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Wolf-Ekkehard Lönnig

16 to 27 June 2023 (Preliminary Internet Version)

A Brief Note on the Multiple Independent Origins of the Long Necks in Sauropod Dinosaurs: Neo-Darwinism or Intelligent Design?

Skeletal Reconstruction of *Mamenchisaurus youngi* in the Dinosaur Museum of Zigong
Author: Einar Fredriksen (2009). Source: Kina 2009[1]

Convergence is a deeply intriguing mystery, given how complex some of the structures are. Some scientists are skeptical that an undirected process like natural selection and mutation would have stumbled upon the same complex structure many different times.

Meyer, Minnich, Moneymaker, Nelson, Seelke[2]

Now it is precisely the phenomenon of convergence that poses further major problems for neo-Darwinism. For if the one-time emergence of completely "adapted" organs or characteristics through selection of random mutations can hardly be explained, the *multiple* formation of similar organs elutes the neo-Darwinian interpretation even further.

Henning Kahle[3]

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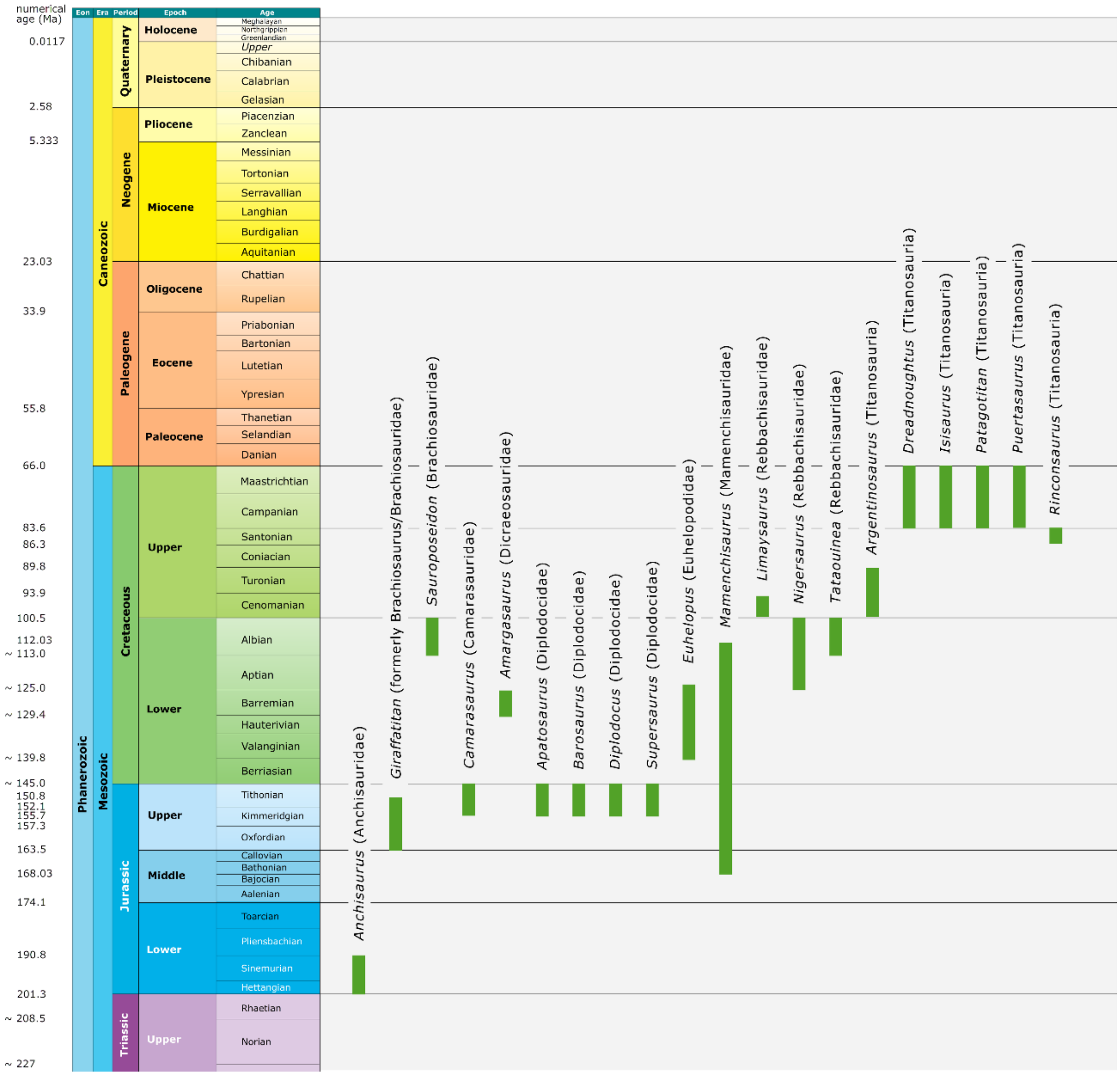
[1] https://de.wikipedia.org/wiki/Mamenchisaurus (retrieved 22 June 2023). However, other sources speak of the very closely related *Omeisaurus*.

[2] Stephen C. Meyer, Paul A. Nelson, Jonathan Moneymaker, Scott Minnich, Ralph Seelke (2007, p. 48; Second Edition 2013): Explore Evolution: The Arguments for and Against Neo-Darwinism. Hill House Publishers. Ossining, New York (State)

[3] Henning Kahle (1999, p 99): Evolution: Irrweg moderner Naturwissenschaft? (4. Auflage) E. Mindt, Bielefeld, Germany. Original German Text: „Nun stellt gerade das Phänomen der Konvergenz den Neodarwinismus vor weitere große Probleme. Denn wenn schon die einmalige Entstehung vollkommen "angepasster" Organe oder Merkmale durch Auslese zufälliger Mutationen kaum erklärbar ist, so entzieht sich die mehrfache Ausbildung gleichartiger Organe noch weiter der neodarwinistischen Interpretation." Siehe zu H. Kahle auch Interview http://www.radio-uebrigens.de/?p=40 / Biologist Dr. H. Kahle; then University Bielefeld.

Abstract

The phenomenon of complex convergences by selection of random mutations is "a deeply intriguing mystery" and "poses further major problems for neo-Darwinism", because "if it is highly improbable for a complex solution to evolve once, "convergent evolution" only exacerbates the improbability". In contrast, "what we do know […] is that intelligence can take a solution to a problem and apply it in different circumstances over and over again" (see references in the text). I have chosen 20 examples (of at least 36 according to D'Emic 2023) of such long-necked sauropod dinosaurs and shown and discussed them in the article below.



Chronological occurrence of the 20 genera distributed in 9 families of the sauropod dinosaurs mentioned and shown in the present article. Note please that 5 and 4 of the genera arose almost simultaneously. And "nearly all did arise independently" (D'Emic, mail 26 June 2023 to W.-E. L.). Figure by Roland Slowik (Dietzenbach, Germany) for the present article (20 June 2023).

Now, the origin of the ingeniously intricate long necks (and their correspondingly fine-tuned body anatomy) in sauropod dinosaurs has been postulated to have arisen more than 35 times independently of each other by selection of random mutations. So, the improbability that such transformations have happened by natural selection of random/accidental/haphazard DNA mutations is again being multiplied almost unimaginably and the improbability of neo-Darwinian evolution becomes virtually immeasurable. How do our Darwinian friends react to such objections?

Well, they presuppose their evolutionary world view as sacrosanct/unassailable/irrefutable and argue that the origin of such sophisticated features must be so very easy, so utterly simple, that they can evolve even many dozens of times independently of each other almost everywhere in the realm of living beings[4] (I have met that 'explanation' first by an article of Mayr & Salvini-Plawen). My comment: Hats off for so much naivety.

Applying Dembski's *Explanatory Filter* to this question, we get the following answers:

a) Law: There is no law, which produces long necks inevitably under any defined ecological conditions.
b) Vast improbability: fulfilled – chance to be excluded.
c) Specification: fulfilled.
Comparing neo-Darwinism with the theory of intelligent design – the latter is definitely the superior explanation.

CONTENTS

[4] See the long list of examples in the Supplement.

Supplement

Convergences according to the impressive *List of examples of convergent evolution*: https://en.wikipedia.org/wiki/List_of_examples_of_convergent_evolution
"This page was last edited on 28 May 2023, at 23:34 (UTC)." (Retrieved 21 June 2023). The authors have to be recommended for their diligent work. See also the history of that site at:
https://en.wikipedia.org/w/index.php?title=List_of_examples_of_convergent_evolution&action=history

And some general points:

If not otherwise stated, virtually all emphasis/highlighting (**bold**, *italics*, **colour**) in the quotations of the following article are made by W.-E. L. (except, of course, for the names of the *genera* and *species*). Also, notes in square brackets were added by me.

The symbol **>** means **greater than**.

The symbol ~ in the **CONSTANCY/stasis** data means ca./around/similar to. In rare cases only *one* fossil skeleton has been found and in the paleontological data banks the entire age for this geological formation is given. In such cases the fossil record is indeed patchy, but the species/genus found will, of course, not have existed only at that moment of fossilization.

Moreover, in spite of the exact age data usually given in these data banks, the age determinations themselves as well as the placements of several genera in the geologic column have shifted continually during the last 80 years or so. The most egregious case is perhaps the dating and redating of the KBS Tuff (see footnote)[5].

[5] "…the 2.6 Ma date attributed to the KBS Tuff was controversial. If the date was accurate, stone artifacts from the KBS Tuff were the oldest known to science and the hominid fossils from below that tuff included the oldest representatives of the genus *Homo*". These findings blatantly conflicted with the "group think" of the paleo-community, and so **the KBS Tuff was re-dated many, many times** until (with the help of pig's teeth) a more "comfortable" age of 1.8 million years was finally accepted", eventually catapulting Lucy onto the throne of human origins in most evolutionary trees and museum displays.

Interestingly, the first date of 2.6 Ma was **based on several 'absolute' (or most probably sure), age determinations, respectively**: (1) Argon-argon, (2) potassium-argon, (3) faunal correlations (elephant fossils), (4) paleomagnetism and (5) fission track dating. About two additional samples (one of pumice and one of felspar crystals) sent by R. Leakey for the dating process to Fitch and Miller in London, Fitch declared in a response to Leakey: "Where to proceed from there depended on the choices offered to Leakey, one of which was twice as expensive as the other but, said Fitch, "would result in this tuff **being incontrovertibly dated and with age greater accuracy than any other site in Africa or elsewhere**"" (emphasis added). Result: 2.61 ± 0. 26 Ma.

I must admit that I am impressed: ***If it is possible to re-date 5 independently obtained 'accurate' ages from 2.6 Ma down to 1.8 Ma (applying the same dating methods) to accommodate the ages to a preconceived evolutionary hypothesis on the origin of humans – to emphasize: a difference of 0.8 Ma = 800,000 years (!)*** – **how sure can we be that such old and new age determinations of all the Ma are really correct?** See also the enormous age differences given for *Homo floresienses* highest numbers: 4,000 years, 92,000 yrs, 190,000 yrs and 700,000 yrs.

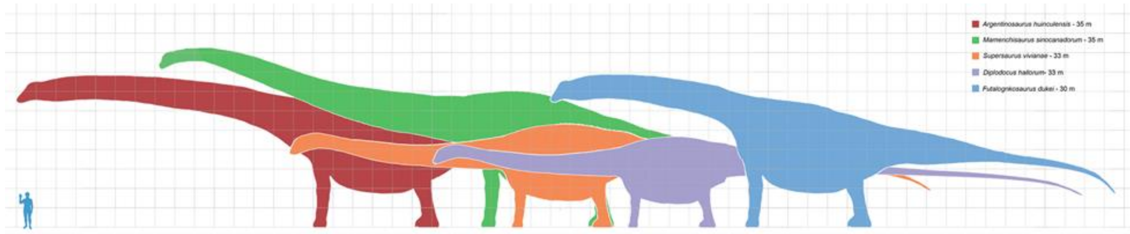
For the larger context and references, see please Wolf-Ekkehard Lönnig (2019): http://www.weloennig.de/HumanEvolution.pdf

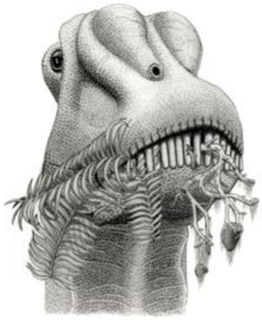
Note of 13 July 2023: Just read the article by paleontologist Günter Bechly (7 July 2023): *Fossil Friday: Alleged Precambrian Fossil Unmasked as Rotten Beehive* (https://evolutionnews.org/2023/07/fossil-friday-alleged-precambrian-fossil-unmasked-as-rotten-beehive/) at Evolution at News & Science Today.

This link is meant to be a little amendment to the footnote above now for an impressive recent/current example of many further such cases past and present, which could perhaps be the topic of a larger volume.

Incidentally I would like to recommend Bechly's series of articles *Fossil Friday* on the abrupt appearances of most fossil forms with special emphasis on the insight of paleontologists Mike Foot and John J. Sepkoski Jr as presented in a *Nature* paper: "As this pattern [of abrupt appearances of new life forms] has become more and more pronounced, ***it has become ever more improbable that the absence of intermediate forms reflects a sampling bias***."

All the *Fossil Friday* articles from 3 June 2022 up to the present: https://evolutionnews.org/tag/fossil-friday/ See perhaps also the *Discussion: Paleontology and the Explosive Origins of Plant and Animal Life - A Dialogue with an Evolutionary Geologist on Gradualism and Intelligent Design*: http://www.weloennig.de/ExplosiveOrigins.pdf





All from: https://de.wikipedia.org/wiki/Sauropoden#/media/Datei:Diplodocinae_jmallon.jpg (retrieved 22 June 2023)
Above: Scale chart comparing the sizes of several of the longest known dinosaurs. Author: Matt Martyniuk (20213). Source: Own work.
Below: Left: *Camarasaurus lentus* skull at the Smithsonian Museum of Natural History. Author? Middle: Sketch of a Diplodocid (Diplodocidae), a member of a taxon of sauropod Dinosaurs, while accidentally ingesting some stones (gastrolithes). Author: Jordan Mallon (2004). Source: PaleoPortfolio. Right: Dorsal vertebrae of *Europasaurus holgeri*. Author and Source: Nils Knötschke

Introduction

Starting point for the following comparisons with the >35 ***times independently arisen long necks of the sauropod dinosaurs***[6] were the long-necked giraffes, *Giraffa camelopardalis*, whose necks are in themselves – for many functional reasons – not only anatomically and physiologically enormously complex, but also functionally precisely tuned to all the other organ systems, yes, the entire animal is precisely tuned to this long neck and *vice versa*. So, let's first have a look at some details of the long necks of the giraffe for inferences regarding the sauropod dinosaurs.

Special Muscular Esophagus and Innervation

> Giraffes: "For rumination, semi-solid food [pulp, mash] must be forced over 3 m high from the reticulum stomach to the mouth!" For this, the giraffe is equipped with a special muscular esophagus.[7]

In contrast to giraffes, dinosaurs are not known for rumination – nevertheless to reach the stomach over a distance of the "fifty foot" (= **15 metres**) long neck of *Mamenchisaurus*, one can postulate that a ***specialized extraordinarily strong peristalsis*** and a corresponding innervation has been necessary to bridge that distance from mouth to stomach within a reasonable short time frame – for these animals had to eat enormous amounts of plant material each day growing to and survive in adulthood.

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[6] "…sauropods ***convergently*** surpassed maximum terrestrial mammalian body mass **at least three dozen times** over the course of 100 million years, on at least six landmasses and in at least five ecomorphologically disparate clades" Michael Daniel D'Emic (2023): https://www.sciencedirect.com/science/article/abs/pii/S0960982223002403

Perhaps a general word in advance. Some claims by dinosaur specialists – such as that sauropod dinosaurs could not hold their heads high ("Undaunted by skeletal rigidity or blood pressure problems, some paleobiologists still reconstruct sauropods in a rearing pose or even a sitting pose to get the head up in the trees…" R. S. Seymour) – reminded me of the old theory that it was mathematically proven (Antoine Magnan 1934: Le Vol des Insectes) that bumblebees cannot fly ("leur vol est impossible") probably because of the fact that "the theoretical maximum lift of a bumblebee's wings is lower than its weight" Michael Dickinson) https://www.pourlascience.fr/sd/technologie/le-vol-des-insectes-4444.php

[7] For the references here and the following quotations from that book *cf.* http://ad-multimedia.de/evo/long-necked-giraffe_mU.pdf

Neck lengths: The *Natural History Museum* speaks of a **12 metres**[8] long neck, **40-60 tonnes** weight and a body length of **27-34** metres for *Sauroposeidon*[9]:

> "When the first *Sauroposeidon* fossils were found in the USA in 1994, experts initially thought that they might be fossilised trees given their enormous size.
>
> The fossils were eventually realised to be vertebrae. The longest is 1.4 metres, meaning that this sauropod's neck is estimated to have been **up to 12 metres** long overall.
>
> While this is very long, it is marginally shorter than the 15-metre-long neck of *Mamenchisaurus sinocanadorum*, which may be the longest dinosaur neck found so far." [10]

However, different sources mention different dinosaur species to answer the question which one was the heaviest/biggest with the longest necks. Here is a vote for *Patagotitan* with **a neck length of ca. 10 metres**:

> "Named Máximo, meaning "maximum" or "most" in Spanish, our titanosaur cast reaches 122 feet across Stanley Field Hall on our main floor and stands 28 feet tall at the head. Modeled from fossil bones excavated in Argentina, this cast conveys the sheer size of the biggest animal ever to live. (It's longer than a blue whale!) ***Patagotitan* weighed about 70 tons in life**—that's as much as 10 African elephants, like the two specimens on display next to Máximo."[11]
>
> Taylor (2022): "To date, the longest known necks of titanosaurs, or supersized sauropods, belong to ***Patagotitan***, *Puertasaurus* and *Dreadnoughtus*, and are thought to be around 32 feet (**10 m**) long, but the material is meager."[12]

The neck of *Argentinosaurus* is also estimated to have been around **10 metres** ("more than 29 feet"[13]). Overall weight: According to *The Dinosaur Museum* "The heaviest dinosaur was *Argentinosaurus* at **77 tonnes**. It was the equivalent to 17 African Elephants. *Argentinosaurus* is a double award winner being also the longest dinosaur. It is also the largest land animal to have ever lived."[14]

Whatever the exact neck lengths (**10 to 15 m**) and weight numbers (something between **40-60 tonnes** and **70-77 tonnes**) of the largest dinosaurs might have been, *they must have eaten pretty quickly an enormous amount of plant material each day to reach and maintain their heigths, weights, and lengths*. Inference: 'For this, the long neck dinosaurs were also equipped with a special muscular esophagus' – despite the absence of rumination.

Large Volume of Air in the Trachea

> Giraffes: "Another problem posed by the possession of a long neck is the large volume of air in the trachea, the tube that connects the back of the throat with the lungs. **This air is unavailable for respiration and the space it occupies is consequently referred to as the dead space**. The dead space has a volume of about five pints (2,5 l) in the giraffe. Since this air has to be moved each time the animal breathes, the **rate of ventilation has to be increased** to compensate for the reduced air flow. A resting giraffe takes **about twenty breaths per minute**, compared with our twelve and an elephant's ten; this is a very high respiration rate for such a large animal."

Correspondingly efficient and "big lungs" have the task of balancing respiration "through a 10 feet [**3,05 metres**] long tube; many muscles, tendons, and bones had to be modified harmoniously [in giraffes]."

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[8] *Cf.* https://sapling.ai/usage/meters-vs-metres
[9] Nevertheless, with the qualification that the size estimates for *Sauroposeidon* "may not be quite right".
[10] https://www.nhm.ac.uk/discover/what-is-the-biggest-dinosaur.html
[11] https://www.fieldmuseum.org/exhibitions/maximo-titanosaur
[12] Mike Taylor, University of Bristol, 2022, in an Interview with Laura Greggel: https://www.livescience.com/problems-long-necked-sauropods. More here: https://www.livescience.com/problems-long-necked-sauropods
[13] http://www.dinopit.com/argentinosaurus/ (2022)
[14] https://www.thedinosaurmuseum.com/dino-facts Britain's original and award winning attraction, The Dinosaur Museum located in Dorchester, the county town of Dorset, only 7 miles from the Jurassic Coast is a great day out for all the family!
"The giant size of Argentinosaurus and other sauropods was likely made possible by a combination of factors; these **include fast and energy-efficient feeding** allowed for by the long neck and lack of mastication, fast growth and fast population recovery due to their many small offspring." https://en.wikipedia.org/wiki/Argentinosaurus (retrieved 24 May 2023)

Now what about the dinosaurs with **10 to 15 m** long necks? One may extrapolate from the giraffe with its 3 metres to the 10 to 15 metres of the long neck dinosaurs: ca. 3 to 5 times 2.5 liters = 7.5 to 12.5 l dead space in the dinosaurs. "Since this air has to be moved each time the animal breathes, the rate of ventilation has to be increased to compensate for the reduced air flow."

