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Biology of the sauropod dinosaurs: the evolution of gigantism

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ABSTRACT

The herbivorous sauropod dinosaurs of the Jurassic and Cretaceous periods were the largest terrestrial animals ever, surpassing the largest herbivorous mammals by an order of magnitude in body mass. Several evolutionary lineages among Sauropoda produced giants with body masses in excess of 50 metric tonnes by conservative estimates. With body mass increase driven by the selective advantages of large body size, animal lineages will increase in body size until they reach the limit determined by the interplay of bauplan, biology, and resource availability. There is no evidence, however, that resource availability and global physicochemical parameters were different enough in the Mesozoic to have led to sauropod gigantism.

We review the biology of sauropod dinosaurs in detail and posit that sauropod gigantism was made possible by a specific combination of plesiomorphic characters (phylogenetic heritage) and evolutionary innovations at different levels which triggered a remarkable evolutionary cascade. Of these key innovations, the most important probably was the very long neck, the most conspicuous feature of the sauropod bauplan. Compared to other herbivores, the long neck allowed more efficient food uptake than in other large herbivores by covering a much larger feeding envelope and making food accessible that was out of the reach of other herbivores. Sauropods thus must have been able to take up more energy from their environment than other herbivores.

The long neck, in turn, could only evolve because of the small head and the extensive pneumatization of the sauropod axial skeleton, lightening the neck. The small head was possible because food was ingested without mastication. Both mastication and a gastric mill would have limited food uptake rate. Scaling relationships between gastrointestinal tract size and basal metabolic rate (BMR) suggest that sauropods compensated for the lack of particle reduction with long retention times, even at high uptake rates.

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