

appear during development. The most important difference is the shape of the vertebral centrum, which is formed in comparatively early developmental stages. A view that could result from anatomical comparisons is that *Palaeobatrachus* could be derived from the Pipidae, but this is doubtful due to biostratigraphic and paleogeographic discrepancies. The earliest palaeobatrachids were recorded from the Late Cretaceous of Europe, but pipids could not invade northern continents after the early Cretaceous, when the Tethys Sea prevented interchanges of anuran faunas. Also, palaeobatrachids retain primitive anatomical features that were more derived even in the earliest pipids.

Development of the Pelvic Girdle in Anurans: Contribution to Understanding the Origin of the Pelvis in Early Tetrapods

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Development of the pelvic girdle and adjacent parts of the vertebral column was studied by means of cleared-and-stained mounts of larval and metamorphic individuals of various anuran genera (*Discoglossus*, *Bombina*, *Pelobates*, *Xenopus*, *Bufo*, *Rana*, *Palaeobatrachus*). These genera should represent taxonomically the most important groups of anurans, as well as principal functional morphology types (swimming, crawling, and saltatory locomotion, burrowing). The common developmental scheme for all these types is: The earliest parts of the pelvic girdle to develop are the puboischiadic plate and ilium, both taking their origin as independent centers of chondrification located ventral and dorsal to the proximal head of the femur. The posterior extremity is already nearly complete at that stage, except for the distal phalanges. The pelvic girdle is located underneath the vertebral column and well separated from it. Only later does the ilium begin to expand dorsally towards the developing sacral vertebra. This elongation continues still later, when the ilia begin to rotate posteriorly into an ultimate horizontal position parallel to fused caudal vertebrae (i.e., urostyle). Except for the rotation, this development supposedly recapitulates evolution from the piscine puboischiadic plate to the tripartite pelvis in tetrapods which is not evidenced in fossils. The development of the anuran pelvis (disregarding heterochrony) and its adult structure seem not to be influenced by the type of locomotion.

Heads or Tails? Anterior Thrust Generation in Numerically Simulated Carangiform Fish

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For carangiform fish, research has focused on the tail and its role in transferring momentum from the body to the water. The body is viewed as a housing for the locomotor muscles. However, because of its anatomical position the head acts as a leading edge and thus may act with the body as a lifting surface. We predict that head, body, and tail act together as a hydrofoil oscillating in pitch and heave, generating lift to supplement other thrust sources. To test this, we created an integrated numerical simulation of the morphology of a pumpkinseed sunfish, *Lepomis gibbosus*, and the inviscid flow of the surrounding water using a Lagrangian formulation. The simulation investigates the interaction of fish and fluid, and the fish body includes realistic shape, viscoelasticity, and contracting muscle. With muscle contraction as input, initial changes in body shape and motion influence the fluid forces, which add load to the muscles. Responding, the muscles alter force production, and so forth. The pressure distribution on the body suggests that the head functions in thrust production. Separate models of pitching and heaving disks indicate that crosswise flow generated by lateral heaving directs a component of body lift anteriorly. For the production of lift the tail functions as a control surface, regulating the position and motion of the pressure distribution anteriorly.

Wet Adhesion in the Feathertail Glider (*Acrobates pygmaeus*), a Mouse-Sized Arboreal Marsupial

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The feathertail glider is small (10–15 g), glides with the aid of a patagium

and flattened tail, and is an arboreal forager in eastern Australia. *Acrobates* can run on a vertical pane of glass, but if it stops, it slides down slowly. We provide a morphological explanation of its adhesive abilities based on SEM and histology. The manus and pes bear adhesive pads that are seen externally as arrays of parallel ridges. The ridges consist of tall columns of cells; it is remarkable that the stratum corneum does not form a stratified squamous epithelium. The core of the adhesive pad is packed with sweat glands that drain into the epidermal columns. Thus, the adhesive pads are composed of epidermal ridge-sweat gland complexes. Feathertail gliders have developed multiple mechanisms for adhering to substrates. Claws and epidermal ridges interlock with rough surfaces. Adhesive pad-sweat gland complexes are effective on smooth, vertical, impenetrable surfaces, where a capillary adhesive mechanism comes into play. Forward momentum generated by limb muscles and wet adhesion work together and allow the animal to traverse vertical surfaces. When forward momentum decreases to zero, adhesive forces are sufficient to hold an animal's feet against the glass but sweat is not viscous enough to resist shearing forces due to the animal's mass. We initiated investigations of the fluid and tissue components of adhesion.

Lumbar Vertebral Number in Hominids and Hominoids

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The long lumbar column of modern humans likely represents a key adaptation to bipedality. Three hominid specimens, Sts 14, Stw 431, and KNM-WT 15000, may be sufficiently complete to provide data on its length in early human evolution. Each has been described as possessing six lumbar, in distinction to a modal number of five in modern humans and four in other hominoids. Here we review the fossil specimens in order to clarify this pattern. We find little evidence that can elucidate lumbar number in KNM-WT 15000. Given Sts 14's mosaic nature, Robinson's original attribution as a lumbar is primarily terminological, but does not preclude a key functional role in lordosis. Using a comparative human and hominoid sample, we agree with Stw 431qb's placement as the sixth presacral element. The next most cranial element, Stw 431l, is likely a last thoracic, given that it exhibits an anapophysis, metapophysis, and orthopophysis. We conclude that Sts 14 and Stw 431 had six lumbar, while the number in KNM-WT 15000 remains unknown. Finally, a recent developmental model supports constraints on precaudal vertebral number in hominoids. However, its authors failed to address issues of *Hox* cis-regulation during vertebral morphogenesis and furthermore conflate the processes of segmentation and vertebral specification. We present an alternative developmental model for the evolution of the lumbar spine in the Hominoidea.

Bone Strain in the Cranial and Postcranial Skeletons of Tetrapods

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Models of bone adaptation have emphasized data from the postcranium; bone strain data from the head have been ignored or suggested to be indicative of different optimality criteria. Bone strain data now available from crania and postcrania of several species of tetrapods make it possible to determine whether cranial and postcranial bones are loaded in similar or different ways. These data suggest that cranial and postcranial bones experience a similar range of strain magnitudes, strain rates, and loading frequencies, with strain rate varying as a function of strain magnitude. While in limb bones strain rate and magnitude are correlated with stride frequency, in skull bones strain rate and magnitude are not correlated with chew frequency. This reflects a fundamental difference in the nature of the external forces acting on cranium and postcranium. Forces acting on the limb bones are largely determined by oscillation of the animal's body mass, which varies with locomotor speed, whereas forces acting on the skull originate primarily from the feeding muscles and bite force and do not increase with chew frequency. Similarities between crania and postcrania in strain magnitudes, rates, and frequencies argue for similar mechanisms of bone adaptation at the tissue level; differences in the external forces acting on them predict different scaling relationships of crania and postcrania with body mass.