Well, one hardly dares to extrapolate further on: Would make how many breaths per minute? We most probably cannot extrapolate in a straight line (see also P. Barret below) – otherwise these dinosaurs would have panted incessantly like dogs after a race.

Muscles, Nuchal Ligament and Tendons

First the giraffe again for further comparisons with the long necked dinos:

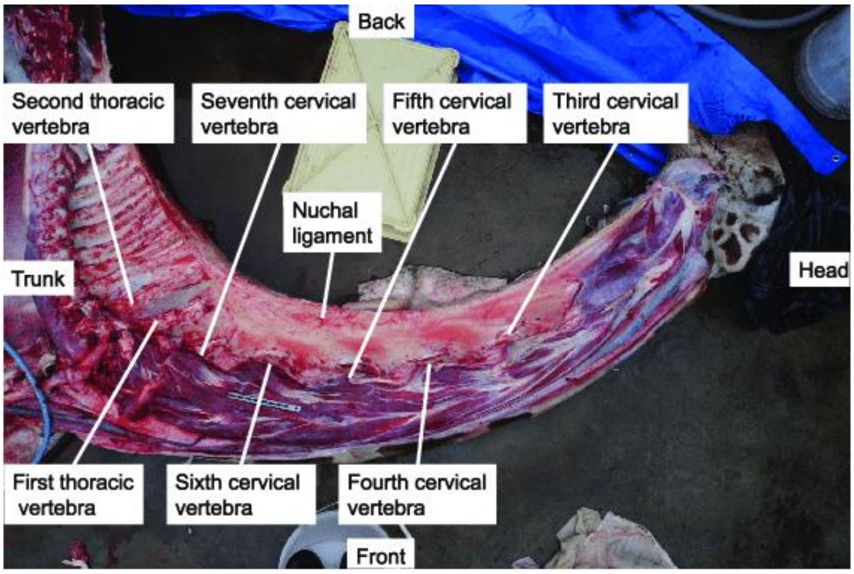
> "The giraffe's head and neck are held up by **large muscles and a nuchal ligament**, which are anchored by long thoracic vertebrae spines, giving them a hump."[15]

> "Mammals have a ligament that runs behind their head and runs along the upper back – the **nuchal ligament.** In large grazing mammals this ligament supports the weight of the head. **In giraffe the same ligament has to support the head AND the massive bulk of the neck**. Giraffe have heavily invested in this useful structure."[16]

After presenting two figures (*cf*. the original article) we are invited to imagine this about the nuchal ligament (according to the same source):

> "Think of the **nuchal ligament as a giant and stiff elastic band**, connecting the base of the skull to the upper back. This really nicely suspends the head and neck in the air, with minimal effort."

Hiroyuki Nabae, G. Endo, Hiroyuki Nabae, Megu Gunji presented the ensuing figure in their paper (2022) about a *Giraffe Neck Robot: First Step Toward a Powerful and Flexible Robot Prototyping Based on Giraffe Anatomy*:[17]



"Dissected giraffe neck. The lower side of the picture shows the front part, and the upper side shows the dorsal part. The nuchal ligament is the white part located on the dorsal side of the neck."

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[15] https://en.wikipedia.org/wiki/Giraffe
[16] https://scatterfeed.wordpress.com/2014/06/21/you-can-take-a-giraffe-to-water/
[17] https://www.researchgate.net/publication/358181872_Giraffe_Neck_Robot_First_Step_Toward_a_Powerful_and_Flexible_Robot_Prototyping_Based_on_Giraffe_Anatomy

Hideki Endo, Daishiro Yamagiwa, Masahiko Fujisawa, Junpei Kimura. Masamichi Kurohmaru, Yoshihiro Hayashi (1997) comment in their contribution on *Modified neck muscular system of the giraffe (Giraffa camelopardalis)*:

> "The **modified spinous processes** provided the large attachment surface for **the strong nuchal ligament and for the muscles of the axis** and other cervical vertebrae, while the **muscle tendons** had their origin in the ventrocaudally-enlarged transverse process. It is concluded that the modified muscles with their expanded belly and tendon have the functions of occupying the interspace among long vertebrae, and also of supporting the head and neck by means of their wide attachment to the altered vertebral processes."[18]

Professor Paul Barrett, a dinosaur expert at the Natural History Museum (London) and one of the authors of the recent study on *Mamenchisaurus sinocanadorum* addressed some of these questions in an interview with Emma Caton (2023).[19]

> "Questions remain about how *Mamenchisaurus sinocanadorum*'s bizarre proportions allowed it to function daily.
>
> **'We really have no idea how that animal would have worked mechanically**.' says Paul.
>
> **It would require a lot of muscles to hold up a neck that size**, and then there's the question of **how it gets air down to the lungs and back up again**.'"

Tim Taylor (2023) quotes R. McNeill Alexander from his book *Dynamics of Dinosaurs and Other Extinct Giants* (Columbia University Press 1989) as follows:

> "I am going to **suggest** that these necks [i.e. those of sauropods] were supported in the same way as the necks of horses, cattle, and their relatives. These animals have a thick ligament called the **ligamentum nuchae** running along the backs of their necks (figure 5.5). Unlike most other ligaments it consists mainly of the protein elastin, which has properties very like rubber. It can be stretched to double its initial length without breaking and snaps back to its initial length when released. The **ligamentum nuchae** is stretched when the animal lowers its head to drink or graze, and shortens again when the head is raised."[20]

Heart and Blood Pressure

Davis and Kenyon summarize the main points for the giraffe as follows:[21]

> "When standing upright, its blood pressure must be extremely high to force blood up its long neck; this in turn requires a **very strong heart**. But when the giraffe lowers its head to eat or drink, the blood rushes down and could produce such high pressure in the head that the blood vessels would burst. To counter this effect, the giraffe is equipped with a coordinated system of blood pressure controls. Pressure sensors along the neck's arteries monitor the blood pressure and **activate contraction of the artery walls** (along with other mechanisms) to counter the increase in pressure."

McGowan lists additional details:

> "The blood leaving the giraffe's heart has to do more than just reach the level of the head, it has to be at a ***high enough pressure to pass through all the fine vessels***, ***the capillaries***, that supply the brain and other organs. To achieve this the blood leaves the heart at a pressure of 200-300 mm Hg [260-350 mm Hg according to Starck], which is probably the highest blood pressure of any living animal. A giraffe's blood pressure is **so high that it would probably rupture the blood vessels of any other animal**, but two mechanisms appear to prevent this. First, the **arterial walls are much thicker than in other animals**. Second, the fluid that bathes the cells of the body is maintained at a high pressure; this is largely achieved by the **thick skin, which is tightly stretched over the body and which functions like the anti-gravity suit worn by pilots of fast aircraft**.
>
> Correspondingly efficient and "big lungs" have the task of balancing respiration "through a 10 feet long tube; many muscles, tendons, and bones had to be modified harmoniously."

[18] https://www.sciencedirect.com/science/article/abs/pii/S0940960297800556
[19] https://phys.org/news/2023-03-longest-necked-dinosaur-china.html
[20] https://www.prehistoriclife.xyz/extinct-giants/dinosaur-necks-and-tails.html
[21] For the references for this and the following quotations, see again http://ad-multimedia.de/evo/long-necked-giraffe_mU.pdf

This is the summary for “Dinosaur Blood Pressure – *Brachiosaurus* and other Long-Necked Dinosaurs” of an educational internet site (2023):

> ”In order to pump enough oxygenated blood to the head to operate a **Brachiosaurus**’ brain (even this tiny sauropod brain) would require:
>
> **A large, powerful heart**
>
> A heart weighing about 880 pounds (400 kg) would be needed to pump blood up the huge blood vessels at high pressure.
>
> **Tremendous blood pressure**
>
> It has been estimated that large sauropods needed a pumping (systolic) blood pressure of over 600 mm of Hg (Mercury). In contrast, most mammals (including people) have systolic pressure of about 100 - 150 mm of Hg. Even the giraffes only have a systolic pressure of about 300 mm of Hg.
>
> **Huge, muscular blood vessels**
>
> Very wide arteries would be necessary to contain neck blood flow. These vessels would need many one-way valves to keep the blood from flowing back down again before reaching the top. Also, when the neck bends downwards, too much back-flow of blood to the head would necessitate one-way valves in the veins.”[22]

However, several points of this general view have been called into question by dinosaur researchers like Roger S. Seamour and Harvey B. Lillywhite.[23]

Riley Black addressed several of these objections in his *National Geographic* article of 2013 on *Barosaurus and Blood Pressure*[24]:

> “Neck posture matters for estimates of blood pressure. Just think of *Supersaurus*, with its 50-foot neck. The sauropod would have required a considerably more powerful heart and higher blood pressure to pump blood to a head held aloft than to one that was kept lower down, closer to the height of the heart. Researchers such as **Roger Seymour and Harvey Lillywhite have used this physical constraint to argue that sauropods must have maintained their necks in a low-slung posture**, similar to what Stevens and Parrish proposed.
>
> After calculating the pressure that a sauropod such as the approximately 80-foot-long Barosaurus would have required for blood to reach the dinosaur’s head (estimated at 700mmHg), Seymour and Lillywhite wrote that the left ventricle of the dinosaur’s heart alone would have weighed two tons, or about fifteen times heavier than the left ventricle of an equally-long fin whale. And even if such an enormous heart existed, the researchers reasoned, the organ would have been grossly inefficient. Such a monstrous heart seemed unlikely. Based upon their estimates and calculations, Seymour and Lillywhite concluded that sauropod dinosaurs probably had more reasonably-sized hearts and, therefore, did not have the pumping power to hold their heads high.”

The author continues in the next paragraph but one as follows:

> “So, what did sauropods do? **Were they permanently restricted to a low-slung lifestyle of sucking down low-lying plants? *Probably not***. As Andreas Christian pointed out in a 2010 study of the dinosaur *Euhelopus*, ***the anatomy of some sauropods very clearly demonstrates that there were species which kept their necks habitually elevated***. And as costly as this might be in energetic terms – such as fueling a powerful heart – the advantage gained by being able to feed high and low may have circumvented the drawbacks. In terms of expending energy, Christian noted, standing in one place to feed over a large vertical swath is less expensive

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[22] https://www.enchantedlearning.com/subjects/dinosaurs/anatomy/Bp.shtml

[23] Sauropod dinosaurs: Roger S. Seymour and Harvey B. Lillywhite (2000) have discussed the different hypotheses on Hearts, neck posture and metabolic intensity of sauropod dinosaurs: “Hypothesized upright neck postures in sauropod dinosaurs require systemic arterial blood pressures reaching 700 mmHg at the heart.” But this appears to be improbable – conclusion: the question is open for further research “If cardiacoutput of a 40 000 kg sauropod were 140 l min71 (20% of the whale), then an 11.5 kg ventricle (as occurs in a 3200 kg elephant) would easily produce 100mmHg blood pressure, pumping at 35 beatsmin71 and a stroke volume of 4 l.To produce 700mmHg, however, the ventricle would thicken to 165 kg, or 0.4% of the body mass (figure 2). Even if the cardiac output were reduced to 50% of the endothermic level, assuming intermediate sauropod metabolic rates (Farlow 1990; Spotila et al. 1991), 700mmHg could be produced with a 530 kg ventricle that is nearly the same proportion of body mass (1.3%), as in giraffes. However, it is important to realize that, despite the reduction in size and energy demands, the ventricle would have the same relative thickness in comparison to end-diastolic volume (the thickness approximately equal to the diameter of the internal blood space), and would suffer the same mechanical inefficiency resulting from highwall stiffness. In addition, a heart rate of 35 beats min71 seems very high for a 40 000 kg animal, be it an ectotherm or an endotherm. It has been elegantly demonstrated that heart rate scales inversely with body size, because it is determined by the characteristics (resistance, compliance and length) of the arterial tree and the requirement for myocardial perfusion (Westerhof & Elzinga 1991). Expected heart rates would be lower than 20 beatsmin71, which would require proportionately larger end-diastolic volumes and thicker ventricles. Ectothermy may solve the problem of heart size, but it leaves some serious problems of cardiac mechanics.”
See also https://pubmed.ncbi.nlm.nih.gov/27708049/ (2016) and https://www.smithsonianmag.com/science-nature/how-long-necked-dinosaurs-pumped-blood-their-brains-180957011/ “Paleontologists have been debating for decades how sauropods could have generated enough blood pressure to pump the vital fluid from the heart to the brain.”

[24] https://www.nationalgeographic.com/science/article/of-barosaurus-and-blood-pressure See also: https://en.wikipedia.org/wiki/Sauropod_neck_posture: “Despite skepticism, *Euhelopus* and Brachiosaurus have been found on **anatomical evidence to have held their necks at a vertical angle**, which has been treated as impossible for sauropods.” (Retrieved 18 June 2023.)

than having to walk great distances when you've got a high-running metabolism to nourish. Some sauropods undoubtedly held their heads aloft, as much as 26 feet above the level of their heart in a dinosaur like *Giraffatitan*. The puzzle is how their bodies were capable of achieving such a wonderful feat. We need to know much more about dinosaur organs and physiology to solve the question.

Despite anatomical clues indicate that some, and perhaps most, sauropods held their heads high, the fact is that paleontologists have yet to solve the mystery of how the dinosaurs solved biological problems involving bloodflow. As Bergita Ganse and coauthors relate in a recent review of sauropod physiology, "The cardiovascular system is still a field of speculation." ***Barosaurus and even larger dinosaurs probably required big hearts and exceptional blood pressures***, but, lacking soft tissue structures, researchers can only approach such biological details in outline."

Here Two Further Questions in this Context:

1. But What Happened When a *Supersaurus* Lowered his Head to Feed and Drink at Ground Level?

National Geographic (as well as *Scientific American* etc.) author Riley Black has addressed that problem in clear words follows:

"When a *Supersaurus* lowered its neck to feed at ground level, the dinosaur would have risked a terrible rush of blood to the head. Although very, very distantly related – seeing as they are mammals – ***giraffes hint at one solution for coping with this problem***. The long-necked mammals have a web of little arteries called the ***rete mirable***, Ganse and coauthors point out, which helps prevent blood pressure from skyrocketing while the giraffe's neck is lowered. Sauropods could have evolved a similar structure. No one has yet found evidence of such an arrangement for sauropods, but it's still a hypothesis worth entertaining since the feature exists in another long-necked vertebrate."

2. And Last, not Least – How did Sauropods Prevent Blood from Pooling in their Limbs?

Riley Black: "Then there's the question of how sauropods prevented blood from pooling in their limbs. Once the blood went out to these extremities, ***how did it overcome gravity to go back to the heart?*** Again, mammals hold possible answers. In horses, Ganse and coauthors point out, there's a kind of cushion that sits between the sole and the foot bones. Blood collects in the cushion, and is squeezed out into the veins when the horse steps. Giraffes have a different way of getting around the same problem. In ***addition to fluid pressure and details of the capillaries, the tight skin of giraffe legs*** helps keep blood moving through spaces where it might otherwise accumulate. We may never know how sauropods got around the same problem, but, given their size and facts of their biology, they must have had some mechanism to prevent edema. Foot cushions or tight skin are reasonable possibilities."

Roger S. Seymour in his *Physiology* paper on the *Cardiovascular Physiology of Dinosaurs* (2016):

"The giraffe's long neck imposes a high MAP [mean arterial blood pressure] at heart level, which is transmitted throughout the arterial system of the entire body. The peripheral resistance throughout the body is therefore high and probably occurs mainly at the arteriole level as it does in other mammals. **MAP is highest at the feet, reaching over 400 mmHg in tall individuals**. **Giraffe legs** are characterized by [1] ***hypertrophic arterial walls,*** [2] ***arterial vasoconstriction to limit blood flow downward,*** [3] ***lymph vessels and veins with valves to push fluids upward during locomotion, and*** [4] ***tight skin,*** [5: tight] ***fascia, and*** [5: tight] ***capillary membranes to prevent edema***."[25]

Thus, some basic anatomical and physiological structures with functions similar to that of the Giraffe (or entirely new ones?) must have been present in the sauropod dinosaurs.[26]

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[25] Seymour, R.S., Cardiovascular physiology of dinosaurs, https://journals.physiology.org/doi/full/10.1152/physiol.00016.2016 *Physiology* **31**:430–441,

[26] For further studies one may critically check the following links: (2021) http://huveta.hu/handle/10832/3164 A Literature Review on The Cardiovascular System of the Sauropod Dinosaurs, With an Emphasis on Their Thermal Physiology. https://pubmed.ncbi.nlm.nih.gov/37160089 / The evolution of maximum terrestrial body mass in sauropod dinosaurs. https://pubmed.ncbi.nlm.nih.gov/?term=%22Dinosaurs%22+nuchal https://pubmed.ncbi.nlm.nih.gov/?term=%22Dinosaurs%22+tendons

Davis and Kenyon summarize the problems of the giraffe for the synthetic evolutionary theory as follows [now plural, emphasis and comments in square brackets for the dinosaurs by W.-E. L – see original text in the footnote[27]]:

"[T]he giraffes [as well as the sauropod dinosaurs] represent ***not a mere collection of individual traits but packages of interrelated adaptations***. They are put together according to an **overall design that integrates all parts into a single pattern**. Where did such an adaptational packages come from? According to Darwinian theory, the giraffe [and sauropod dinosaurs] evolved to their present [and past] forms by the accumulation of individual, random changes preserved by natural selection. ***But it is difficult to explain how a random process could offer to natural selection an integrated package of adaptations, even over time***. Random mutations might adequately explain change in a relatively isolated trait, such as color. **But major changes, like the macroevolution of the giraffes [and the sauropod dinosaurs] from some other animals, would require an extensive suite of coordinated adaptations**."

Convergence

At the beginning of this article, I had quoted S. C. Meyer et al. as well as the biologist H. Kahle on the extreme improbability of multiple origins of very similar – yes, of often almost identical – complex biological structures on all levels by the undirected process of natural selection of accidental/haphazard/random DNA mutations and also that, if the one-time emergence of such characteristics can hardly be explained through this mechanism, the multiple formation of similar organs elutes the neo-Darwinian interpretation even further.

Freelance science writer David Coppedge has succinctly put it as follows (2015/2023):

> "If it is highly improbable for a complex solution to evolve once, "convergent evolution" ***only exacerbates the improbability***. In Illustra Media's new film *Living Waters*, Timothy Standish explains why "convergent evolution" is not a plausible explanation for unrelated similarities. "Evolution is blind," he says. It doesn't know that another organism has an elegant solution to a problem. It cannot drive a different animal to converge on a similar solution. ***What we do know***, *Standish continues*, ***is that intelligence can take a solution to a problem and apply it in different circumstances over and over again***.
>
> It makes sense that a designer would understand optics and electromagnetic waves [and gravitation, and physics in general, and chemistry etc.]. A mind can take parts and arrange them into corneas, lenses, and receptors [and hearts and blood vessels, muscles, nuchal ligaments etc.] appropriate for the needs and sizes of disparate organisms. **Unguided selection cannot do that**. The environment cannot do that. **From our uniform experience, the only cause we know that can organize parts into a functioning whole is intelligence**. **This is positive evidence for design**."[28]

So, let's keep please these basic points in mind when we now turn to the topic of convergence of the giraffe and the long neck sauropod dinosaurs. We are going to come back to the topic of convergence at the end of this article.

