

Blood vessels provided the template for vertebral pneumatization in sauropod dinosaurs

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Pneumatization of the vertebral column was a key innovation in the evolution of gigantism in sauropod dinosaurs. In extant birds, pneumatic diverticula of the lungs and air sacs follow nerves and blood vessels as they develop. In extant amniotes, seven distinct groups of arteries and veins enter or exit the axial skeleton at distinctive locations: (1) lateral surface of the neural arch; (2) dorsal roof or lateral walls of the neural canal (neural arch elements); (3) ventral floor of the neural canal (centrum); (4) ventral surfaces of the transverse processes, or inner surfaces of the ribs; (5) lateral surfaces of the centrum; (6) ventral surface of the centrum; (7) medial surface of the haemal arch. In the skeletons of sauropods, pneumatic fossae and foramina have been documented at all seven of these locations, although not all locations may be pneumatized in a single individual, or even across a clade. The close correspondence suggests that sites of vertebral pneumatization in sauropods follow conserved patterns of vertebral vasculature in amniotes. The same relationship of pneumatic features to blood vessels probably existed in non-avian theropods and pterosaurs, but has not yet been documented. Despite sauropods having attained masses an order of magnitude greater than other terrestrial animals, this is evidence that they were built just like other animals, rather than being special magical monsters. Axial pneumaticity gives us a window on the fact that, at the most basic level, sauropod skeletons developed much like those of extant amniotes.