help us constrain the affinities of other enigmatic fossil taxa.

EVALUATING HYPOTHESES OF NECK SUPPORT IN SAUROPOD DINOSAURS

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Long necks were an evolutionary key innovation for sauropod dinosaurs. Necks longer than 10 meters evolved at least 4 times in sauropods, but there is no consensus on how sauropods held up such immense necks. Three competing mechanisms have been proposed: large supraspinous ligaments similar to the nuchal ligaments of mammals, stabilization by air-filled diverticula, and ventral bracing using cervical ribs. However, all three hypotheses are contradicted by the anatomy of sauropods and their living relatives.

Ligament scars on sauropod vertebrae show that supraspinous ligaments were present in some taxa. However, they could not have completely filled the available space, because pneumatic foramina show that air-filled diverticula were also present between neural spines. Furthermore, calculations of ligament strength have ignored dorsal muscles.

Stabilization of the neck by pneumatic diverticula seems unlikely. To provide support, the diverticula would have to be pressurized, but the necessary valves are not present in any extant animal. Furthermore, fossils show that sauropods had supramedullary airways inside the neural canal like those of birds. Pressurization of the lateral diverticula would force air back into air sacs in the trunk through these airways. The ventral bracing hypothesis is based on ligaments that bind together the cervical ribs of crocodilians. It has been proposed that similar ligaments in sauropods bound their cervical ribs together and supported the neck. However, overlapping cervical ribs probably do not support the neck in either crocodilians or sauropods. Cervical ribs are attachments for ventral neck muscles, and contraction of these muscles would load the cervical ribs in tension rather than compression. Furthermore, for ventral bracing to work the cervical ribs must form an incompressible system. Once the cervical ribs lock, no further flexion would be possible, so ventral bracing could only occur at the bottom of the range of motion. The intercostal ligaments of crocodilians probably do not function in ventral bracing, but rather reinforce the neck against the large forces incurred during prey capture. Long cervical ribs in sauropods are probably ossified tendons of ventral neck muscles, homologous with the long unossified tendons in bird necks.

Sauropods resemble birds in having light, air-filled vertebrae and large attachment scars for dorsal neck muscles. Therefore, the null hypothesis is simply that sauropods held up their relatively light necks with large dorsal neck muscles, and this null hypothesis is better supported than any of the proposed alternatives.

HINDWING FUNCTION IN THE FEATHERED DINOSAUR *MICRORAPTOR*

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The evolution of powered flight in birds remains contentious issue in vertebrate paleontology. The small raptorial dinosaur *Microraptor gui* preserves evidence of extensive, lift-generating feathers on each manus and forearm, but also preserves evidence of lift-generating feathers associated with the hindlimbs, effectively forming a pair of "hindwings". Phylogenetic analyses consistently place *M. gui* among Dromaeosauridae and thus close to the origin of birds. Combined with anatomical and functional studies, this indicates that flight evolved at least once within the lineage originating with the common ancestor of birds and dromaeosaurids. Thus, flight performance in *M. gui* may represent an ancestral four-winged stage in avian flight evolution. Alternatively, the evolution of flight may not have represented a single monophyletic event and there could be multiple abandoned body plans attempting to solve flight performance issues. Under such a case, *M. gui* may represent an alternative solution to aerodynamic issues experienced by early flying theropods. Prior authors modeled the hindlimb of *M. gui* in a strongly abducted four-winged gliding position that may require an anatomically implausible orientation of the hip socket. We suggest an alternative model in which the hindwings were generally held below the body during steady flight, but deployed unilaterally, or bilaterally, to produce additional roll and yaw during unsteady flight