"Dinosaurs" blood pressure
https://pubmed.ncbi.nlm.nih.gov/?term=%22Dinosaurs%22+blood+pressure https://pubmed.ncbi.nlm.nih.gov/26944489/ Neck length and mean arterial pressure in the sauropod dinosaurs. "We derive relating an equation relating to neck height and mean arterial pressure, which indicates that with a mean arterial pressure similar to that of the giraffe**, the maximum safe vertical distance between heart and head would have been about 12 m**. A hypothesis is presented that the maximum neck length in the fossil record is due to the siphon height limit. The equation indicates that to migrate over high ground, sauropods would have had to either significantly increase their mean arterial pressure or keep their necks below a certain height dependent on altitude."
https://onlinelibrary.wiley.com/doi/full/10.1111/apha.13677
https://pubmed.ncbi.nlm.nih.gov/?term=%22Dinosaurs%22%5BMAJR%5D&sort=date&sort_order=desc
https://en.wikipedia.org/wiki/Physiology_of_dinosaurs
In German: https://de.wikibrief.org/wiki/Physiology_of_dinosaurs

[27] Original Text by Davis and Kenyon: "In short, the giraffe represents not a mere collection of individual traits but a package of interrelated adaptations. It is put together according to an overall design that integrates all parts into a single pattern. Where did such an adaptational package come from? According to Darwinian theory, the giraffe evolved to its present form by the accumulation of individual, random changes preserved by natural selection. But it is difficult to explain how a random process could offer to natural selection an integrated package of adaptations, even over time. Random mutations might adequately explain change in a relatively isolated trait, such as color. But major changes, like the macroevolution of the giraffe from some other animal, would require an extensive suite of coordinated adaptations."

[28] "Convergence? One-Celled Creature Has an Eye!" https://evolutionnews.org/2023/03/convergence-one-celled-creature-has-an-eye/ Also: "A Post-Hoc Observation. But "convergent evolution" is not a process. **It is a post-hoc observation based on evolutionary assumptions**. An environment has no power to force an organism to respond to it with a complex function. ***Light exists, whether or not an organism sees it. Magnetism exists, too; does it contain the power to nudge fish, turtles, and butterflies to employ it for navigation?"*** See also my answers to Kutschera's explanations of the Cambrian Explosion (2019, pp.35/36): "**Where is the causal nexus** supposed to be between global warming, ice melt, rising sea levels, flooding of shorelines, erosion of rock layers, increasing calcium phosphate ion levels, rising oxygen levels ***and the formation of entirely new species, genera, families, orders, classes and blueprints*** [Baupläne]?" http://www.weloennig.de/KutscheraPortner.pdf (*cf.* there several additional points).

Mamenchisaurus sinocanadorum in the New York Times

The following illustration of the sauropod Dinosaur *Mamenchisaurus sinocanadorum* has just recently been shown in many popular[29] as well as in scientific[30] media around the globe and hailed to be the dinosaur species with the longest neck ever discovered.

https://news.stonybrook.edu/university/new-fossil-analysis-reveals-dinosaur-with-record-holding-15-meter-long-neck-2/

When I first showed that picture to a lady, she immediately said that this was impossible, the long neck animals would all have fallen on their noses: No balance.

However, the **New York Times**[31] had reported the following under the headline:

It's Not a Stretch: This Dinosaur Had a 50-Foot Neck

"Researchers developed a new estimate of the neck length of Mamenchisaurus, which foraged for foliage more than 150 million years ago in what is now China."

From the New York Times article by Jack Tamisiea (March 15, 2023)[32]

> "Few creatures have pushed anatomy to its limits like sauropods. These supersized dinosaurs moved on pillar-like limbs that supported massive girth, wielded whip-like tails to ward off predators and used long necks to vacuum up foliage.
>
> While this entire group of dinosaurs is commonly referred to as "long necks," Mamenchisaurus, which roved around what is now China during the late Jurassic period, would have given other sauropods neck envy. In a study published Wednesday in the Journal of Systematic Paleontology, researchers estimate that Mamenchisaurus's neck stretched to a length of nearly 50 feet. Longer than the average school bus, its neck is the longest estimated of any sauropod species. It may be the longest neck on an animal ever observed."

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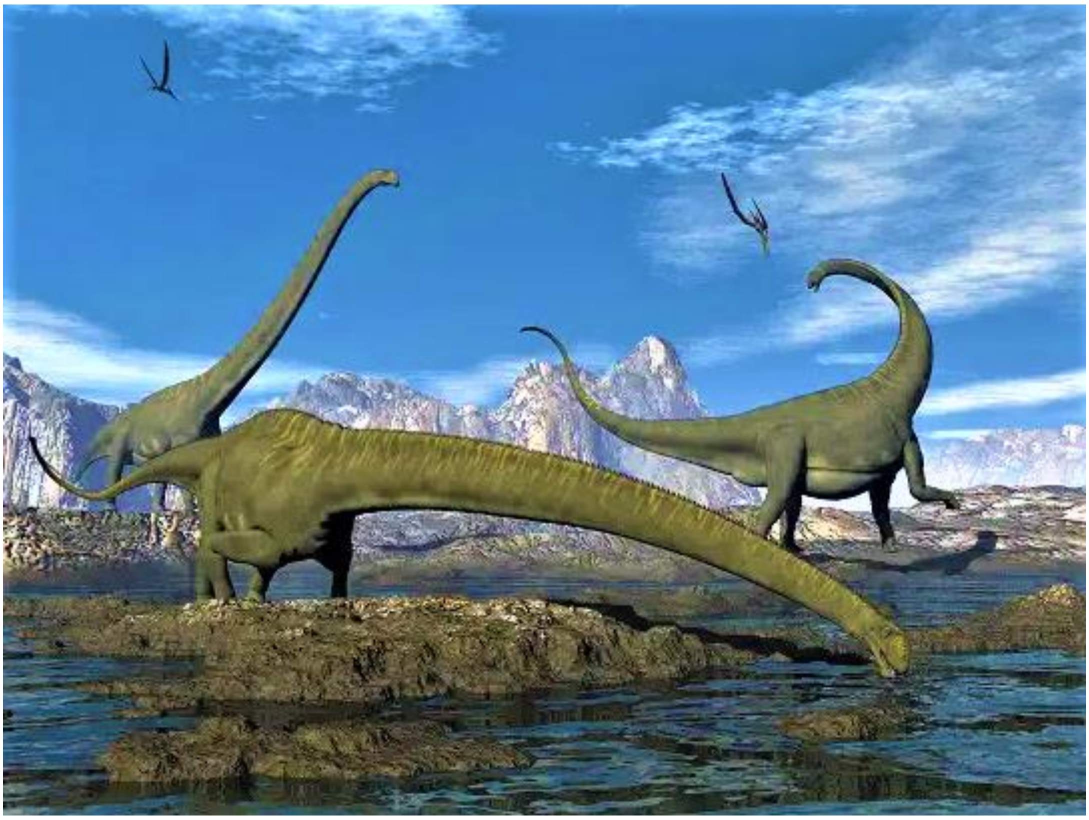
[29] And similar pictures even for kids. Google please „Mamenchisaurus Ein Hals so lang wie bei sechs Giraffen" and you'll find about **1280 results**. (and similar pictures even for kids)

[30] Or check Google for "Mamenchisaurus longest neck scientific articles": About **25300 results** (16 May 2023)

[31] For their articles on science it could perhaps (at least sometimes) be called to be somewhat of "missing link" between popular and scientific presentations of facts.

[32] All emphasis in typeface in this and the following citations by W.-E. L):



Representation of *Mamenchisaurus sinocanadorum* as presented in an article for kids.[33]
If that reconstruction is correct – a special peristalsis seems have been necessary to get water all the way down to the stomach.

But how do the discoverers know for sure that *Mamenchisaurus*' neck was really that long?

For that question, the author mentioned above, Jack Tamisiea, a freeland science writer, has this report from his interview with paleontologist Andrew More on the basic problems encountered for long dinosaur necks as well its solution for that dinosaur:

> "Researchers named the dinosaur Mamenchisaurus sinocanadorum and connected it to several other long-necked sauropods from East Asia. But Mamenchisaurus's true size remained an enigma. No other fossilized remains of the sauropod have been excavated, leaving scientists **with only those couple vertebrae** to examine.
>
> Andrew Moore, a paleontologist at Stony Brook University who studies sauropod anatomy, said that this was the case for many of the largest dinosaurs. "What's particularly tantalizing and frustrating is that oftentimes, *the longest necks belong to the things that are the least known in the fossil record for the simple reason that it's really hard to bury something that large*," Dr. Moore, who led the new study, said.
>
> So, he turned to the fossils of **several close relatives** of Mamenchisaurus, especially Xinjiangtitan, a slightly older sauropod discovered in northwest China in 2013. Remarkably, **researchers unearthed Xinjiangtitan's entire vertebral column**. At nearly **44 feet** [**=13.41 m**] long, it represents the longest complete neck in the fossil record." [For the collections, see also *Mamenchisauruns* below.]
>
> "By using these more complete, but smaller specimens, we can scale up and make a pretty competent estimate of what Mamenchisaurus would have looked like," Dr. Moore said.
>
> After comparing Mamenchisaurus and Xinjiangtitan, Dr. Moore and his team concluded that Mamenchisaurus possessed a neck nearly **50 feet** long. This would account for roughly half of its estimated total body length and is **equivalent to just over eight giraffe necks stacked end-to-end**."

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[33] https://dinosaurfactsforkids.com/12-most-popular-long-neck-dinosaurs/ (retrieved 16 May 2023)

How Many Dinosaur Species got their Long Neck Independently of Each Other?

Now, of the "At Least Three Dozens" of Them, Here are 20 Candidates From 9 Different Families:[34]

Note of 15 June 2023: The ensuing genera and families had been chosen before I received the PDF on 14 June 2023 of the full paper (*Current Biology* of May 2023) *The evolution of maximum terrestrial body mass in sauropod dinosaurs* by Michael D. D'Emic, distinguished dinosaur researcher at Adelphi University in Garden City, New York. Among many other important points, he states (p. 349) that "Over the course of 100 million years, a remarkable 36 sauropod lineages **independently** surpassed the body masses evolved by other terrestrial clades, before or since, including **two nonneosauropod** lineages, **two lineages within Turiasauria**, **seven within Diplodocoidea**, **and 25 within Macronaria**, including **three within Brachiosauridae** and **15 within Titanosauria** (Figures 1 and S2), based on current knowledge." Before that I knew only the abstract. As for the following references: although not always correct, the Wikipedia is usually up to date concerning dinosaurs. And the PBDB is probably the best source for data on the collections and age ranges.

1) ***Anchisaurus*** **(Anchisauridae)**[35]
2) ***Giraffatitan*** **(formerly Brachiosaurus/Brachiosauridae)**[36]
3) ***Sauroposeidon*** **(Brachiosauridae)**[37]
4) ***Camarasaurus*** **(Camarasauridae)**[38]
5) ***Amargasaurus*** **(Dicraeosauridae)**[39]
6) ***Apatosaurus*** **(Diplodocidae)**[40]
7) ***Barosaurus*** **(Diplodocidae)**[41]
8) ***Diplodocus*** **(Diplodocidae)**[42]
9) ***Supersaurus*** **((Diplodocidae)**[43]
10) ***Euhelopus*** **(Euhelopodidae)**[44]
11) ***Mamenchisaurus*** **(Mamenchisauridae)**[45]
12) ***Limaysaurus*** **(Rebbachisauridae)**[46]
13) ***Nigersaurus*** **(Rebbachisauridae)**[47]
14) ***Tataouinea*** **(Rebbachisauridae)**
15) ***Argentinosaurus*** **(Titanosauria[48])**[49]
16) ***Dreadnoughtus*** **(Titanosauria)**[50]
17) ***Isisaurus*** **(Titanosauria)**[51]
18) ***Patagotitan*** **(Titanosauria)**[52]
19) ***Puertasaurus***[53] **(Titanosauria)**[54]
20) ***Rinconsaurus*** **(Titanosauria)**[55]

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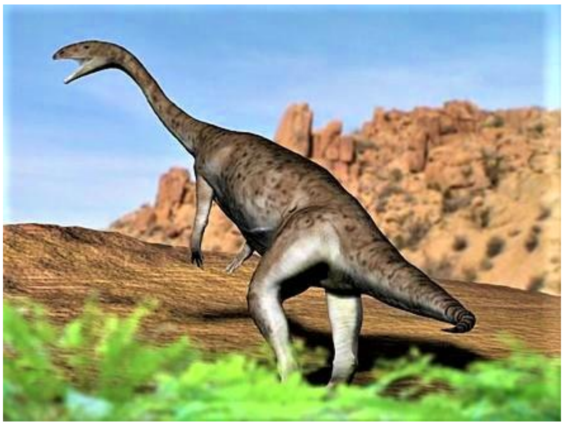
[34] In alphabetical order of the families and within the families.
[35] https://de.wikipedia.org/wiki/Anchisaurus
[36] https://de.wikipedia.org/wiki/Giraffatitan
[37] https://de.wikipedia.org/wiki/Sauroposeidon
[38] https://de.wikipedia.org/wiki/Camarasaurus
[39] https://de.wikipedia.org/wiki/Amargasaurus
[40] https://de.wikipedia.org/wiki/Apatosaurus
[41] https://de.wikipedia.org/wiki/Barosaurus
[42] https://de.wikipedia.org/wiki/Diplodocus
[43] https://de.wikipedia.org/wiki/Supersaurus
[44] https://en.wikipedia.org/wiki/Euhelopus
[45] https://de.wikipedia.org/wiki/Mamenchisaurus
[46] https://en.wikipedia.org/wiki/Euhelopus
[47] https://de.wikipedia.org/wiki/Nigersaurus
[48] https://en.wikipedia.org/wiki/Titanosauria ("Within Sauropoda, titanosaurs were once classified as close relatives of Diplodocidae due to their shared characteristic of narrow teeth, but this is now known to be the result of convergent evolution.") Mehrere Stammbäume
[49] https://de.wikipedia.org/wiki/Argentinosaurus / https://en.wikipedia.org/wiki/Argentinosaurus
[50] https://de.wikipedia.org/wiki/Dreadnoughtus
[51] https://de.wikipedia.org/wiki/Isisaurus
[52] https://de.wikipedia.org/wiki/Patagotitan
[53] https://www.nhm.ac.uk/discover/what-is-the-biggest-dinosaur.html (Natural History Museum) https://dinosaurfactsforkids.com/12-most-popular-long-neck-dinosaurs/
[54] https://de.wikipedia.org/wiki/Puertasaurus
[55] https://de.wikipedia.org/wiki/Rinconsaurus

Anchisaurus (Anchisauridae)



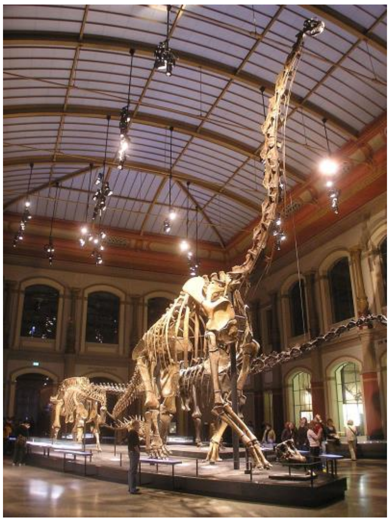
Left: *Anchisaurus* skeleton restoration by O. C. Marsh. **Right**: Life restoration according to Nomu Tamura (2010): https://commons.wikimedia.org/wiki/File:Anchisaurus_NT.jpg

"*Anchisaurus* was a rather **small dinosaur, with a length of just over 2 meters (6.6 ft),** which helps explain why it was once mistaken for human bones."

PBDB (2023) "Age range: base of the Hettangian to the top of the Sinemurian or 201.30000 to 190.80000 Ma" "Collections (2 total)."

CONSTANCY/stasis: ~ 10.5 Ma

Giraffatitan (Brachiosauridae)



Left: "The *Giraffatitan brancai* on display at the Museum für Naturkunde, Berlin" (1 May 2017 by Shadowgate from Novara, ITALY https://commons.wikimedia.org/wiki/File:Museum_f%C3%BCr_Naturkunde_(36556352434).jpg

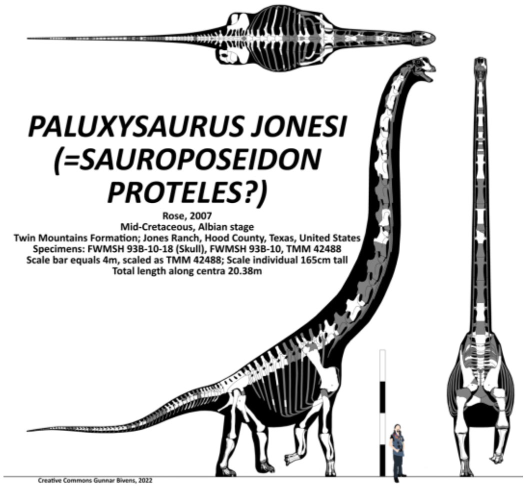
Right: Restoration of *Giraffatitan* Dmitry Bogdanov - Богданов (Bogdanov) dmitrchel@mail.ru (26 July 2007/21 October 2018 https://commons.wikimedia.org/wiki/File:Giraffatitan_DB.jpg) https://en.wikipedia.org/wiki/Giraffatitan

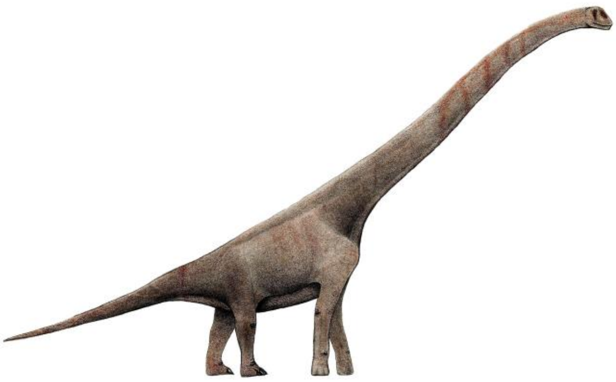
"*Giraffatitan* (name meaning "titanic giraffe") is a genus of sauropod dinosaur that lived during the late Jurassic Period (Kimmeridgian–Tithonian stages) in what is now Lindi Region, Tanzania… ***Giraffatitan* was for many decades known as the largest dinosaur** but recent discoveries of several larger dinosaurs prove otherwise;" "*Giraffatitan* and *Brachiosaurus* are still the largest sauropods known from relatively complete material." "In 2020, Molina-Perez and Larramnedi estimated the size of the HMN XV2 specimen at **25 meters (82 ft) and 48 tonnes (53 short tons), with a shoulder height of 6.8 meters (22 ft).[31]**"

PBDB (2023): "Age range: base of the Oxfordian to the top of the Late/Upper Kimmeridgian or 163.50000 to 150.80000 Ma" "Collections (42 total)"

CONSTANCY/stasis: ~12.5 Ma

***Sauroposeidon* (*Paluxysaurus jonesi* = *Sauroposeidon proteles*?) (Brachiosauridae)**

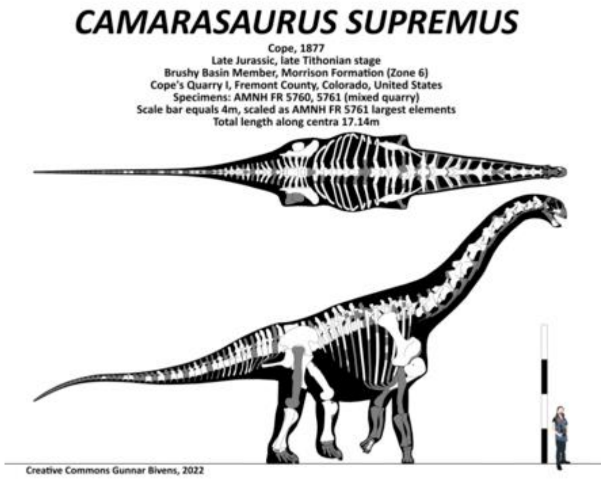


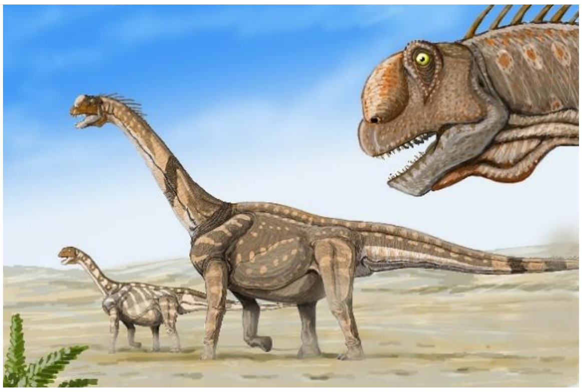


Left: *Paluxysaurus jonesi*, which possibly is (on the species and genus level) identical with *Sauroposeidon proteles*. For the latter only 4 enormously large cervical vertebrae have been detected so far. See details at https://en.wikipedia.org/wiki/Sauroposeidon. "Author Gunnar Bivens. Source Own Work" (30 May 2022.)
Right: Life reconstruction of *Sauroposeidon proteles*. "User: Levi bernardo/Gallery" (8 February 2016
Sauroposeidon: "The [**cervical**] **vertebrae are extremely elongated**, with the largest one having an overall length of **1.4 m (4.6 ft**), making it the longest sauropod neck vertebra on record."
https://en.wikipedia.org/wiki/Sauroposeidon (retrieved 21 May 2023)
PBDB (2023): "Age range: Albian or 113.00000 to 100.50000 Ma" "Collections (5 total)"

