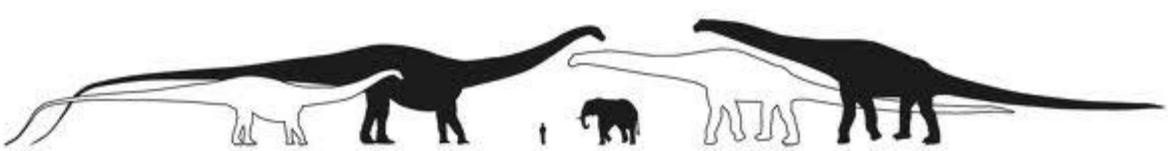
ScienceWatch - The Biggest by a Neck

"What makes a sauropod a sauropod is its most conspicuous feature, its enormously long neck." – P. M. Sander

Sauropods, those long-necked, long-tailed herbivorous dinosaurs, were the largest land animals ever to exist. Some like *Amphicoelias fragilimmus*, *Seismosaurus halli* and *Argentinosaurus huinculensis* attained heights of up to 55 feet, lengths reaching 150 feet and weights approaching 200,000 pounds. Today only the blue whale (*Balaenoptera musculus*), at 400,000 pounds, is bigger. If sauropods were alive today they could easily graze a five-story rooftop garden as they ambled by on the other side of the street! By contrast, today's largest land animals, elephants (*Loxodonta africana*), weigh a mere 15,000 pounds and stand only 11 feet tall. Adult elephants spend up to 18 hours a day consuming as much as 600 pounds of vegetation. So how did sauropods achieve their unsurpassed dimensions?

For seven years a team of German and Swiss paleontologists, physiologists and zoologists headed by P. Martin Sander*, University of Bonn, Germany, have tested the science behind many hypotheses about organ function, metabolism and even eating habits to solve the mystery of sauropod gigantism. Their findings, which appeared online in *Biological Reviews* on April 29, 2010, and those of others, have now become a book, *Biology of the Sauropod Dinosaurs-Understanding the Life of Giants*, Indiana University Press (March 2011).

Sauropods were extremely successful. Their colossal body size protected them from large predators like *Tyrannosaurus rex*, which was only one-tenth their weight. They first achieved their large-scale life style during the late Triassic, about 200 million years ago, and flourished through the Jurassic until the great asteroid-caused extinction at the end of the Cretaceous, 65 million years ago. Scientists once thought it was the profusion of plants like cycads, ginkgoes and ferns, and other extrinsic factors that favored the massive growth of sauropods. But Sander *et al*. point out that the ancient plants eaten by sauropods were no more nutritious than modern plants and conditions for life were tougher then. For example, oxygen levels were lower. Instead, they say the signature sauropod characteristic of a long neck played a pivotal role in their huge size.



A long neck allowed sauropods to consume massive amounts of foliage without expending much energy because they could stand in one place and effectively mow down large swaths of foliage. Lacking grinding molars, they didn't waste time chewing. Instead, they used small cutting incisors to wolf down their food, relying on microbial fermentation to digest the vegetation as it slowly moved through their immensely long intestine—a two-week transit time is the estimate. Their necks could grow long because their skulls, lacking large teeth and strong jaws, remained small and lightweight. Even their neck bones were lightweight, as was the rest of their axial skeleton because the bones were "pneumatized", filled with air sacs.

Sander and his colleagues argue that sauropods never ate their way into starvation. As fast breeders they could maintain a lower population density than slow-breeding large mammals without facing extinction. Since each female laid many eggs, they could quickly recover from population crashes.

Consuming huge amounts of food doesn't make you grow larger, only fatter. Therefore sauropods had to evolve other special features besides long necks to become supersized. Baby sauropods could double their weight every five days, adding several thousand pounds a year as adolescents. Sander *et al*. believe such phenomenal growth rates were fueled by a high rate of metabolism.

Other evidence for a high metabolic rate is provided by the air sacs found throughout the axial skeleton. They indicate sauropods had a highly efficient birdlike lung, which could support a warm-blooded lifestyle. The avian respiratory system allows one-way air flow through tubes (parabronchi) connected to air sacs, creating a loop that allows old air to exit as fresh air comes in. This means old and new air do not mix as occurs in the less efficient mammalian system. Sander *et al*. contend that a birdlike lung was another key component to supersizing and that it would also help sauropods remove excess heat. According to Sander, "The avian lung is crucial for gigantism. If an elephant had birdlike lungs it would grow even bigger."

Whatever special adaptations allowed these megagiants to achieve such titanic proportions, nothing like them has been seen on earth since their demise. For them bigger truly was better.

Saul Scheinbach

*Dr. Sander will guest curate "The World's Largest Dinosaur", an exhibit featuring a 60-foot model of the sauropod *Mamenchisaurus* at the American Museum of Natural History in New York. It will run April 16-January 2, 2012.