corresponding size. A significant degree of water uptake post oviposition seems likely. These and other findings such as evidence for hyper-precociality in hatchlings suggest that the reproductive biology of pterosaurs was much more like that of reptiles than birds or bats, but offered important advantages (such as mass reduction) to these flying vertebrates.

New insights into the interrelationships of the *Halitherium*-species-complex

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The systematics of sirenians is obscure. The Dugongidae and the therein included Halitheriinae are a paraphyletic assemblage, as is the genus *Halitherium*. However, in recent studies these groups are considered, conversely, to be monophyletic. For a revision of the *Halitherium*-species-complex with focus on the species *H. schinzii*, best sampled from lower Oligocene sediments of Germany, a morphological (re)-investigation of the available skeletal material and a phylogenetic analysis employing cladistic principles is aspired. Beside the late Oligocene *H. christolii* from Austria and *H. taulannense* from the late Eocene of France, the set of taxa is complemented for the first time with the Central and North American species *H. alleni* and *H. antillense*. The status and affinities of several specimens actually considered invalid and synonymous with *H. schinzii* and *H. christolii* is additionally tested.On the basis of this morphological and systematic study, the hypothesis of the presence of two different morpho-species of *Halitherium* at least in the early Oligocene of Germany is corroborated. A specimen consisting of a skullcap with a significant detail morphology, especially in the area of the supraoccipital, and known under the name "*Halitherium bronni*" is supported to be a valid taxon.

Quantitative characterisation of avian brain morphology using X-ray CT approaches

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X-ray computer tomography is increasingly being used by palaeontologists to reveal otherwise inaccessible internal structures in fossils. However, these powerful data are normally used only for comparative morphological analysis; quantitative data collection is usually restricted to simple measurements of linear distance, angles and overall volume. Investigations of vertebrate brain evolution have thus concentrated on overall volume and subjective comparison of brain region size. I describe a new quantitative approach involving characterisation of the avian brain based on brain region volume. Segmentations of the endocranial cavity are first converted from voxel data to polygon mesh stereolithograph (STL) models. Individual brain regions are then separated from the model at their base using mesh editing software. Volume values can then be derived from these separated regions, although these values probably underestimate the true region volume because internal extent of regions cannot be determined in scans of skulls. Brain morphotypes can be characterised by multivariate analysis of these 'partial' volumes as percentages of overall endocranial cast volume. Soft tissue dissections of brains in living species have previously revealed correlations between region volume variation and behaviour. If similar correlations are found using this 'partial' volume approach, behavioural aspects in extinct species can be predicted.

Caudal pneumaticity and pneumatic hiatuses in the sauropod dinosaurs *Giraffatitan* and *Apatosaurus*

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Skeletal pneumaticity is present in the presacral vertebrae of most sauropod dinosaurs, but pneumatic cavities are less common in the vertebrae of the tail: prominent caudal pneumaticity is restricted to diplodocines and saltasaurines. We describe previously overlooked pneumatic fossae in mid-caudal vertebrae of *Giraffatitan* and *Apatosaurus*. In both taxa, the most distal pneumatic vertebrae are separated from other pneumatic vertebrae by sequences of three to seven bilaterally apneumatic vertebrae. These gaps in pneumatization constitute pneumatic hiatuses, which until now were assumed to divide separate pneumatizing diverticula. Caudal pneumaticity is not prominent in most individuals of either taxon, and its unpredictable development means that it may be more taxonomically widespread than previously recognized within Sauropoda and elsewhere in Saurischia. The erratic patterns of caudal pneumatization in *Giraffatitan* and *Apatosaurus*, including asymmetry and the pneumatic hiatuses, show that pneumatic diverticula were more

broadly distributed in the bodies of the living animals than are their traces in the skeleton. Together with recently published evidence of subcutaneous diverticula in pterosaurs, this shows that pneumatic diverticula in ornithodirans are underdetermined by their skeletal traces, and suggests that their prevalence has been systematically underestimated.

Mammalian brain evolution: Marsupials vs. placentals

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The evolution of mammalian brain size is directly linked with the evolution of the brain's unique structure and performance. Both maternal investment traits and basal metabolic rate (BMR) seem to correlate with relative brain size, but this has only been researched in-depth in placentals . Here we provide the first direct quantitative comparison of brain size evolution in marsupials and placentals, whose maternal investment traits and metabolism differ extensively. We show that the misconception that marsupials are systematically smaller-brained than placentals is driven by the inclusion of Primates. Marsupials do not exhibit a body-size adjusted residual correlation of BMR with brain size, whereas placentals do. This contradicts suggestions that larger brains require higher BMRs. We suggest that a positive BMR/brain size residual correlation is derived for placentals and related to the intimate physiological mother/offspring contact during gestation. Marsupials instead achieve large brain size through extended lactation. Comparison with avian brain evolution suggests that placental brain size should be constrained due to their relative precociality, as has been hypothesized for precocial bird hatchlings. We propose that this constraint is circumvented in placentals because of their focus on gestation. Marsupials instead represent the less constrained, plesiomorphic condition.

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The evolution of body size, stance and gait in Allosauroidea (Dinosauria: Theropoda)

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Allosauroids were a diverse group of non-avian theropods that dominated predatory niches during the Mesozoic. Cladistic analysis reveals contrasts in hindlimb osteology between basal allosauroids and the derived subclade Carcharodontosauria. Myological reconstructions indicate that carcharodontosaurian synapomorphies are not associated with restructuring of hindlimb musculature. Body mass and muscle moment arm predictions across allosauroids suggest mass distribution and 3D muscle mechanics remained fundamentally unchanged. Femoral diameters show isometry, while hip extensor moment arms exhibit positive allometry, aiding limb support as mass increased. Horizontally orientated femoral heads in non-carcharodontosaurians are associated with augmented mediolateral diameters relative to dorsally inclined femora in carcharodontosaurians. These morphological correlations are present in extant bovids, where greater mediolateral diameters reflect higher bending loads incurred from the horizontally orientated head. Inclination of the head may therefore have reduced bending stress in carcharodontosaurian femora. Carcharodontosauria includes the smallest and largest allosauroids, and primitive members of its component clades had intermediate body sizes. Therefore adaptations for improved weight support appeared independent of size changes, prior to the evolution of large multiton taxa. Similar changes occurred independently in tyrannosaurids suggesting these features are important and potentially related to body size, as functional requirements or adaptations predisposed by large size.

Geometric morphometrics of skull shape in frogs