CONSTANCY/stasis: ~12.5 Ma

***Camarasaurus* (Camarasauridae)**

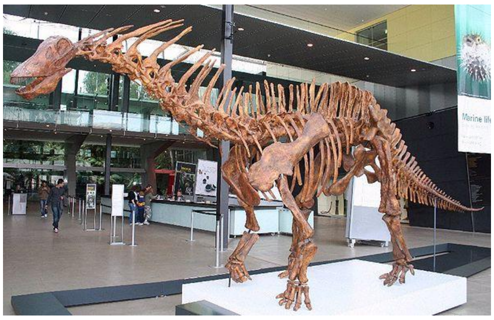


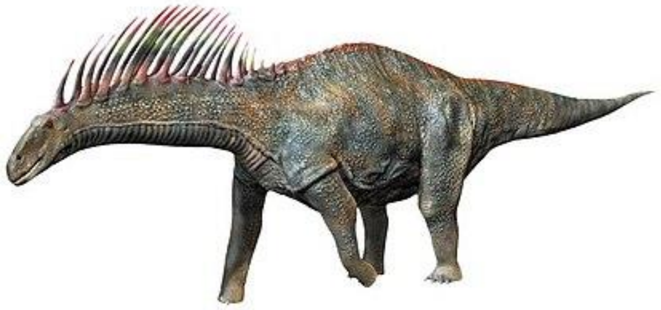


Left: Multiview skeletal reconstruction of *C. supremus*. See further details (including **several skeletons**) in https://en.wikipedia.org/wiki/Camarasaurus (retrieved 21 May 2023). "Author Gunnar Bivens. Own work" (23 August 2022).
Right: Life reconstruction of *Camarasaurus supremus* herd. "Source dmitrchel@mail.ru. Author Creator: Dmitry Bogdanov" (2007/2008).
PBDB (2023): "Age range: base of the Late/Upper Kimmeridgian to the top of the Early/Lower Tithonian or 155.70000 to 145.00000 Ma. Collections (108 total)"

CONSTANCY/stasis: ~10.7 Ma

Amargasaurus (Dicraeosauridae)

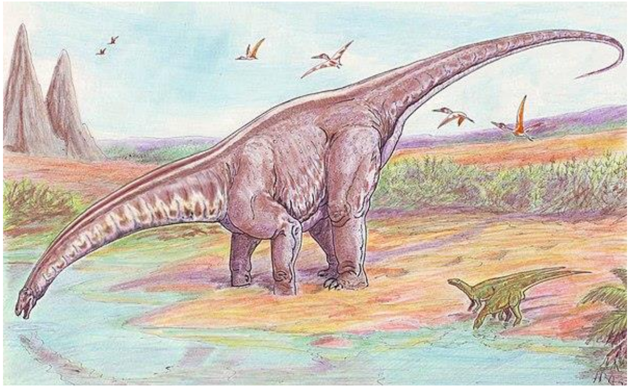




Left: “*Amargasaurus* mounted skeleton cast Foyer - Melbourne Museum.” Photo: cas Liber (2006).
Right: “Life reconstruction of Amargasaurus cazaui. The proportions match diagrams by palaeontologists Gregory S. Paul (The Princeton Field Guide to Dinosaurs, 2010, p. 188).” Nobu Tamura: Own work (2016). https://en.wikipedia.org/wiki/Amargasaurus (retrieved 3 June 2023).
PBDB (2023): Collections (2 total). “Age range: Barremian or 129.40000 to 125.00000 Ma”
Wiki: “The only known **skeleton** [but two in the interim] was discovered in 1984 and is **virtually complete**, including a fragmentary skull, making Amargasaurus one of the best-known sauropods of its epoch [Early Cretaceous].” … “It was a large animal, but small for a sauropod, reaching 9 to 13 meters (30 to 43 feet) in length. Most distinctively, it sported **two parallel rows of tall spines down its neck and back**, taller than in any other known sauropod.”

CONSTANCY/stasis: At least 4.4 Ma

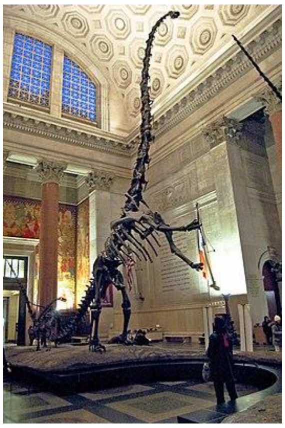
Apatosaurus (Diplodocidae)



Left: *Apatosaurus louisae*, Carnegie Museum. Author: Tadek Kurpaski. Uploaded by FunkMonk (2009).
Right: “Artistic interpretation of an individual of *A. louisae* arching its neck down to drink. Originally from ru.wikipedia; “Anatomical corrections by FunkMonk and Dinoguy2” (2011) .
PBDB (2023): **Collections (56 total)** “Age range: base of the Late/Upper Kimmeridgian to the top of the Early/Lower Tithonian or 155.70000 to 145.00000 Ma
Wiki: “Apatosaurus had an average length of 21–23 m (69–75 ft), and an average mass of 16.4–22.4 t (16.1–22.0 long tons; 18.1–24.7 short tons). A few specimens indicate a maximum length of 11–30% greater than average and a mass of approximately 33 t (32 long tons; 36 short tons). … *Apatosaurus* was a generalized browser that **likely held its head elevated**. To lighten its vertebrae, Apatosaurus had **air sacs** that made the bones internally full of holes.

CONSTANCY/stasis: ~10.7 Ma

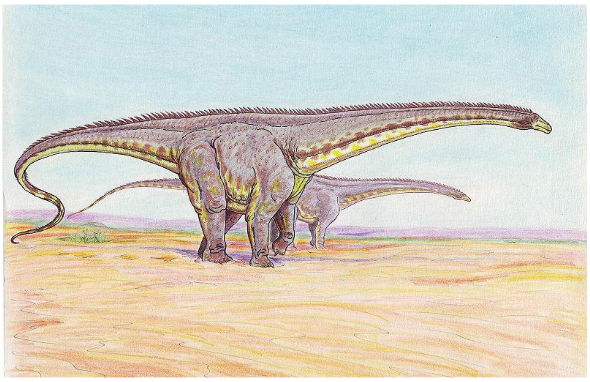
Barosaurus (Diplodocidae)



Left: "Mounted skeleton in rearing posture with a juvenile *Kaatedocus siberi*, American Museum of Natural History." "…originally classified as a juvenile *Barosaurus*, has since been reclassified as a specimen of *Kaatedocus siberi*." Sourse: "Christina fights the dragon" (2008). Author: Greg from New York, NY, America.
Right: "Life reconstruction of an individual rearing up to defend itself against a pair of *Allosaurus*."
Author: Fred Wierum. Source: Own work (2016).
PBDB (2023): **Collections: 18 total including 19 occurrences.** **"**Age range: base of the Late/Upper Kimmeridgian to the top of the Early/Lower Tithonian or 155.70000 to 145.00000 Ma
Wiki: "*Barosaurus* was an enormous animal, with some adults measuring about 25–27 m (82–89 ft) in length and weighing about 12–20 metric tons (13–22 short tons).[2][3][4] There are some indications of even larger individuals, such as the ***enormous cervical vertebra*** from the BYU 9024 specimen, which is ***1.37 m (4.5 ft) long***. Assuming it belongs to *Barosaurus*, this was an animal that was **48 m (157 ft) long and around 66 t (73 short tons**) in weight making it one of the largest known dinosaurs, with a ***neck length of at least 15 m*** (49 ft) according to Mike Taylor.[5] In 2020 Molina-Perez and Larramendi estimated it to be slightly smaller at 45 m (148 ft) and 60 t (66 short tons)." https://en.wikipedia.org/wiki/Barosaurus

CONSTANCY/stasis: ~10.7 Ma

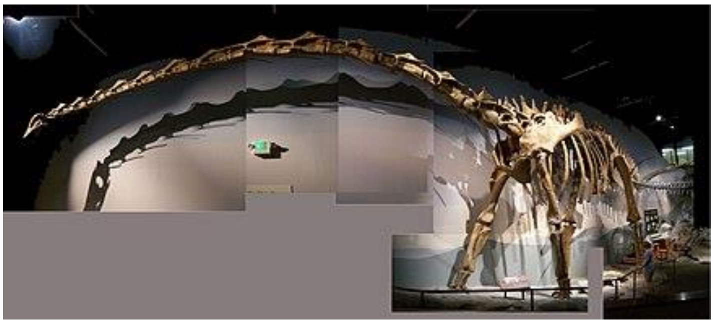
Diplodocus (Diplodocidae)

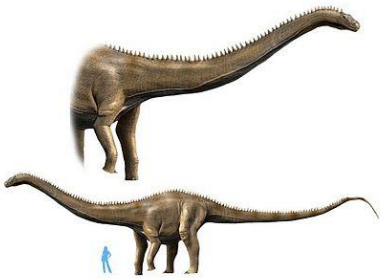


Left: Skelettrekonstruktion von *Diplodocus* [*Kaatedocus*?] im Sauriermuseum Aathal. Source: Author: Domser (2009). Own work (Original text: "selbst erstellt")
Right: Restoration of two *D. longus*. Author: Dmitry Bogdanov (2000)
https://de.wikipedia.org/wiki/Diplodocus and https://en.wikipedia.org/wiki/Diplodocus
PBDB (2023): **Collections: 57 including 58 occurrences.** "Age range: base of the Late/Upper Kimmeridgian to the top of the Early/Lower Tithonian *or* 155.70000 to 145.00000 Ma
Wiki: *D. carnegii* is currently one of the **longest dinosaurs** known from a **complete skeleton**, with a total length of 24–26 meters (79–85 ft). Modern mass estimates for *D. carnegii* have tended to be in the 12–14.8-metric-ton (13.2–16.3-short-ton) rang."

CONSTANCY/stasis: ~10.7 Ma

Supersaurus (Diplodocidae)





Left: "A reconstructed skeleton, Museum of Ancient Life, Utah, USA." Author: Zach Tirrell from Plymouth, USA (2005). Source: Supersaurus.
Right: Life reconstruction of *Supersaurus vivianae*. Author: Nobu Tamura (2017). https://en.wikipedia.org/wiki/Supersaurus
PBDB (2023): **Total: 4 collections including 5 occurrences**. Age range: base of the Late/Upper Kimmeridgian to the top of the Early/Lower Tithonian or 155.70000 to 145.00000 Ma
Wiki: "… in most respects it was very similar in anatomy to *Apatosaurus* but less robustly built with ***especially elongated cervical vertebrae, resulting in one of the longest known sauropod necks*.**

CONSTANCY/stasis: ~10.7 Ma

Euhelopus (Euhelopodidae)

Left: "A reconstructed skeleton in Japan. Author: Kumiko (2017). Source: https://www.flickr.com/photos/kmkmks/26386211978/
Right: Restoration. Author: DiBgd at English Wikipedia (2007). Source: "Transferred from en.wikipedia to Commons." https://commons.wikimedia.org/wiki/File:EuhelopusDB2.jpg
PBDB (2023): **Total: 5 collections**. "Age range: base of the Valanginian to the top of the Early/Lower Aptian or 139.80000 to 122.46000 Ma."
Wiki: "Since its original description, *Euhelopus* was often been considered a rather large sauropod. It has been thought to weigh about 15–20 tonnes (17–22 tons) and attain an adult length of 15 metres (49 feet). ***Later estimates have downsized this considerably.*** In 2016, Gregory S. Paul estimated the weight at 3.5 tonnes (3.9 tons) and the body length at 11 metres (36 feet). Benson et al. estimated its mass as 5,924 kg. Larramendi et al. later estimated its mass as 3,628 kg." https://en.wikipedia.org/wiki/Euhelopus
Just a few special points on the neck (best see the original article). "The axis, the **second neck vertebra**, has a hollow at the rear of its neural spine, with three deeper pneumatic depressions in it. The postaxial cervical vertebrae, the **neck vertebrae behind the axis**, have variably developed epipophyses and more subtle "pre-epipopophyses" below the prezygapophyses, projections on the front of the ridge between the prezygapophysis and the vertebral body. The **cervical neural arches** have an epipophyseal-prezygapophyseal lamina, a horizontal ridge running from the epipophysis to the prezygapophysis, separating two pneumatocoels by dividing the usual depression at the side base of the neural spine. In the **neck vertebrae** the pleurocoels are reduced to foramina, smaller openings. [Also] In the **neck vertebrae** the neural spines are reduced in height and length. The **third neck vertebra** has a neural spine with a transversely flattened forwardly directed process. The **anterior cervical vertebrae** have three costal spurs between the tuberculum and capitulum, the heads of their ribs. **The neck rib shafts** are strongly positioned below the vertebral body due to an appending parapophysis and a long section between the two rib heads.

CONSTANCY/stasis: ~17.3 Ma

Mamenchisaurus **(Mamenchisauridae)**

Left: "A reconstructed skeleton, Museum of Ancient Life, Utah, USA." Author: Zach Tirrell from Plymouth, USA (2005). Source: Supersaurus.
Right: Life reconstruction of *Supersaurus vivianae*. Author: Nobu Tamura (2017). https://en.wikipedia.org/wiki/Supersaurus

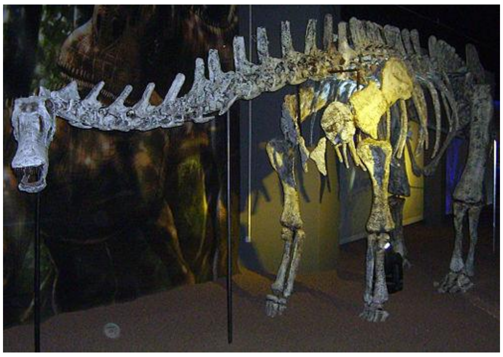
PBDB (2023): **Total: 22 collections including 23 occurrences**. Age range: base of the Bathonian to the top of the Late/Upper Aptian or 168.30000 to 112.03000 Ma.

Wiki: "Some *Mamenchisaurus* species are **almost completely known**, and others are fragmentary. The species differ in overall size and specific features of the skull and skeleton but share typical sauropod traits, like quadrupedalism, large bodies, small heads, and long tails. The most distinctive feature of mamenchisaurids is their ***exceptionally long necks which approach half their total length***. **Complete necks** are known in *M. youngi* and *M. hochuanensis*, which consist of 18 and 19 vertebrae, respectively.

… Two as-yet-undescribed cervical vertebrae possibly suggest one of the largest dinosaurs known. Gregory S. Paul suggested that these might belong to *M. sinocanadorum* and estimated a length 35 meters (115 ft) and possibly weighing 60 to 80 tonnes (66 to 88 short tons). However, the referral of these vertebrae to *M. sinocanadorum* has been questioned."

CONSTANCY/stasis: >56 Ma

Limaysaurus **(Rebbachisauridae)**



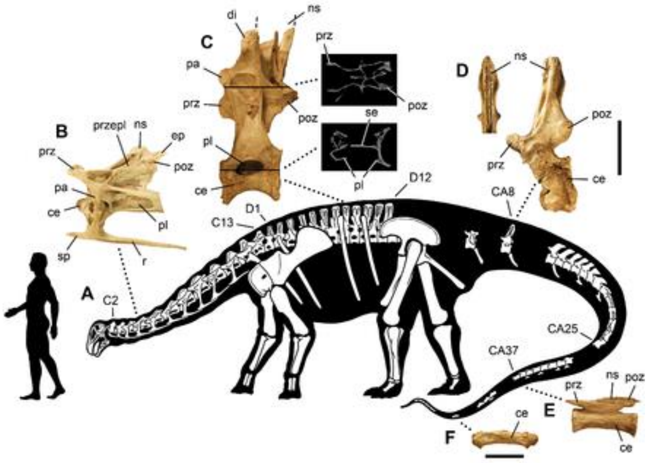
Left: *Limaysaurus tessonei* skeleton restoration, Copenhagen. Author: FunkMonk (Michael B. H.) (2010). Source: [His] Own work.
Right: "Restoration of *Limaysaurus* (front left) with contemporary dinosaurs." Author: ABelov2014 (2022). https://en.wikipedia.org/wiki/Limaysaurus

PBDB (2023): Total: **5 collections** each including a single occurrence. Age range: base of the Late/Upper Cenomanian to the top of the Cenomanian or 99.60000 to 93.90000 Ma

Wiki: *Limaysaurus* was a medium-sized sauropod. Gregory S. Paul in 2010 estimated its length at fifteen meters (50 ft) and its weight at seven tonnes."

CONSTANCY/stasis: ~5.7 Ma

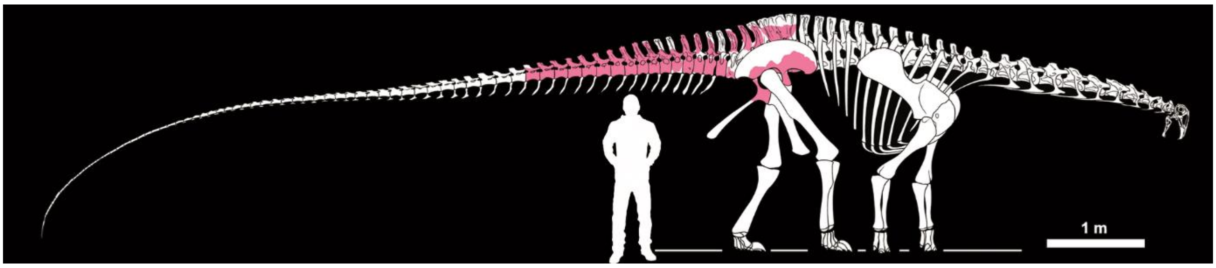
Nigersaurus **(Rebbachisauridae)**



Left: *Nigersaurus* skeleton. Author Kabacchi (2009). Source: Nigersaurus – 01. Uploaded by FunkMonk.
Right: "Skeletal diagram showing **known elements** and size comparison." Author: Carol Abraczinskas et al. Source: Structural Extremes in a Cretaceous Dinosaur. https://en.wikipedia.org/wiki/Nigersaurus
PBDB (2023): Collections: one only. Age range: base of the Aptian to the top of the Albian or 125.00000 to 100.50000 Ma.
Wiki: "Like all sauropods, ***Nigersaurus*** was a quadruped with a small head, thick hind legs, and a prominent tail. Among that clade, Nigersaurus was fairly small, with a body length of only 9 m (30 ft) and a femur reaching only 1 m (3 ft 3 in); it may have weighed around 1.9–4 t (2.1–4.4 short tons), **comparable to a modern elephant**. It **had a short neck *for a sauropod***, with thirteen cervical vertebrae. **Nearly all rebbachisaurids had relatively short necks and a length of 10 m (33 ft) or less. The only members of the family that reached the size of larger sauropods were *Rebbachisaurus* and *Maraapunisaurus***.

