unaltered since pioneering work of Martinsson (based on toponomy) in 1970, and in relation to activity (ethology) Seilacher, as far back as 1953. This paper reconsiders the fundamentals of trace fossil preservation, and considers whether these existing broad classification tools can be given greater fitness for purpose by combining these styles of classification.

This new method of classification is then considered against the established concept of ichnofaunal facies analysis.

Dinoflagellate cyst response to palaeoceanographic change in a greenhouse climate: the Cenomanian-Turonian.

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At the Cenomanian-Turonian boundary (CTB; 93 million years ago) eustatic sea-level was ~100-200 m higher than at present, average surface temperature was ~14°C higher, and atmospheric CO_2 reached concentrations of up to 5000 ppm. During this time interval, extensive organic-rich and black shale deposition occurred in association with a global ocean anoxic event (OAE2). Peaking in the early Turonian, temperature and eustatic sea-level then both fell through the remainder of the Turonian.
The Cenomanian-Turonian succession at White Nothe, Dorset, represents the farthest west outcrop of grey chalk and marl facies in southern England, passing laterally westwards into detritus-rich limestones and glauconitic sand facies in SE Devon. The White Nothe section has yielded a well-preserved organic walled

dinoflagellate cyst (dinocyst) assemblage that shows a continual high diversity throughout the section, but with a fall in absolute abundance (measured in dinocysts per gram, dpg), from the mid-Cenomanian to the Turonian. The peridinioid/gonyaulacoid ratio fluctuates greatly through the section, mainly due to alternations in the dominance of the peridinioid cyst *Palaeohystrichophora infusorioides* and the gonyaulacoid cyst *Spiniferites*. *P. infusorioides* is particularly abundant immediately below the CTB. This may indicate increased nutrient flux, because *P. infusorioides* is considered to be a heterotroph that thrived in eutrophic conditions.

Future work will extend this study into European Tethyan and Boreal realms, to include sections in southern France, northern Germany, the Czech Republic and the North Sea Basin, allowing comparisons to be made over east to west and north to south transects. This will result in an improved dinoflagellate biostratigraphy for the interval, enabling improved correlation of European chalks with North Sea and higher latitude siliciclastic deposits, which include potential petroleum source rocks. Comparison of dinocyst data with elemental and stable-isotope geochemistry will aid inter-regional correlation and palaeoenvironmental interpretation.

Skull Biomechanics of *Isisfordia duncani* and Crocodylian secondary palate evolution

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The secondary palate has been a long recognised feature of crocodilian evolution but factors driving its evolution remain less understood. Recent analyses demonstrate the dorso-ventrally flattened (platyrostral) crocodylian rostrum is biomechanically sub-optimal at resisting feeding related loading forces. These

suggest the secondary palate evolved to support the platyrostral skull in resisting these loads. However biomechanical effects of the secondary palate are yet to be tested in an extinct crocodilian.

This study examines rostrum biomechanics of the Mid Cretaceous derived stem/basal eusuchian *Isisfordia duncani*. Second moment of area (I) analysis was used to calculate rostrum resistance in bending and torsion (J (polar moment of inertia)) from 20 evenly spaced CT scan slices between the snout tip and palatal fenestrae of both *Isisfordia duncani* and a comparably sized *Alligator mississippiensis* with either the secondary palate present or digitally removed.

The alligator rostrum showed greater bending resistance than that of *Isisfordia*, slices with a secondary palate possessing I and J values higher or equal to slices without for both taxa. This resistance increase being greater in dorso-ventral bending compared to medio-lateral or torsional bending. With secondary palate *Isisfordia* exhibited greater increased dorso-ventral bending resistance compared to *A.mississippiensis*, whereas in contrast *A.mississippiensis* showed greater increase in medio-lateral and torsional resistance.

Results support conclusions of previous studies that the secondary palate assists the rostrum in accommodating feeding behaviour related loading forces. Further biomechanical study of basal taxa is required to examine biomechanics as an evolutionary driving factor during the earliest stages of crocodilian secondary palate evolution.

The second Westbury pliosaur: excavation, preparation and cranial anatomy

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During the past 15 years the Lafarge Cement Works at Westbury (Wiltshire) has yielded a fantastic variety of Upper Jurassic vertebrate fossils, making it one of the major Kimmeridgian localities in the UK and providing evidence for diverse marine communities during that Stage. One specimen, a giant pliosaur discovered by Simon Carpenter in May 1994, is currently under study. It is housed in the Bristol City Museum and Art Gallery (BRSMG Cd6172) and has been undergoing preparation since 1994. The remains have yielded a crushed skull (1.7 m long) with an exceptionally complete palate, a complete mandible, numerous teeth and post cranial material. The specimen exhibits several pathologies, suggestive of an older animal. This is the second pliosaurid to emerge from the Westbury locality. The first, found in 1980, was identified as *Pliosaurus brachyspondylus* (Taylor and Cruickshank, 1993; Taylor *et al*., 1993) and has been on display at the Bristol City Museum and Art Gallery since the 1990s (BRSMG Cc332). A reliable identification of the second Westbury pliosaur down to species level has not yet been made, though several anatomical features place it in the genus *Pliosaurus*. Because of its relative completeness, the specimen represents an important datum for understanding the family Pliosauridae. A full description is pending.

Disparity and Evolutionary Novelty in Two Paleogene Primate Radiations

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Primates, including extant lemurs, monkeys, apes, and humans encompass many diverse forms. A unique suite of features including a large brain, well-developed

stereoscopic vision, and arboreal locomotion characterize the order but the rate and timing of the evolution of these features is uncertain. Understanding the relationship between taxonomic diversity and morphological disparity of fossil primates may help explain the biodiversity in modern primate clades.

Forty-six mammals including Paleogene plesiadapiforms, Eocene euprimates, extant primates, scandentians, and dermopterans were analyzed using novel numerical techniques to extract data on evolutionary rates and morphospace occupation through time for different clades and character complexes. Euclidean distances were derived from a character-taxon matrix of 348 craniodental and postcranial characters. Principal coordinates analysis enabled the visualization of the disparity morphospace and inter-taxon relationships were quantified with several multivariate statistical tests.

Our results show that Paleogene primates occupy a relatively small volume of the total disparity morphospace but within this area, differences in morphospace occupation mirror higher-level taxonomic divisions. The Eocene euprimates form two subgroups that contain the Tarsiiformes and Adapiformes, respectively. The plesiadapiforms comprise a third cluster, and two omomyid taxa fall between the plesiadapiform and the Eocene euprimate clusters. The three major clusters of fossil taxa in morphospace represent shifts in relative morphological disparity as new subclades arose in the Paleogene. Extant taxa are scattered throughout the clusters of fossil taxa, demonstrating that the disparity of Paleogene primate subclades is retained in extant clades. Further study of character partitions will assess the relative importance of different character complexes during early primate radiations.

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