CONSTANCY/stasis: >24 Ma

Tataouinea **(Rebbachisauridae)**



Skeletal reconstruction of *Tataouinea hannibalis*, with missing elements based on other known nigersaurines. Author: Federico Fanti et al. (2015). Source: https://en.wikipedia.org/wiki/Tataouinea (more there)
PBDB (2023): Collections: **one** only. Age range: Albian or 113.00000 to 100.50000 Ma
Comment (2013) Matt: "First, it's awesome to see so much pneumaticity, and in elements that have not previously been reported as pneumatic in sauropods. The authors make a good case that we're looking at actual pneumaticity here, for example in the pelvic elements, and not something else. So that's cool. What's even cooler is that we're seeing this in a diplodocoid: Tataouinea is a rebbachisaurid. We've seen extreme pneumaticity in *saltasaurines, and now we've got a* ***parallel evolution*** *of this character complex in diplodocoids. … The case for a* ***birdlike lung-air sac system in sauropods, in saurischians, and in ornithodirans generally only keeps getting stronger***. That is, we're seeing more evidence not just that air sacs were there, but that **they were bird-like in their layout**, e.g., pneumatization of the pectoral girdle by clavicular air sacs, in both saltasaurines and theropods (avian and otherwise), and now extensive pelvic pneumatization (i.e., going beyond what we've seen previously in saltasaurines) by abdominal air sacs in rebbachisaurids and theropods (and pterosaurs, can't forget about them). Happy times."
More here: https://svpow.com/2013/07/16/tataouinea-hannibalis-and-its-crazy-pneumatic-pelvis/

CONSTANCY/stasis: ~12.5 Ma

Argentinosaurus (Titanosauria)

Left: "*Argentinosaurus huinculensis* reconstruction at Museo Municipal Carmen Funes, Plaza Huincul, Neuquén, Argentina. Author: MathKnight and Zachi Evenor https://en.wikipedia.org/wiki/Argentinosaurus http://www.ploscollections.org/article/info:doi/10.1371/journal.pone.0078733;jsessionid=441A913F8D576BBA46BF0960D01599FD
Right: "Modelo de un *Argentinosaurus* en el Instituto Weizmann de Ciencias, Israel." Author: MathKnight and Zachi Evenor"(2013). Source: "Own work." https://es.wikipedia.org/wiki/Argentinosaurus_huinculensis
PBDB (2023): "Collections: **one** only. Age range: base of the Late/Upper Cenomanian to the top of the Turonian or 99.60000 to 89.80000 Ma"
Wiki: "*Argentinosaurus* is a genus of giant sauropod dinosaur that lived during the Late Cretaceous period in what is now Argentina. Although it is only known from **fragmentary remains**, *Argentinosaurus* is **one of the largest known land animals of all time**, perhaps the largest, reaching 30–35 metres (98–115 ft) in length and 60–75 tonnes (66–83 short tons) in body mass. It was a member of Titanosauria, the dominant group of sauropods during the Cretaceous. It is widely regarded by many paleontologists as the biggest dinosaur ever, and perhaps lengthwise the longest animal ever, though both claims have no concrete evidence yet."

Some interesting points from the history of reconstruction:

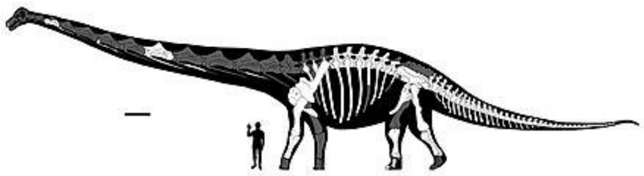
"A reconstruction of *Argentinosaurus* created by Gregory Paul in 1994 yielded a length estimate of **30–35 metres** (98–115 ft). Later that year, estimates by Bonaparte and Coria suggesting a **hind limb length of 4.5 metres (15 ft),** a **trunk length (hip to shoulder) of 7 metres** (23 ft), and **an overall body length of 30 metres** (98 ft) were published. In 2006, Kenneth Carpenter reconstructed Argentinosaurus using the more complete ***Saltasaurus as a guide*** and estimated a length of **30 metres** (98 ft). In 2008, Jorge Calvo and colleagues used the proportions of *Futalognkosaurus* to estimate the length of *Argentinosaurus* **at less than 33 metres** (108 ft). In 2013, William Sellers and colleagues arrived at a length estimate of **39.7 metres** (130 ft) and a shoulder height of **7.3 metres** (24 ft) by measuring the skeletal mount in Museo Carmen Funes. During the same year, Scott Hartman suggested that because *Argentinosaurus* was then thought to be a basal titanosaur, it would have a shorter tail and narrower chest than *Puertasaurus*, which he estimated to be about **27 metres (89 ft)** long, indicating *Argentinosaurus* was slightly smaller. In 2016, Paul estimated the length of Argentinosaurus at **30 m** (98 ft), but later estimated a greater length of **35 metres** (115 ft) **or longer** in 2019, restoring the unknown neck and tail of *Argentinosaurus* after those of other large South American titanosaurs."

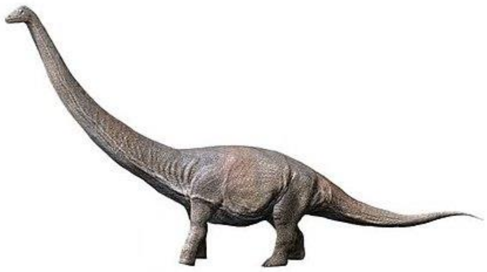
Vertebrae: "*Argentinosaurus* likely possessed 10 dorsal vertebrae, like other titanosaurs. ***The vertebrae were enormous even for sauropods;*** one dorsal vertebra has a reconstructed height of **159 centimetres** (63 in) and a width of **129 centimetres** (51 in), and the vertebral centra are up to **57 centimetres** (22 in) in width. In 2019, Paul estimated the total length of the dorsal vertebral column at **447 centimetres** (176 in) and the width of the pelvis at 0.6 times the combined length of the dorsal and sacral vertebral column. The dorsals were opisthocoelous (concave at the rear) as in other macronarian sauropods. The pleurocoels (excavations on the sides of the centra) were proportionally small and positioned in the front half of the centrum. **The vertebrae were internally lightened by a complex pattern of numerous air-filled chambers.**"

See more in the original article: https://en.wikipedia.org/wiki/Argentinosaurus (retrieved 19 June 2023)

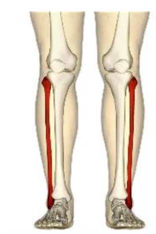
CONSTANCY/stasis: ~9.8 Ma

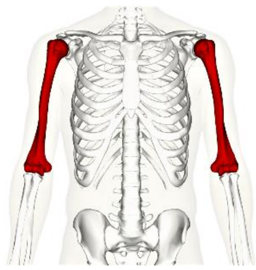
***Dreadnoughtus* (Titanosauria)**





Left: "Skeletal reconstruction of *Dreadnoughtus schrani*, showing the **recovered elements in white**. Scale bar equals 1 meter. CC-BY Kenneth Lacovara." Author: ArcaneHalveKnot (2013).
Source: File:Dreadnoughtus_Published_Reconstruction.jpg
Right: "Life reconstruction of *Dreadnoughtus schrani*. Author: Nobu Tamura. Source: Own work.
PBDB (2023): "Collections: **one** [two] only" "Age range: base of the Campanian to the top of the Maastrichtian or 83.60000 to 66.00000 Ma"
Wiki: "*Dreadnoughtus* is a genus of titanosaurian sauropod dinosaur containing a single species, *Dreadnoughtus schrani*. *D. schrani* is known from **two partial skeletons** discovered in Upper Cretaceous (Campanian to Maastrichtian; approximately 76–70 Ma) rocks of the Cerro Fortaleza Formation in Santa Cruz Province, Argentina. It is **one of the largest terrestrial vertebrates known**, with the immature type specimen measuring 26 metres (85 ft) in total body length and weighing 48–49 metric tons (53–54 short tons) (the greatest mass of any land animal that can be calculated with reasonable certainty). *D. schrani* is **known from more complete skeletons than any other gigantic titanosaurian**. https://en.wikipedia.org/wiki/Dreadnoughtus

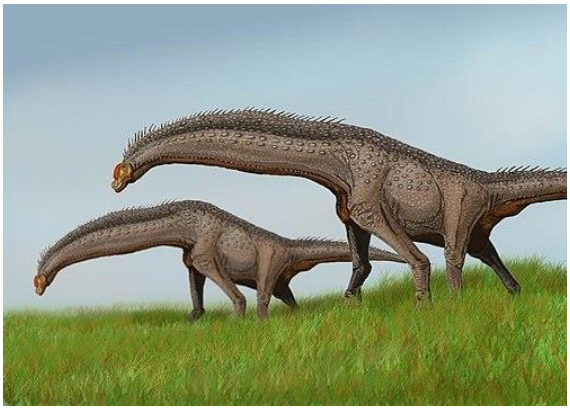
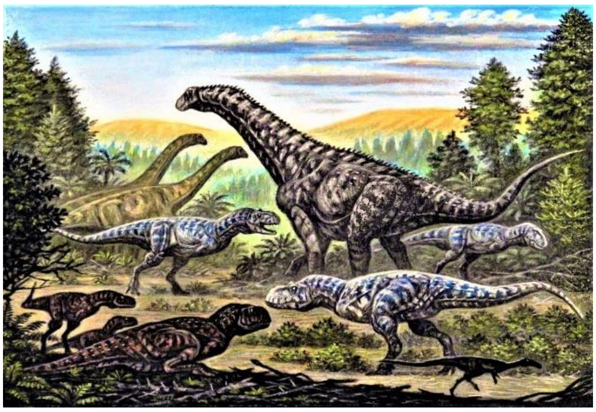




Dr. Kenneth J. Lacovara and the fibula (center) and humerus (right) of *Dreadnoughtus schrani*
Author: ArcaneHalveKnot (2012). Source: Own work
https://commons.wikimedia.org/wiki/File:Kenneth_J._Lacovara_and_Dreadnoughtus.jpg
https://en.wikipedia.org/wiki/Fibula https://en.wikipedia.org/wiki/Humerus

CONSTANCY/stasis of *Dreadnoughtus*: ~17.6 Ma

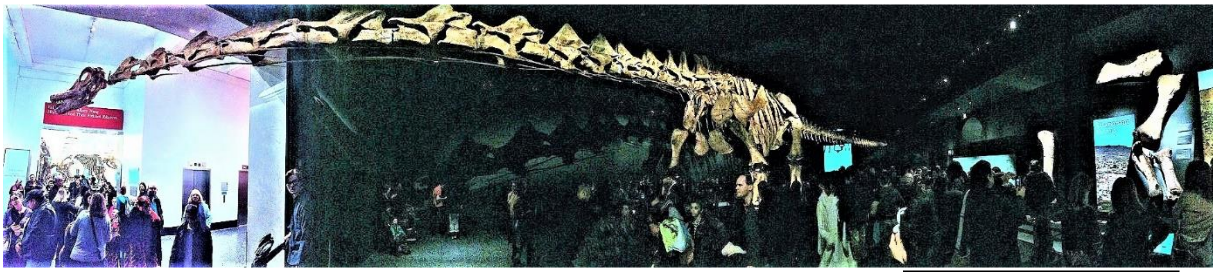
Isisaurus (Titanosauria)

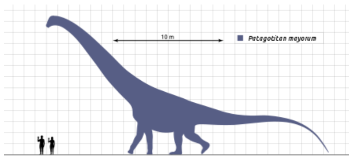
Left: "*Isisaurus colberti*_in_landscape – reconstruction. Autor: Bogdanov/ dmitrchel@mail.ru (2007). Source: "Transferred from en.wikipedia to Commons."
Right: "Life restoration of Isisaurus (middle) with contemporary dinosaurs. Author: ABelov2014 (2022) Source: https://www.deviantart.com/abelov2014/art/Morning-hunting-in-india-hunting-stories-919290211
PBDB (2023): "Collections: **one** [two] only" "Age range: base of the Campanian to the top of the Maastrichtian or 83.60000 to 66.00000 Ma"
Wiki: "*Isisaurus* is known from better remains than many other titanosaurs that were known at the time of its description. **Much of its postcranial skeleton is known**. The skeletal material found by Jain and Bandyopadhyay between 1984 and 1986 was "***in associated and mostly articulated condition***." The holotype includes cervical, dorsal, sacral and caudal vertebrae, ribs, pelvis, scapula, coracoid, left forelimb and other bones. No skull, hindlimb, or foot bones are known. Since the original description of *Isisaurus*, ***titanosaur fossils belonging to more complete individuals have been discovered***. [Das Skelett (Holotyp, Exemplarnummer ISI R335/1-65) ist assoziiert und gut erhalten.] https://en.wikipedia.org/wiki/Isisaurus https://de.wikipedia.org/wiki/Isisaurus

CONSTANCY/stasis: ~17.6 Ma

Patagotitan (Titanosauria)



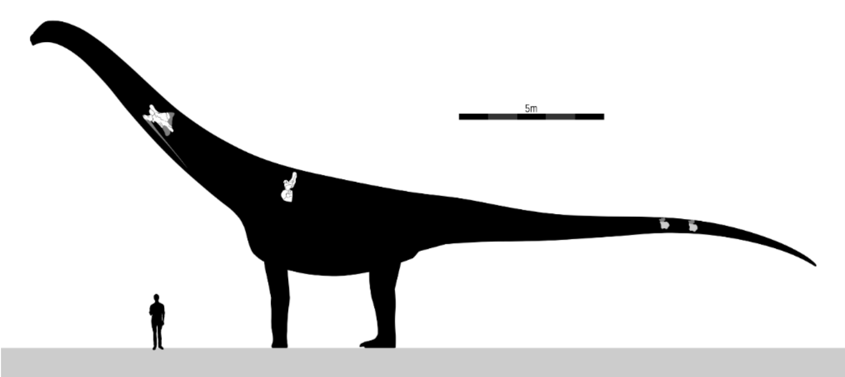




For all the pictures see please: https://es.wikipedia.org/wiki/Patagotitan_mayorum
PBDB (2023): "Collections: **one** [two] only" "Age range: base of the Campanian to the top of the Maastrichtian or 83.60000 to 66.00000 Ma."
Wiki: Like *Argentinosaurus* and other members of the Lognkosauria, ***Patagotitan* was a particularly large and robust titanosaur**. It can be distinguished from its close relatives by a suite of ***unique characteristics in its back and tail vertebrae, scapulae and humeri in the forelimb, and ischia and femora in the hindlimb***. Among these was the presence of accessory vertebral articulations known as the hyposphene-hypantrum articulations between only one pair of vertebrae at the level of the scapular blade, which was likely a weight-bearing adaptation not seen in any other sauropod (where they were either present between all pairs or between none). Several unique features in the limbs were also likely attachment scars for muscles." https://en.wikipedia.org/wiki/Patagotitan

CONSTANCY/stasis: ~17.6 Ma

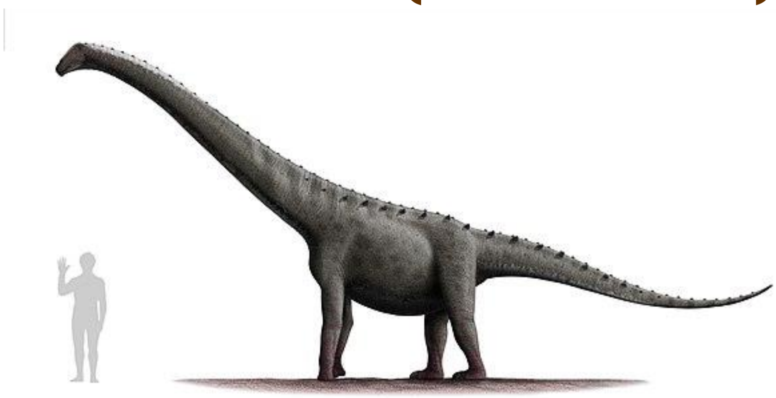
***Puertasaurus* (Titanosauria)**



Skeletal restoration of *Puertasaurus*. The holotype, MPM 10002, consists of a cervical vertebra, a dorsal vertebra, and two unfigured caudal vertebrae. Missing elements were restored after *Patagotitan*, *Futalognkosaurus*, *Notocolossus*, and *Tapuiasaurus*. Author: Slate Weasel (2018). Source: Own work.
PBDB (2023): "Collections: **one** only" "Age range: base of the Campanian to the top of the Maastrichtian or 83.60000 to 66.00000 Ma."
Wiki: "**Due to a lack of better material, the size of *Puertasaurus* is difficult to estimate**. Novas estimated the new species was approximately 35 to 40 meters (115 to 131 ft) long and weighing between 80 and 100 metric tons (88 and 110 short tons). This would place it as one of the largest dinosaurs, only rivaled in size by its relative Argentinosaurus, which has been estimated at up to 39.7 meters (130 ft) in length and 90 metric tons (99 short tons) in mass. The discovery of **the more complete *Futalognkosaurus*** revealed that these previous estimates were likely too high, and suggested that giants such as *Puertasaurus* and *Argentinosaurus* were **probably less than 33 meters (108 ft) long**." https://en.wikipedia.org/wiki/Puertasaurus

CONSTANCY/stasis: ~17.6 Ma

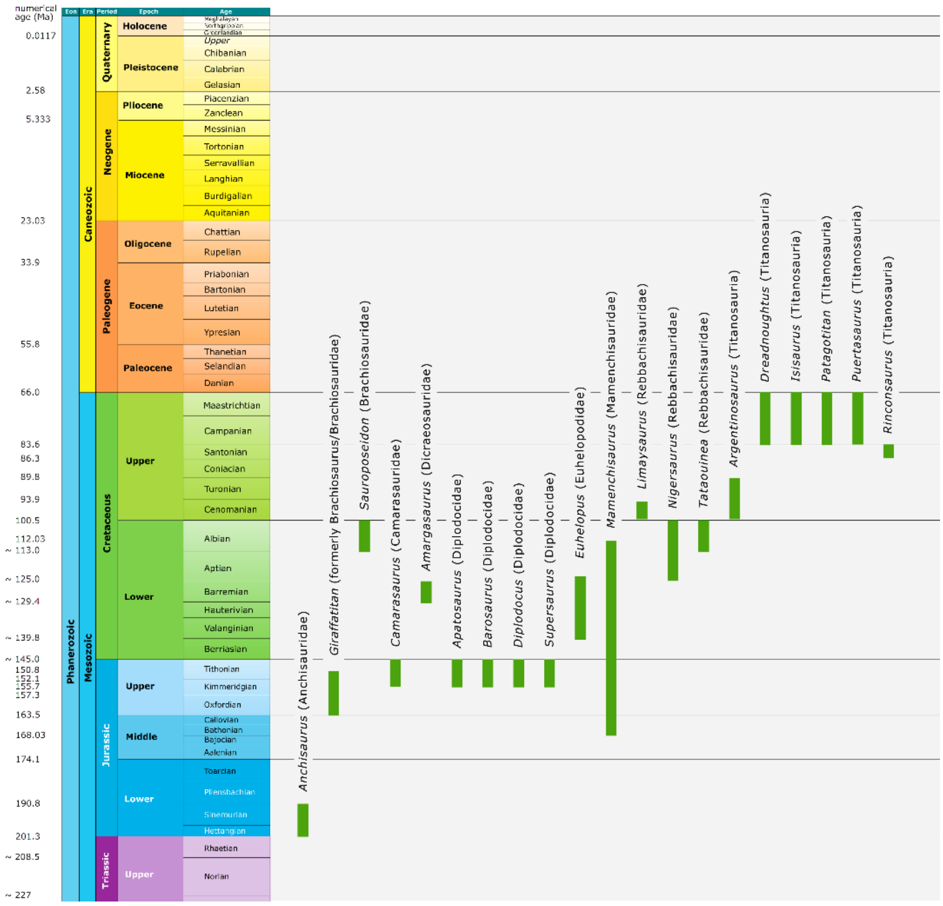
***Rinconsaurus* (Titanosauria)**



"***Rinconsaurus*** is a genus of titanosaur sauropod dinosaur from the Late Cretaceous in what is now Argentina. The type species, *Rinconsaurus caudamirus*, was described by Calvo and Riga in 2003, and is based on **three partial skeletons**."
"**Like** [almost[56]] **all sauropods, *Rinconsaurus* was a large long-necked quadrupedal animal**, with a long, whip-like tail and four pillar-like legs. *Rinconsaurus* was **an unusually slender sauropod**. Although fossil discoveries are incomplete, and no complete necks or heads have been found, fully grown ***Rinconsaurus* are estimated to have been 11 meters (36 ft) long and approximately 2.5 meters (8 ft) high at the shoulder.**The body mass of *Rinconsaurus* has been estimated to be between 3.21 and 5.39 tonnes."
PBDB (2023): Collections: one only. Age range: Santonian or 86.30000 to 83.60000 Ma.

CONSTANCY/stasis: ~2.7 Ma

[56] Example: "*Brachytrachelopan* is a short-necked sauropod dinosaur from the Late Jurassic (Oxfordian to Tithonian) of Argentina." https://en.wikipedia.org/wiki/Brachytrachelopan



Chronological occurrence of the 20 genera distributed in 9 families of the sauropod dinosaurs mentioned and shown above. And "nearly all did arise independently" (D'Emic, mail 26 June 2023 to W.-E. L. see also postscript below). Figure by Roland Slowik (Dietzenbach, Germany) for the present article (20 June 2023).

In the view of a large majority of neo-Darwinian biologists most of these genera (and also many more not shown here) arose independently of each other by the improbable process of *convergent evolution* by selection of random/accidental/haphazard DNA mutations[57]. In contrast, the proponents of the ID theory have cogent scientific reasons to postulate that these life forms were *intelligently designed*. Also, none of them is linked to any other by a series of transitional fossils, i.e. by a series of "infinitesimally small inherited variations" (Darwin and the neo-Darwinians – see below).

How Good is the Fossil Record?

"We estimate that **29% of discoverable dinosaur genera are now known**. … 90% of dinosaur genera are monospecific (the mean number of species is 1.2, with 98.3% of genera having 3 or fewer species), **so the percentage completeness at the species level is likely to be close to the generic figure of 29%**. Using this figure, the dinosaur fossil record is less complete than that of North American fossil mammal species, of which 56–67% are estimated to be known."[58] (So, in the case of the sauropod dinosaurs also some **30% transitional fossils should be known, which is not the case.**)

"Sauropods: "Age range: base of the Anisian to the top of the Late/Upper Maastrichtian or 247.20000 to 66.00000 Ma. Collections (**2997** total)"[59]

"Sauropoda is a clade of dinosaurs that consists of **roughly 300 species** of large, long-necked herbivores and includes the largest terrestrial animals ever to exist."[60]

Inference: Many more sauropod genera and species will be discovered and **thus also many additional cases of convergences** – from long necks to pneumatized bones like in birds.

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[57] Each of them had to arise ca. 50 times before having a realistic chance to become established in a population: http://www.weloennig.de/jfterrorchipmunks.pdf
[58] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1564218/ (2006) https://phys.org/news/2015-08-good-bad-fossil-dinosaurs.html (2015)
See also Lönnig (1990): http://www.weloennig.de/NeoB.Ana4.html
[59] https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=91972&is_real_user=1 (2023)
[60] https://en.wikipedia.org/wiki/List_of_sauropod_species ("This page was last edited on 20 June 2023, at 00:09 (UTC)"). (Retrieved 20 June 2023)

Convergence and Evolutionary Hypotheses

Before I'm going to start on the evolutionary hypotheses, let's first have a brief look at the objection of another critic: The MIT-trained evolutionary physicist Lee Spetner has put it in somewhat exaggerated terms[61] as follows – *cf.* abstract by David Klinghoffer[62]:

> "What's even more implausible than evolution? That would have to be convergent evolution, as Dr. Spetner, an MIT-trained physicist, points out. Darwinists pulled the concept out of thin air to describe how widely separated creatures on the phylogenetic tree independently "converge" on wondrous biological innovations, such as echolocation (in dolphins and bats, for example). **That remarkable coincidence extends down to fine chemical details not found in other animals**. How did such things get there? If explaining the unguided evolution of echolocation in whales is tough enough, explaining how it popped up in bats, too, naturally multiplies the difficulty. In fact, **Spetner says of convergent evolution that it explains nothing but is simply a case of "giving a name to our ignorance**."

A Wikipedia article has provided an impressive *List of examples of convergent evolution*: https://en.wikipedia.org/wiki/List_of_examples_of_convergent_evolution (retrieved 2 June 2023, at that time last edited 28 May 2023 with 266 references):

> "Convergent evolution — the repeated evolution of similar traits **in multiple lineages which all ancestrally lack the trait** — is rife in nature, as illustrated by the examples below."

And now: This is the general evolutionary explanation on the doubtful presupposition that natural selection of accidental/haphazard/random mutations "with slight or even invisible effects on the phenotype" (Mayr and in principle also all other neo-Darwinians) can really do this:

> "The ultimate cause of convergence is usually a similar evolutionary biome, as **similar environments will select for similar traits in any species occupying the same ecological niche,** even if those species are only distantly related. In the case of cryptic species, it can create species which are only distinguishable by analysing their genetics. Distantly related organisms often develop analogous structures by adapting to similar environments."

Under the subheading "*Prehistoric reptiles*" we read among many other examples of convergences: "The sauropods and giraffes independently evolved long necks." – However, it is not disclosed, not pointed out, that within the sauropods themselves long necks "evolved" almost forty times independently.

Moreover, for further reading the book of George R McGhee Jr. (2011): *Convergent Evolution – Limited Forms Most Beautiful*[63] recommended in this article. Part of the book description:

> "Convergent evolution **occurs on all levels, from tiny organic molecules to entire ecosystems of species.** McGhee demonstrates its **ubiquity in animals, both herbivore and carnivore; in plants; in ecosystems; in molecules, including DNA, proteins, and enzymes**; and even in **minds**, describing problem-solving behavior and group behavior as the products of convergence. For each species example, he provides an abbreviated list of the major nodes in its phylogenetic classification, allowing the reader to see the evolutionary relationship of a group of **species that have independently evolved a similar trait by convergent evolution**. McGhee analyzes the role of **functional and developmental constraints** in producing convergent evolution, and considers the scientific and philosophical implications of convergent evolution for the predictability of the evolutionary process." [64]

[61] In German „überspitzt"
[62] https://evolutionnews.org/2017/09/evolution-is-even-more-improbable-than-evolution-itself/ See also https://evolutionnews.org/2014/10/the_evolution_r/
[63] https://mitpress.mit.edu/9780262539098/convergent-evolution/ MIT Press. McGhee is Professor of Paleontology at Rutgers University.
[64] **Detailed excerpt/reading sample** of McGhee's book (unfortunately with interruptions), see https://books.google.de/books?id=QwDSr1qdqXUC&pg=PA13&hl=de&source=gbs_toc_r&cad=2#v=onepage&q&f=false

P Martin Sander et al. state in their paper the about the *Biology of the sauropod dinosaurs the evolution of gigantism* (2011):

> "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**.

The authors also think

> "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***. … The long neck, in turn, could only evolve because of the small head and the extensive pneumatization of the sauropodaxial skeleton [again many cases of convergence], lightening the neck."[65]

Michael Daniel D'Emic comments in his contribution on *The evolution of maximum terrestrial body mass in sauropod dinosaurs* (2023):

> "**The long-necked dinosaurs, sauropods**, are famous for their extreme body sizes, evolving body masses several times greater than the next-heaviest terrestrial animals, elephant-like and rhinoceros-like mammals and 'duck-billed' dinosaurs. … Likelihood-based ancestral state reconstruction reveals that sauropods convergently ***surpassed maximum terrestrial mammalian body mass*** **at least three dozen times** over the course of 100 million years, **on at least six landmasses and in at least five ecomorphologically disparate clades**."[66]

Sander et al. emphasize that "A notable size increase is seen within basal sauropodomorphs, but the **phylogenetic uncertainty** in this part of the dinosaur tree makes an interpretation of the evolution of body size difficult." Also: "Evolutionary size increase in 'prosauropods' was ***obviously not linear***: based on the phylogenetic hypotheses of Yates (2004, 2007), one of the smallest known 'prosauropods', *Anchisaurus*, with an estimated mass of less than 50 kg (Peczkis, 1994), is more closely related to sauropods than several taxa that exceeded 1 t".

Moreover:

> "Very large sauropod humeri (Buffetaut et al., 2002) from the **Triassic** of Thailand document **the very rapid evolution** (within a few million years after their origin) of very large body size in sauropods (Buffetaut et al., 2002; Sander et al., 2004). This **rapid body size increase** resulted from an evolutionary increase in growth rate compared to relatively small basal sauropodomorphs such as Plateosaurus (Sander et al., 2004). This increase in growth rate appears to be linked to the evolution of tachymetabolic endothermy in the sauropodomorph lineage (Sander et al., 2004; Sander & Klein, 2005; Sander et al., in press b; see also section II.10b)."

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[65] Sander, P M; Christian, A; Clauss, Marcus; Fechner, R; Gee, C T; Griebeler, E M; Gunga, H C; Hummel, J; Mallison, H; Perry, S F; Preuschoft, H; Rauhut, O W M; Remes, K; Tütken, T; Wings, O; Witzel, U (2011). Biology of the sauropod dinosaurs: the evolution of gigantism. Biological Reviews, 86(1):117-155.*Cf.* full article https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3045712/

[66] https://www.sciencedirect.com/science/article/abs/pii/S0960982223002403 (One of the many important points is this: "The extensive sauropod trackway record potentially will inform us on the issue of the habitual neck position. Sauropod trackways always show much larger pes prints than manus prints, and the pes prints are more deeply impressed (Thulborn, 1990; Lockley & Meyer, 2000; Wright, 2005), indicating that **most of the body weight was carried on the hindlimbs. This appears inconsistent with a horizontally held neck which would exert considerable leverage on the front limbs**, necessitating larger feet and resulting in deeper imprints than observed, while this leverage would be much reduced if the neck were held more erect, consistent with the small and shallow manus prints." "… some researchers have argued that no sauropod would have been able to hold the neck upright habitually because of the very high blood pressure required which would damage the arterial tissue and also the brain if the sauropod ever were to lower its head (Choy & Altmann, 1992). **These arguments do not take into account hypothetical soft tissue structures** (Badeer & Hicks, 1996; Ganse et al., in press) such as a rete mirabile (Colbert, 1993) or hypertrophied cardiac and arterial structures, which could have served to ensure an adequate supply of blood to the brain at a minimum energetic cost, as is seen in giraffes (Mitchell & Skinner, 2009)."

Similarly D'Emic (2023):

> "Sauropod maximum body mass **rapidly increased early in their evolutionary history** from under 5,000 kg before levelling off around 40,000 kg (with notable exceptions)."

Keep in mind, please, that expressions like "*Evolutionary size increase in 'prosauropods' was obviously not linear*", "*...the very rapid evolution*" and "*This rapid body size increase*" as well as "*body mass rapidly increased early*" are the evolutionary paraphrase for the fact that the thousands of links postulated for a continuous evolution of these life forms are missing. However, gradualism is still the dominant evolutionary theory in biology. As I have cited the main points elsewhere (2023[67]):

> Gradualism in biology and geology refers to a theory that changes of organic life and of the Earth occur through gradual increments, and that transitions between different species, genera, families are continual and slow rather than periodic and rapid.
>
> Thus, according to today's dominant theory of evolution – neo-Darwinism, also called "the synthetic theory of evolution" and "modern synthesis" – all life forms have evolved gradually from earlier life forms by natural selection of an almost endless array of mutations with "slight or even invisible effects on the phenotype" (in the words of Mayr, one of the architects of the modern synthesis) or phenotypically exactly as in Darwin's formulations of his theory between 1859 and 1882 by "...innumerable slight variations", "extremely slight variations" and "infinitesimally small inherited variations".
>
> And since this key point of the theory, its bottom line, core and essence, even "the same yesterday, and today and forever" – gradualism in combination with omnipotent natural selection – can hardly be overemphasized, I would like to continue to point out that Darwin correspondingly imagined the origin of species (and, in fact, of all life forms) by selection of "infinitesimally small changes", "infinitesimally slight variations" and "slow degrees" and hence imagined "steps not greater than those separating fine varieties", "insensibly fine steps" and "insensibly fine gradations", "for natural selection can act only by taking advantage of slight successive variations; she can never take a leap, but must advance by the shortest and slowest steps" or "the transition [between species] could, according to my theory, be effected only by numberless small gradations" (All emphasis added).
>
> In the 1st edition of Darwin's Origin (1859) we find his assertion that "Natura non facit saltum" ("nature doesn't jump") eight times and in the 6th edition (1872) twelve times, so even four times more. Darwin comments inter alia (1872, p. 166): "On the theory of natural selection we can clearly understand the full meaning of that old canon in natural history, "Natura non facit saltum." This canon, if we look to the present inhabitants alone of the world, is not strictly correct; but if we include all those of past times, whether known or unknown, it must on this theory be strictly true."

Virtually the same answer as that of Darwin (natural selection of randomly arisen "infinitesimally small inherited variations") is presented by neo-Darwinism today.

Now let us briefly turn back to the extensive reviews of Sander et al. (2011) and D'Emic (2023).

The first group of authors have discussed – among a series of other points – in detail the many different and (as expected in the absence of

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[67] http://www.weloennig.de/Rhinoceros.pdf

knowledge of many biological structures) often contradictory hypotheses on the *Bauplan and biology of sauropod dinosaurs* (with page references to their original article) – Just the topics under their Point II.:

Also, the authors have emphasized the ensuing important point (subsequently shown by several examples from the Late Jurassic and Early and Late Cretaceous):

> "Although sauropods were large animals in general, it is important to point out that **extreme sizes (close to or in excess of 40 t) were reached independently by several different lineages** of sauropods at different times throughout the later Mesozoic (Fig. 6). … **Extreme size among these very large titanosaurs probably evolved independently as well**, but this is difficult to evaluate because of the uncertain relationships of these taxa within Titanosauria. **Other examples of independent evolution** of gigantism in sauropods may include the poorly known *Huanghetitan ruyangensis* from the middle Cretaceous of China, which has **ribs over 3 m in length** (Lüet al., 2007).
>
> Giant sauropods thus occurred from the Late Jurassic to the Late Cretaceous, over a time span of at least 85 million years, and **this extreme gigantism developed independently in most major groups of neosauropods** (Fig. 6). The large number of very recently described giant forms suggests that truly giant forms may have been even more common than suggested by the current fossil record."[68]

Now, Michael Daniel D'Emic (2023) has found that the "likelihood-based ancestral state reconstruction" for the long-necked dinosaurs suggests the ensuing result:

> "Likelihood-based ancestral state reconstruction reveals that sauropods **convergently *surpassed maximum terrestrial mammalian body mass*** **at least three dozen times** over the course of 100 million years, **on at least six landmasses and in at least five ecomorphologically disparate clades**. Sauropod maximum body mass **rapidly increased early** in their evolutionary history from under 5,000 kg before levelling off around 40,000 kg (with notable exceptions)2, in a pattern similar to that observed in terrestrial mammals."[69]

[68] Also: "Differences in skull morphology, neck anatomy and reconstructed neck position in the different lineages that evolved giant sauropods indicate different feeding types (Upchurch & Barrett, 2000; Barrett & Upchurch, 2005). This suggests adaptations other than a specific feeding mode lead to very large body size."

[69] https://www.sciencedirect.com/science/article/abs/pii/S0960982223002403 (One of the many important points is this: "The extensive sauropod trackway record potentially will inform us on the issue of the habitual neck position. Sauropod trackways always show much larger pes prints than manus prints, and the pes prints are more deeply impressed (Thulborn, 1990; Lockley & Meyer, 2000; Wright, 2005), indicating that **most of the body weight was carried on the hindlimbs**. **This appears inconsistent with a horizontally held neck which would exert considerable leverage on the front limbs**, necessitating larger feet and resulting in deeper imprints than observed, while this leverage would be much reduced if the neck were held more erect, consistent with the small and shallow manus prints." "… some researchers have argued that no sauropod would have been able to hold the neck upright habitually because of the very high blood pressure required which would damage the arterial tissue and also the brain if the sauropod ever were to lower its head (Choy & Altmann, 1992). **These arguments do not take into account hypothetical soft tissue structures** (Badeer & Hicks, 1996; Ganse et al., in press) such as a rete mirabile (Colbert, 1993) or hypertrophied cardiac and arterial structures, which could have served to ensure an adequate supply of blood to the brain at a minimum energetic cost, as is seen in giraffes (Mitchell & Skinner, 2009)."

In more details (see also above):

> "Over the course of 100 million years, a remarkable 36 sauropod lineages independently surpassed the body masses evolved by other terrestrial clades, before or since, including two nonneosauropod lineages, two lineages within Turiasauria, seven within Diplodocoidea, and 25 within Macronaria, including three within Brachiosauridae and 15 within Titanosauria (Figures 1 and S2), based on current knowledge."

Thus, an enormous amount of convergence – even if one is only focusing on the long necks of sauropod dinosaurs – must have occurred "at least three dozen times" in these animals. And now including many other structures as well, as for instance in almost all the points already mentioned above, to repeat: *Bauplan and skeletal anatomy, musculature reconstruction and locomotor evolution*[70], *locomotion: gait and speed, integument,* ***respiratory system****, dentition and digestive system,* ***circulatory system****, nervous system and sense organs, organ size and its scaling,* ***physiology and thermoregulation****, and even many more*.

The evolution of many of these later almost identical organ systems on one or more different biologic levels (anatomy, physiology, genetics? etc.) is believed to have started from often widely different points of departure. D'Emic, 2023, p. 350:

> "Sauropods first surpassed maximum terrestrial mammal body mass during the Middle Jurassic, a time characterized by the breakup of Pangaea into discrete landmasses. These **first sauropods and the other lineages that later surpassed mammalian body mass *differed markedly from one another*** in body proportions and associated locomotory biomechanics, craniodental anatomy and inferred diet, life history and growth rates, the development of postcranial pneumaticity, and inferred habitats."
>
> "…Both the fossil record and modern biodiversity attest to **the rampancy of convergent evolution**, and in myriad clades body size is no exception."

"The rampancy of convergent evolution" – really by natural selection[71] of random/accidental/haphazard DNA mutations[72] with "slight or even invisible effects on the phenotype" i.e. by "insensibly fine gradations" etc. from in many respects clearly different forms?

Models: "The pattern of sauropod maximum body mass through time ***can be fit to a variety of models***, as has been done for terrestrial mammals, with the caveat that maxima are prone to be influenced by sampling bias or outliers."[73]

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[70] See, for example. Jannel et al (2022): https://www.science.org/doi/10.1126/sciadv.abm8280 (entire article):
"…these findings do indicate that distinct lineages of large terrestrial tetrapods **evolved convergent soft tissue pad structures within their pedes**. Hence, there is probably a biological link between the acquisition of gigantism and the benefits of having a soft tissue structure to absorb and redirect some loads away from the pedal skeleton."
[71] Study please the problems of natural selection in http://www.weloennig.de/NaturalSelection.html http://www.weloennig.de/OmnipotentImpotentNaturalSelection.pdf http://www.weloennig.de/jfterrorchipmunks.pdf
[72] *Cf.* http://www.weloennig.de/Gesetz_Rekurrente_Variation.html http://www.weloennig.de/Loennig-Long-Version-of-Law-of-Recurrent-Variation.pdf http://www.weloennig.de/ShortVersionofMutationsLawof_2006.pdf
[73] M. D. D'Emic, 2023, p. 350. The author continues: "Comparing the fit of various models using Akaike's Information Criterion shows that, as in mammals, sauropod body mass evolution is well explained by saturating trajectories such as the Gompertz model (Figure S1C and Table S2), consistent with model based investigations of sauropod body mass evolution. Sauropods plateaued in maximum body mass by the latter two-thirds of their evolutionary history, with the plateau sustained by the aforementioned 36 instances of exceptional body mass evolution (Supplemental information; Figure S1C). A saturating trajectory sustained by disparate clades through time has been **ascribed to convergent niche-filling** in mammals (Figure S1D). This explains the pattern in sauropods as well, evidenced by the great phenotypic disparity of the three dozen sauropod lineages that evolved to sizes unrivaled on land." Even among evolutionary biologists, **niche concepts are controversially discussed**. Recall in this context perhaps also D. Coppedge: "An environment has no power to force an organism to respond to it with a complex function. Light exists, whether or not an organism sees it. Magnetism exists, too; does it contain the power to nudge fish, turtles, and butterflies to employ it for navigation?"

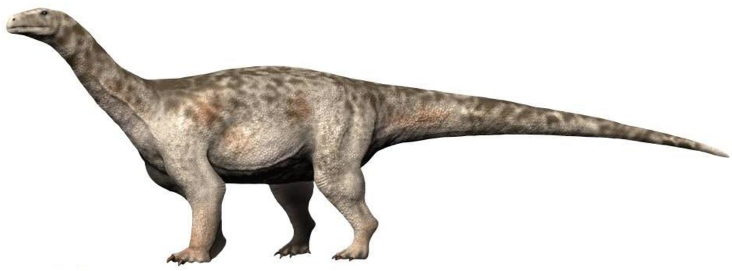
And there are further caveats as another evolutionary biologist has pointed out:

> "*The presence of convergence by itself* ***does not indicate that any particular influence****, such as adaptation in response to shared selective pressures, or shared developmental constraint,* ***has been acting on the evolutionary process****. In fact, it does not even mean that any influence has been acting at all, although even when adaptation is driving the evolution of individual lineages,* ***convergence does not necessarily imply that the lineages share a common selective regime***. Additional evidence, often readily available, is needed to support a non-stochastic mechanism for convergent evolution."[74]

Whether additional evidence is "often readily available" appears to be a different question (moreover: "…well-documented patterns of change within lineages are rare, however"), which I am not going to discuss here.

Some more convergences:

> "The quadrupedal Sauropods — the biggest dinosaurs to walk the Earth — evolved from bipedal ancestors. Two new early sauropodomorphs from South Africa and Argentina indicate that very large, ***flexed-limbed sauropodomorphs coexisted with early columnar-limbed sauropods for 20 million years***. … Sauropods evolved **from some sort of prosauropods** (more properly 'basal sauropodomorphs') in the Late Triassic. Prosauropods, like all basal dinosaurs, originally walked on their hind legs only (bipedal), and the origin of sauropods **thus** entailed the transition from a bipedal gait to a quadrupedal gait. **This transition also occurred in several other plant-eating dinosaur groups**. Only the meat-eating dinosaurs (theropods), a subgroup of which are the living birds, never evolved quadrupedality."[75]



https://en.wikipedia.org/wiki/Ledumahadi#/media/File:Ledumahadi_NT.jpg

Question: How many thousands of connecting links would have been necessary to fulfil the criteria mentioned above by Darwin and the neo-Darwinians (selection of "infinitesimally small changes", "infinitesimally slight variations" and "slow degrees" and hence imagined "steps not greater than those separating fine varieties", "insensibly fine steps" and "insensibly fine gradations", "infinitesimally small inherited variations" etc.)?

Moreover:

> "…the track record also provides the earliest convincing evidence for the columnar sauropod-type stance and mode of locomotion, and it ***considerably predates both Ledumahadi and the earliest sauropod body fossils***. The trackway is about 209 million years old and comes from the Late Triassic of Greenland. The prints of both the forefoot and hind foot are located close to the midline of the trackway, indicating a columnar limb posture."

If columnar limb posture was selectively so decisively advantageous – why did "two new early sauropodomorphs from South Africa and Argentina indicate that

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[74] C. Tristan Stayton (2015): What does convergent evolution mean? The interpretation of convergence and its implications in the search for limits to evolution. Entire paper here: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4633856/

[75] P. Martin Sander and Jens N. Lallensack (2018) Dinosaurs; Four Legs Good, Two Legs Bad. https://www.sciencedirect.com/science/article/pii/S0960982218310704 (full article). But why do these evolutionary scientists believe at all that such transformations happened? Answer, as just read: "***Prosauropods, like all basal dinosaurs, originally walked on their hind legs only*** (bipedal)…" Since they gave rise to 'all the rest' "the origin of sauropods **thus** entailed the transition from a bipedal gait to a quadrupedal gait." So, it is due to evolutionary presuppositions that this hypothesis is formed (Irgendwo müssen die Sauropodomorpha ja herkommen).

very large, flexed-limbed sauropodomorphs ***coexisted*** with early columnar-limbed sauropods for 20 million years”[76]?

How often did this transition occur?

> “The secondary evolution of quadrupedality from bipedal ancestry is a rare evolutionary transition in tetrapods ***yet occurred convergently at least three times*** within ornithischian dinosaurs.”[77]

So, the improbability that such transformations have happened by natural selection of random/accidental/haphazard DNA mutations is again being multiplied almost unimaginably. How do neo-Darwinians react to such an objection?

In my book about the origin of the eyes, I commented a statement of Luitfried von Salvini-Plawen und Ernst Mayr on “considering the ease with which eyes are apparently acquired during evolution”[78] as follows:

> “...considering the ease with which eyes are apparently acquired during evolution...". - How do the authors know that the evolution of a visual organ is obviously not as highly improbable as was thought in Darwin's time? "Proof": photoreceptors have "evolved" independently of each other in different animal groups at least 40, if not 65 times or even more. But how does one know that they actually "evolved" through the known factors of (random) mutation and selection from undifferentiated cells without mind, plan or goal? You can comb through the work as often and as thoroughly as you can - you won't find a word about it.
>
> It is the worldview of Salvini-Plawen and Mayr (*cf*. Ruse above) that summarily presupposes the statements of the Synthetic Theory of Evolution as scientific facts, whereby the line of thought runs something like this: Evolution is a fact and its causes are completely clarified by mutation, recombination and selection. All structures of all organisms have been formed in this way. If photoreceptors could develop independently of each other not only once, but more than 60 times, then the evolution of a visual organ can obviously not be as highly improbable as was thought in Darwin's day!
>
> Hats off for so much naivety[79]

And now – coming back to the origin of the long-necked dinosaurs:

> “The elongation of the neck involves **both the elongation of single vertebrae as well as an increase in the total number of cervical vertebrae** (up to 19 in *Mamenchisaurus*), which ***happened independently in several lineages.***”[80]

Also:

> “*Giant theropods and sauropods convergently evolved highly cartilaginous hip joints by reducing supraacetabular ossifications*, a condition unlike that in early dinosauromorphs. However, transitions in femoral and acetabular soft tissues indicate that large sauropods and theropods built their hip joints in fundamentally different ways.”[81]

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[76] See again P. Martin Sander and Jens N. Lallensack (2018).
[77] Matthew Dempsey, Susannah C. R. Maidment, Brandon P. Hedrick and Karl T. Bates (2023): Convergent evolution of quadrupedality in ornithischian dinosaurs was achieved through disparate forelimb muscle mechanics https://royalsocietypublishing.org/doi/10.1098/rspb.2022.2435 (also the entire article)
[78] See context at http://www.weloennig.de/AuIINeAb.html
[79] I continued: “From a scientific point of view, however, the situation is as follows: All we know about the probability structure of the emergence of photoreceptors from undifferentiated precursors through mutation, recombination and selection is that the postulated evolution cannot be reproduced. The deeper we penetrate into the matter, the more complex the structures and processes become, i.e. the more improbable the postulate becomes that the emergence of such structures can be achieved solely through aimless mutations and selection. **If, in addition, such receptors have arisen independently of each other 60 times or more, then the improbability of random evolution becomes immeasurable**. Because: if the formation of new photoreceptors as a unique process is already so highly improbable due to the known evolutionary factors that it cannot be reproduced, then one can confidently place a 60-fold independent random repetition in the realm of myths.

Based on experience, on the other hand, it is becoming increasingly likely that the formation of photoreceptors was planned and purposeful. If one day, in the course of genetic engineering, the precisely thought-out, planned and targeted construction of such a photoreceptor should succeed, then man would have reproduced a tiny piece of the ingenious primordial creation with great effort of his mind and his technical abilities, and in the process would presumably have gained knowledge of connections that should move him all the more to bow humbly before the tremendous intelligence and outstanding wisdom and power of the intelligent designer of all life forms.”
[80] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3045712/
[81] https://pubmed.ncbi.nlm.nih.gov/32433795/

Additionally:

> A "team also uncovered evidence for how the dinosaur could support itself without collapsing under its own weight. CT scans of the vertebrae revealed the ***bones were mostly hollow*** [pneumatized], with air comprising up to **77% of their volume**. This would have made them relatively light, ***using the same weight-saving mechanism as the skeletons of modern birds***. To prevent injuries, the neck bones were strengthened by 4-m (13-ft) -long rods protruding from the vertebrae that formed bundles along either side of the neck."[82]

Now, let all the convergences mentioned so far pass before your mind's eye (from the **at least** 36 times independently arisen long necks[83] in sauropod dinosaurs to their mostly hollow bones – is it therefore any wonder that many authors use adjectives like "surprising", "fascinating", "remarkable", "extensive", "unexpected", "staggering", for such and similar phenomena involved in the topic of convergence?[84]

And most of those who use such terms have not even taken into account the infinite/ inexhaustible/ immeasurable improbability evolutionarily associated with these phenomena by selection of accidental 'micro'-mutations – at least not consciously.

In order to visualize the dimension of the problem once more, recall please the convergence-subtopics for the long necks of the sauropod dinosaurs and the long-necked giraffe as discussed above and some for dinos mentioned in addition:

1. Special Muscular Esophagus and Innervation	>35 times
2. (Solving the problem of) Large Volume of Air in the Trachea	>35 times
3. Muscles, Nuchal Ligament and Tendons	>35 times
4. Heart and Blood Pressure	>35 times
5. But What Happened When a *Supersaurus* Lowered his Head to Feed and Drink at Ground Level?	>35 times
6. How did Sauropods Prevent Blood from Pooling in their Limbs?	>35 times
7. Sauropods Bones were Mostly 'Hollow' (pneumatized) as in the Skeletons of Modern Birds	>35 (?) times
8. Elongation and increase of the neck vertebrae	>35 times

Moreover: Several points of the topics referred to by Sander et al. could be added.

To avoid further repetitions regarding ID: As for basics of the scientific theory of intelligent design, I would like to refer my readers to the ensuing document with many further references and links: http://www.weloennig.de/Rhinoceros.pdf (2023), pp. 8, 16, 19, 32, **47-49**, **51** (especially the long footnote), 52, 54, and invite them to apply the principles of these insights now also on the sauropod dinosaurs.

[82] https://newatlas.com/science/dinosaur-50-ft-neck-longest-animal
[83] Even if not necessarily in every structural detail.
[84] Google please: "Convergent evolution" surprising
See also: Nature: "Convergent Evolution Seen in Hundreds of Genes" and "Surprisingly, Extensive" by Casey Luskin https://evolutionnews.org/2013/09/nature_converge/ and the contribution on Zombie Science: Jonathan Wells on Convergence Versus Common Ancestry https://evolutionnews.org/2017/06/zombie-science-jonathan-wells-on-convergence-versus-common-ancestry/

Supplement:

Convergences according to the impressive *List of examples of convergent evolution*: https://en.wikipedia.org/wiki/List_of_examples_of_convergent_evolution
"This page was last edited on 28 May 2023, at 23:34 (UTC)." (retrieved 21 June 2023). The authors have to be recommended for their diligent work, **even if one has powerful scientific reasons not to accept most of their evolutionary interpretations**[85] (they have always ***presupposed*** overall evolution by natural selection of accidental/random DNA mutations[86]).

See also the history of that site at:
https://en.wikipedia.org/w/index.php?title=List_of_examples_of_convergent_evolution&action=history
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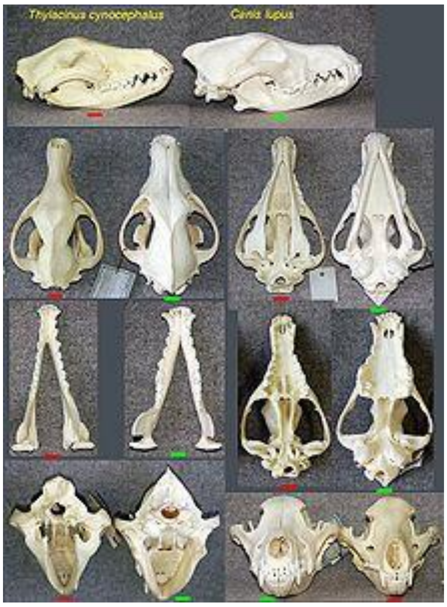
For all the references see please the Original Article:
https://en.wikipedia.org/wiki/List_of_examples_of_convergent_evolution

"Convergent evolution — the repeated evolution of similar traits in multiple lineages which all ancestrally lack the trait — is rife in nature, as illustrated by the examples below. The ultimate cause of convergence is usually a similar evolutionary biome, as similar environments will select for similar traits in any species occupying the same ecological niche [**see objections concerning this interpretation above**], even if those species are only distantly related. In the case of cryptic species, it can create species which are only distinguishable by analysing their genetics. Distantly related organisms often develop analogous structures by adapting to similar environments.

In animals



The skulls of the thylacine (left) and the grey wolf, *Canis lupus*, are similar, although the species are only very distantly related (different infraclasses). The skull shape of the red fox, *Vulpes vulpes*, is even closer to that of the thylacine.[1]

Mammals

- Several groups of ungulates have independently reduced or lost side digits on their feet, often leaving one or two digits for walking. That name comes from their hooves, which have evolved from claws several

[85] Except several examples of devolution by losses of functions.
[86] As already noted in http://www.weloennig.de/Rhinoceros.pdf for facts against this theory, *cf.* the books and articles on this topic by Douglas Axe, Günter Bechly, Michael J. Behe, David Berlinski, Tom Bethell, William A. Dembski, Michael Denton, [Douglas Dewar,] Marcos Eberlin, Phillip E. Johnson, [Henning Kahle,] Matti Leisola, Wolf-Ekkehard Lönnig, Casey Luskin, Stephen C. Meyer, J. P. Moreland et al. (eds.), Walter James ReMine, Paul Nelson, John C. Sanford, Siegfried Scherer, Granville Sewell, David W. Swift, James Tour, Jonathan Wells and many others.

times. For example, horses have one walking digit and domestic bovines two on each foot. Various other land vertebrates have also reduced or lost digits.[2]

- Similarly, laurasiathere perissodactyls and afrothere paenungulates have several features in common, to the point of there being no obvious distinction among basal taxa of both groups.[3]
- Many aquatic mammals or marine mammals independently came to have adaptations to live in water, such as similar-looking tail flukes in dugongs and whales. Unrelated herbivores and carnivores have adapted to marine and freshwater environments.[4]
- The flipper forelimbs of marine mammals (cetaceans, pinnipeds, and sirenians) are a classic example of convergent evolution. There is widespread convergence at the gene level.[5] Distinct substitutions in common genes created various aquatic adaptations, most of which also constitute parallel evolution because the substitutions in question are not unique to those animals.[6]
- The pronghorn of North America, while not a true antelope and only distantly related to them, closely resembles the true antelopes of the Old World, both behaviorally and morphologically. It also fills a similar ecological niche and is found in the same biomes.[7]
- Members of the two clades Australosphenida and Theria evolved tribosphenic molars independently.[8]
- The marsupial thylacine (Tasmanian tiger or Tasmanian wolf) had many resemblances to placental canids.[9]
- Several mammal groups have independently evolved prickly protrusions of the skin – echidnas (monotremes), the insectivorous hedgehogs, some tenrecs (a diverse group of shrew-like Malagasy mammals), Old World porcupines (rodents) and New World porcupines (another biological family of rodents). In this case, because the two groups of porcupines are closely related, they would be considered to be examples of parallel evolution; however, neither echidnas, nor hedgehogs, nor tenrecs are close relatives of the Rodentia. In fact, the last common ancestor of all of these groups lived in the age of the dinosaurs.[10] The eutriconodont Spinolestes that lived in the Early Cretaceous Period represents an even earlier example of a spiny mammal, unrelated to any modern mammal group.
- Catlike sabre-toothed predators evolved in three distinct lineages of mammals – carnivorans like the sabre-toothed cats, and nimravids ("false" sabre-tooths), the sparassodont family Thylacosmilidae ("marsupial" sabre-tooths), the gorgonopsids and the creodonts also developed long canine teeth, but with no other particular physical similarities.[11]
- A number of mammals have developed powerful fore claws and long, sticky tongues that allow them to open the homes of social insects (e.g., ants and termites) and consume them (myrmecophagy). These include the four species of anteater, more than a dozen armadillos, eight species of pangolin (plus fossil species), eight species of the monotreme (egg-laying mammals) echidna (plus fossil species), the *Fruitafossor* of the Late Jurassic, the marsupial numbat, the African aardvark, the aardwolf, and possibly also the sloth bear of South Asia, all unrelated.[12]
- Marsupial koalas of Australia have evolved fingerprints, indistinguishable from those of non-related primates, such as humans.[13]
- The Australian honey possums acquired a long tongue for taking nectar from flowers, a structure similar to that of butterflies, some moths, and hummingbirds, and used to accomplish the same task.[14]
- Marsupial sugar glider and squirrel glider of Australia are like the placental flying squirrel. Both lineages have independently developed wing-like flaps (patagia) for leaping from trees, and big eyes for foraging at night.[15]
- The North American kangaroo rat, Australian hopping mouse, and North African and Asian jerboa have developed convergent adaptations for hot desert environments; these include a small rounded body shape with large hind legs and long thin tails, a characteristic bipedal hop, and nocturnal, burrowing and seed-eating behaviours. These rodent groups fill similar niches in their respective ecosystems.[16]
- Opossums and their Australasian cousins have evolved an opposable thumb, a feature which is also commonly found in the non-related primates.[17]
- The marsupial mole has many resemblances to the placental mole and the golden mole.[18][19]
- Marsupial mulgaras have many resemblances to placental mice.[20]
- *Planigale* has many resemblances to the deer mouse.[21]
- The marsupial Tasmanian devil has many resemblances to the placental hyena or a wolverine. Similar skull morphology, large canines and crushing carnassial molars.[22]
- Marsupial kangaroos and wallabies have many resemblances to the springhares, the viscachas (rodents which are also related to chinchillas), the maras (a large rodent from the cavy family (Caviidae)), rabbits and hares (lagomorphs).[23]
- The marsupial lion, *Thylacoleo carnifex*, had retractable claws, the same way the placental felines (cats) do today.[24]
- Microbats, toothed whales and shrews developed sonar-like echolocation systems used for orientation, obstacle avoidance and for locating prey. Modern DNA phylogenies of bats have shown that the

traditional suborder of echolocating bats (Microchiroptera) is not a true clade, and instead some echolocating bats are more related to non-echolocating Old World fruit bats than to other echolocating species. The implication is that echolocation in at least two lineages of bats, Megachiroptera and Microchiroptera has evolved independently or been lost in Old World fruit bats.[25][26]

- Echolocation in bats and whales also both necessitate high frequency hearing. The protein prestin, which confers high hearing sensitivity in mammals, shows molecular convergence between the two main clades of echolocating bats, and also between bats and dolphins.[27][28] Other hearing genes also show convergence between echolocating taxa.[29] Recently the first genome-wide study of convergence was published, this study analysed 22 mammal genomes and revealed that tens of genes have undergone the same replacements in echolocating bats and cetaceans, with many of these genes encoding proteins that function in hearing and vision.[30]
- Both the aye-aye lemur and the striped possum have an elongated finger used to get invertebrates from trees. There are no woodpeckers in Madagascar or Australia where the species evolved, so the supply of invertebrates in trees was large.[31]
- *Castorocauda*, a Jurassic Period mammal and beavers both have webbed feet and a flattened tail, but are not related.[32]
- Prehensile tails evolved in a number of unrelated species marsupial opossums, their Australasian cousins, kinkajous, New World monkeys, tree-pangolins, tree-anteaters, porcupines, rats, skinks and chameleons, and the salamander *Bolitoglossa*.[33]
- Pig form, large-headed, pig-snouted and hoofs are independent in true pigs in Eurasia, peccaries in South America and the extinct entelodonts.[34]
- Tapirs and pigs look much alike, but tapirs are perissodactyls (odd-toed ungulates) and pigs are artiodactyls (even-toed ungulates).[35]
- Filter feeding: baleen whales like the humpback and blue whale (mammals), the whale shark and the basking shark separately, the manta ray, the Mesozoic bony fish *Leedsichthys*, and the early Paleozoic anomalocaridid *Aegirocassis* have separately evolved ways of sifting plankton from marine waters.[36]
- The monotreme platypus has what looks like a bird's beak (hence its scientific name *Ornithorhynchus*), but is a mammal.[37] However, it is not structurally similar to a bird beak (or any "true" beak, for that matter), being fleshy instead of keratinous.
- Red blood cells in mammals lack a cell nucleus. In comparison, the red blood cells of other vertebrates have nuclei; the only known exceptions are salamanders of the genus *Batrachoseps* and fish of the genus *Maurolicus*.[38]
- Caniforms like skunks and raccoons in North and South America and feliforms such as mongoose and civets in Asia and Africa have both evolved to fill the niche of small to medium omnivore/insectivore on their side of the world. Some species of mongoose and civet can even spray their attacker with musk similar to the skunk and some civets have also independently evolved similar markings to the raccoon such as the African civet.[39]
- River dolphins of the three species that live exclusively in freshwater, live in different rivers: Ganges and Brahmaputra Rivers of India, the Yangtze River of China, and the Amazon River. Mitochondrial and nuclear DNA sequence analysis demonstrates the three are not related.[40]
- Mangabeys comprise three different genera of Old World monkeys. The genera *Lophocebus* and *Cercocebus* resemble each other and were once thought to be closely related, so much so that all the species were in one genus. However, it is now known that *Lophocebus* is more closely related to baboons, while the *Cercocebus* is more closely related to the mandrill.[41]
- Sperm whale and the microscopic copepods both use the same buoyancy control system.[42]
- The wombat is a marsupial that is often considered to be the marsupial equivalent of the North American groundhog.[43][44]
- The fossa of Madagascar looks like a small cat. Fossa have semi-retractable claws. Fossa also has flexible ankles that allow it to climb up and down trees head-first, and also support jumping from tree to tree. Its classification has been controversial because its physical traits resemble those of cats, but is more closely related to the mongoose family, (Herpestidae) or most likely the family Malagasy carnivores family, (Eupleridae).[45][46]
- The raccoon dog of Asia looks like the raccoon of North America (hence its scientific name *Procyonoides*) due to its black face mask, stocky build, bushy appearance, and ability to climb trees. Despite their similarities, it is actually classified as part of the dog family (Canidae).
- Gliders or passive flight has developed independently in flying squirrels, Australian marsupial, lizards, paradise tree snake, frogs, gliding ants and flying fish and the ancient volaticotherium that lived in the Jurassic Period looked like a flying squirrel, but is not an ancestor of squirrels.[47][48]
- Amynodontidae a family of extinct rhinoceroses that are thought to have looked and behaved like squat, aquatic, hippopotamuses.[49][50]

- Trichromatic color vision, separate blue, green and red vision, is found only in a few mammals and came about independently in humans, Old World monkeys and the howler monkeys of the New World, and a few Australian marsupials.[51][52]
- Ruminant forestomaches came about independently in: hoatzin bird and tree sloths of the Amazon, ruminant artiodactyls (deer, cattle), colobus monkeys of the Old World and some Macropodidae.[53][54]
- Adept metabolic water, acquiring water by fat combustion in xerocole desert animal and others came about independently in: camel, kangaroo rat, migratory birds must rely exclusively on metabolic water production while making non-stop flights and more.[55][56][57][58]
- Glyptodontidae, a family of extinct mammals related to armadillos, had a shell much like a tortoise or turtle. Pangolins have convergently evolved the same features.
- *Megaladapis*, a genus of extinct lemur, bears a great resemblance to an indri or a koala (hence its nickname "koala-lemur") due to their stocky bear-like build, short stumpy tail, and presumed tufted ears.
- Palaeopropithecidae, a family of extinct lemurs, which are most likely related to the family Indriidae due to their morphology, have many similarities to sloths due to their appearance and behaviour, such as long arms, hooked fingers, and slow moving, giving them the nickname "sloth-lemurs".
- Archaeolemuridae, another family of extinct lemurs, which are also most likely related to the family Indriidae, have many similarities to monkeys and baboons due to their body plans, which are both adopted to arboreal and terrestrial lifestyle, giving them the nickname "monkey-lemurs" or "baboon-lemurs".
- South American foxes look like true foxes, despite being a unique canid genus more closely related to wolves and jackals.[59]
- Whales exhibit hyperphalangy -- an increase in the number of phalanges beyond three phalanges-per-digit. Whales share this characteristic with extinct marine reptiles, but not present-day marine mammals.[60]
- A very derived form of hyperphalangy, with six or more phalanges per digit, evolved convergently in rorqual whales and oceanic dolphins, and was likely associated with another wave of signaling within the interdigital tissues.[61]
- *Palorchestes*, a genus of the extinct marsupial family Palorchestidae, which are closely related to wombats and koalas in the suborder Vombatiformes, was nicknamed the "marsupial tapir" due to the shape of the animal's nasal bones, which was presumed that they possessed a short proboscis,[62] like those of placental tapirs today.
- Mongooses bear a striking resemblance to many mustelids, but belong to a distinctly different suborder—the Feliformia (all those carnivores sharing more recent origins with the cats) and not the Caniformia (those sharing more recent origins with the dogs). Because mongooses and mustelids occupy similar ecological niches, they had led to similarity in form and behavior.[63]
- Despite being from different families, both the giant panda (Ursidae) and the red panda (Ailuridae) are called "pandas" not only because of their fur pattern, but because they both have false thumbs and are adapted for a specialised bamboo diet despite having the digestive system of a carnivore (hence the order Carnivora).
- Multituberculates (named for the multiple tubercles on their "molars") are often called the "rodents of the Mesozoic", due to their appearances, traits and attributes.
- In general, marsupial cuscuses, brushtail possums, and their close relatives (Phalangeridae), are more terrestrial than other members of the suborder Phalangeriformes, and resemble terrestrial primates in some respects,[64] especially lemurs of Madagascar, which are prosimians.[65]
- Both the placental superorder Euarchontoglires and diprotodont marsupials are documented to possess a vermiform appendix.[66]

Prehistoric reptiles

- Pterosaurian pycnofibrils strongly resemble mammalian hair, but are thought to have evolved independently.[67]
- Ornithischian (bird-hipped) dinosaurs had a pelvis shape similar to that of birds, or avian dinosaurs, which evolved from saurischian (lizard-hipped) dinosaurs.[68]
- The Heterodontosauridae evolved a tibiotarsus which is also found in modern birds. These groups aren't closely related.[69]
- Ankylosaurs and glyptodont mammals both had spiked tails.[70]
- The sauropods and giraffes independently evolved long necks.[71]
- The horned snouts of ceratopsian dinosaurs like *Triceratops* have also evolved several times in Cenozoic mammals: rhinos, brontotheres, *Arsinoitherium*, and *Uintatherium*.[72]
- Rhyncosaur teeth resemble that of the extant rodents.

- Billed snouts on the duck-billed dinosaurs hadrosaurs strikingly convergent with ducks and duck-billed platypus.[73]
- Ichthyosaurs (such as *Ophthalmosaurus*)[74] are marine reptile of the Mesozoic era which looked strikingly like dolphins.[75] Several groups of marine reptiles evolved hyperphalangy similar to modern whales.[60]
- Toothless beaks are independently derived in ornithomimosaurian, alvarezsaurian, therizinosaurian, oviraptorosaurian and ceratopsian dinosaurs like *Triceratops*, certain pterosaurs, birds, turtles, and cephalopods like squid, cuttlefish, and octopus.[76]
- The "Pelycosauria" and the Ctenosauriscidae bore striking resemblance to each other because they both had a sail-like fin on their back. The pelycosaurs are synapsids (more closely related to mammals) while the ctenosauriscids are archosaurs (closely related to crocodilians, pterosaurs and dinosaurs). Also, the spinosaurids had sail-like fins on their backs, when they were not closely related to either.[77][78]
  - Also, *Acrocanthosaurus* and *Ouranosaurus*, which are not closely related to either pelycosaurs, ctenosauriscids or spinosaurids, also had similar, but thicker, spines on their vertebrae.
- *Noasaurus*, *Baryonyx*, and *Megaraptor*, all unrelated, all had an enlarged hand claw that were originally thought to be placed on the foot, as in dromaeosaurs. A similarly modified claw (or in this case, finger) is on the hand of *Iguanodon*.[79]
- The ornithopods had feet and beaks that resembled that of birds, but are only distantly related.[80]
- Three groups of dinosaurs, the Tyrannosauridae, Ornithomimosauria, and the Troodontidae, all evolved an arctometatarsus, independently.[81]
- Some placodonts (like *Cyamodus*, *Psephoderma*, *Henodus* and especially *Placochelys*) bear striking resemblance to sea turtles (and turtles in general) in terms of size, shell, beak, mostly toothless jaws, paddle-shaped limbs and possibly other adaptations for aquatic lifestyle.[82]
- Herbivorous dinosaurs exhibited convergent evolution towards one of two feeding strategies, one strategy resembling mammalian herbivores (emphasizing chewing-specialized morphology, with the skull acquiring and processing food) and another strategy analogous to herbivory in birds and reptiles (emphasizing a specialized gut as in the avian gizzard, with the skull used only for acquiring rather than processing food).[83]

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Henodus chelyops (Late Triassic), a placodont

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Proganochelys quenstedti (Late Triassic), a turtle

Extant reptiles

- The thorny devil (*Moloch horridus*) is similar in diet and activity patterns to the Texas horned lizard (*Phrynosoma cornutum*), although the two are not particularly closely related.[84]
- Amphisbaenian skulls closely resemble those of caecilians and mammals
- Modern crocodilians resemble prehistoric phytosaurs, champsosaurs, certain labyrinthodont amphibians, and perhaps even the early whale *Ambulocetus*. The resemblance between the crocodilians and phytosaurs in particular is quite striking; even to the point of having evolved the graduation between narrow- and broad-snouted forms, due to differences in diet between particular species in both groups.[85]
- Death adders strongly resemble true vipers, but are elapids.[86]
- Legless lizards evolved multiple times independently, including snakes, which are also legless lepidosaurs nested among legged lizards. Major examples of unrelated legless lizards include glass lizards (family Anguidae, related to legged alligator lizards)[87] and flap-footed lizards (family Pygopodidae, related to geckos), which each may be mistaken for snakes.[88]

- Large tegu lizards of South America have converged in form and ecology with monitor lizards, which are not present in the Americas.[89]
- Anole lizards, with populations on isolated islands, are one of the best examples of both adaptive radiation and convergent evolution. Anoles on a given island evolve into multiple body types and ecological preferences, and the same set of body types appears in unrelated species across distant islands.[90]
- The Asian sea snake *Enhydrina schistosa* (beaked sea snake) looks just like the Australian sea snake *Enhydrina zweifeli*, but in fact is not related.[91]
- The emerald tree boa and the green tree python are from two different families (boas and pythons), yet are very similar in appearance and ecology.[92]

Avian

- Cretaceous *Hesperornithes* were much like modern diving ducks, loons and grebes. *Hesperornithes* had the same lobed feet like grebes, with the hind legs very far back, that most likely they could not walk on land.[93][94]
- The little auk of the north Atlantic (Charadriiformes) and the diving-petrels of the southern oceans (Procellariiformes) are remarkably similar in appearance and habits.[95]
- The Eurasian magpie is a corvid, the Australian magpie is not.[96]
- Penguins in the Southern Hemisphere evolved similarly to flightless wing-propelled diving auks in the Northern Hemisphere: the Atlantic great auk and the Pacific mancallines.[97]
- Vultures are a result of convergent evolution: both Old World vultures and New World vultures eat carrion, but Old World vultures are in the eagle and hawk family (Accipitridae) and use mainly eyesight for discovering food; the New World vultures are of obscure ancestry, and some use the sense of smell as well as sight in hunting. Birds of both families are very big, search for food by soaring, circle over sighted carrion, flock in trees, and have unfeathered heads and necks.[98]

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Nubian vulture, an Old World vulture

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Turkey vulture, a New World vulture

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Hummingbird, a New World bird, with a sunbird, an Old World bird

- Hummingbirds resemble sunbirds. The former live in the Americas and belong to an order or superorder including the swifts, while the latter live in Africa and Asia and are a family in the order Passeriformes. Also the nectar-feeding Hawaiian honeycreepers resemble the two and differs from other honeycreeper.[99][100]
- Flightlessness has evolved in many different birds independently. However, taking this to a greater extreme, the terror birds, Gastornithiformes and dromornithids (ironically all extinct) all evolved the similar body shape (flightlessness, long legs, long necks, big heads), yet none of them were closely related. They also share the trait of being giant, flightless birds with vestigial wings, long legs, and long necks with the ratites, although they are not related.[101][102]
- Certain longclaws (*Macronyx*) and meadowlarks (*Sturnella*) have essentially the same striking plumage pattern. The former inhabit Africa and the latter the Americas, and they belong to different lineages of Passerida. While they are ecologically quite similar, no satisfying explanation exists for the convergent plumage; it is best explained by sheer chance.[103]
- Resemblances between swifts and swallows is due to convergent evolution. The chimney swift was originally identified as chimney swallow (*Hirundo pelagica*) by Carl Linnaeus in 1758, before being moved to the swift genus *Chaetura* by James Francis Stephens in 1825.[104]
- Downy woodpecker and hairy woodpecker look almost the same, as do some '*Chrysocolaptes* and *Dinopium* flamebacks, the smoky-brown woodpecker and some *Veniliornis* species, and other *Veniliornis* species and certain *"Picoides"* and *Piculus*. In neither case are the similar species particularly close relatives.[105]
- Many birds of Australia, like wrens and robins, look like Northern Hemisphere birds but are not related.[106]
- Oilbird like microbats and toothed whales developed sonar-like echolocation systems used for locating prey.[107]
- The brain structure, forebrain, of hummingbirds, songbirds, and parrots responsible for vocal learning (not by instinct) is very similar. These types of birds are not closely related.[108]
- Seriemas and secretary birds very closely resemble the ancient dromaeosaurid and troodontid dinosaurs. Both have evolved a retractable sickle-shaped claw on the second toe of each foot, both have feathers, and both are very similar in their overall physical appearance and lifestyle.[109]
- Migrating birds like, Swainson's thrushes can have half the brain sleep with the other half awake. Dolphins, whales, Amazonian manatee and pinnipeds can do the same. Called Unihemispheric slow-wave sleep.[110]
- Brood parasitism, laying eggs in the nests of birds of other species, happens in types of birds that are not closely related.[111]
- The charadriiform buttonquails closely resemble the galliform quails.
- Gallopheasants and junglefowl have similar tail-feathers but evolved them independently.

Fish

- Aquatic animals that swim by using an elongated fin along the dorsum, ventrum, or in pairs on their lateral margins (such as Oarfish, Knifefish, Cephalopods) have all come to the same ratio of amplitude to wavelength of fin undulation to maximize speed, 20:1.[112]
- Mudskippers and exhibit a number of adaptations to semi-terrestrial lifestyle which are also usually attributed to Devonian tetrapodomorphs such as *Tiktaalik*: breathing surface air, having eyes positioned on top of the head, propping up and moving on land using strong fins.[113] Pacific leaping blennies also resemble mudskippers though they are not related.

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Tiktaalik roseae - artistic interpretation. Neil Shubin, suggests the animal could prop up on its fins to venture onto land, though many palaeontologists reject this idea as outdated

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Boleophthalmus boddarti - a mudskipper which is believed to share some features with extinct fishapods in terms of adaptations to terrestrial habitats

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A group of mudskippers coming ashore - they use pectoral fins to prop up and move on land. Some scientists believe Tiktaalik to have acted likewise

- Goby dorsal finned like the lumpsuckers, yet they are not related.
- The Rhenanids became extinct over 200 million years before the first stingrays evolved, yet they share quite a similar appearance.
- Sandlance fish and chameleons have independent eye movements and focusing by use of the cornea.[114]
- Acanthurids and mbuna are both aggressive, brightly colored fish that feed principally on aufwuchs, although the former is found only in marine environments, while the latter is only found in freshwater Lake Malawi.
- Cichlids of South America and the "sunfish" of North America are strikingly similar in morphology, ecology and behavior.[115]
- The peacock bass and largemouth bass are excellent examples. The two fishes are not related, yet are very similar. Peacock bass are native of South America and is a Cichla. While largemouth bass are native to Southern USA states and is a sunfish.[116] others will surely be described (but see the results based on DNA data[117]).
- The antifreeze protein of fish in the arctic and Antarctic, came about independently.[118] AFGPs evolved separately in notothenioids and northern cod. In notothenioids, the AFGP gene arose from an ancestral trypsinogen-like serine protease gene.[119]
- Electric fish: electric organs and electrosensory systems evolved independently in South American Gymnotiformes and African Mormyridae.[120]
- Eel form are independent in the North American brook lamprey, neotropical eels, and the African spiny eel.[121]
- Stickleback fish have repeatedly moved between marine and freshwater environments, with widespread convergent evolution to adapt and readapt to these environments in different species.[122]
- Flying fish can fly up to 400 m (1,300 ft) at speeds of more than 70 kilometres per hour (43 mph) at a maximum altitude of more than 6 m (20 ft), much like other flying birds, bats and other gliders.[123]
- Extinct fish of the family Thoracopteridae, like *Thoracopterus* or *Potanichthys*, were similar to modern flying fish (gliding ability thanks to enlarged pair of pectoral fins and a deeply forked tail fin) which is not, however, considered to be their descendant.[124]
- The cleaner wrasse *Labroides dimidiatus* of the Indian Ocean is a small, longitudinally-striped black and bright blue cleaner fish, just like the cleaner goby *Elacatinus evelynae* of the western Atlantic.[125]
- The fish of the now discredited genus *Stylophthalmus* are only distantly related, but their larvae (Stomiiformes and Myctophiformes) have developed similar, stalked eyes.[126] (see: Stylophthalmine trait)
- Sawfish, a ray and unrelated sawshark have sharp transverse teeth for hunting.[127]
- Underwater camouflage is found independently in many fish like: leafy seadragon *(large part of its body is just for camouflage*, pygmy seahorse, leaf scorpionfish, flounder, peacock flounder. Some have active camouflage that changes with need.[128]
- Distraction eye, many fish have spot on the tail to fool prey. Prey are not sure which is the front, the direction of travel.[129]
- Gills appear in unrelated fish, some amphibians, some crustacean, aquatic insects and some mollusk, like freshwater snails, squid, octopus.[130]

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Cleaner wrasse *Labroides dimidiatus* servicing a Bigeye squirrelfish

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Caribbean cleaning goby *Elacatinus evelynae*

Amphibians

- Plethodontid salamanders and chameleons have evolved a harpoon-like tongue to catch insects.[131]
- The Neotropical poison dart frog and the *Mantella* of Madagascar have independently developed similar mechanisms for obtaining alkaloids from a diet of mites and storing the toxic chemicals in skin glands. They have also independently evolved similar bright skin colors that warn predators of their toxicity (by the opposite of crypsis, namely aposematism).[132]
- Caecilians are lissamphibians that secondarily lost their limbs, superficially resembling snakes and legless lizards.[133]
- Oldest known tetrapods (semi-aquatic Ichthyostegalia) resembled giant salamanders (body plan, lifestyle), though they are considered to be only distantly related.[134]
- A number of amphibians such as lungless salamanders and the Bornean flat-headed frog separately evolved lunglessness.[135]

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Elginerpeton pacheni, the oldest known tetrapod

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Andrias japonicus, a giant salamander which resembles first tetrapods

- Many different amphibians are neotenic, evolved to retain larval traits (such as external gills) as part of an aquatic lifestyle. For example, *Ambystoma mexicanum*, an extant salamander, is difficult to tell apart from the Permian temnospondyl *Branchiosaurus*.[136]

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Branchiosaurus, a Permian genus

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Mexican salamander (axolotl), extant

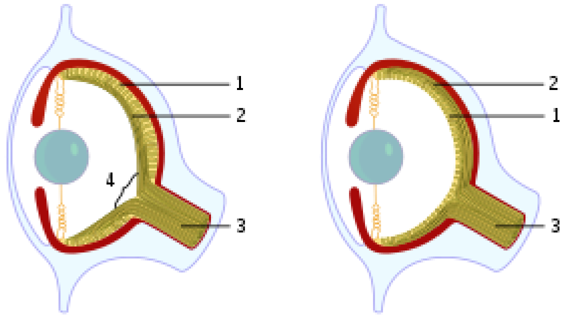
Arthropods

Pill bugs look like pill millipedes, but are actually wood lice that have converged on the same defenses, until they are difficult to tell apart

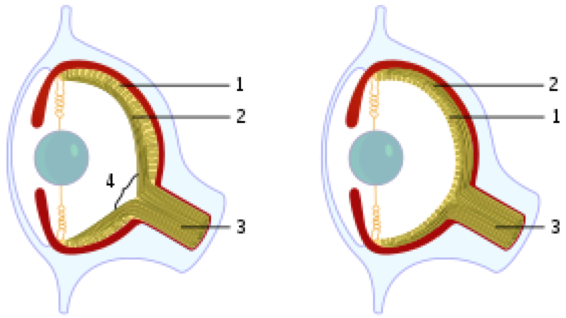
- The smelling organs of the terrestrial coconut crab are similar to those of insects.[137]
- In an odd cross-phyla example, an insect, the hummingbird hawk-moth (*Macroglossum stellatarum*), also feeds by hovering in front of flowers and drinking their nectar in the same way as hummingbirds and sunbirds.[138]
- Pill bugs and pill millipedes have evolved not only identical defenses, but are even difficult tell apart at a glance.[139] There is also a large ocean version: the giant isopod.[140]
- Silk: Spiders, silk moths, larval caddis flies, and the weaver ant all produce silken threads.[141]
- The praying mantis body type – raptorial forelimb, prehensile neck, and extraordinary snatching speed - has evolved not only in mantises but also independently in neuropteran insects Mantispidae.[142]
- Gripping limb ends have evolved separately in scorpions and in some decapod crustaceans, like lobsters and crabs. These chelae or claws have a similar architecture: the next-to-last segment grows a projection that fits against the last segment.[143]
- Agriculture: Some kinds of ants, termites, and ambrosia beetles have for a long time cultivated and tend fungi for food. These insects sow, fertilize, and weed their crops. A damselfish also takes care of red algae carpets on its piece of reef; the damselfish actively weeds out invading species of algae by nipping out the newcomer.[144]
- Slave-making behavior has evolved several times independently in the ant subfamilies Myrmicinae and Formicinae,[145][146] and more than ten times in total in ants.[147]
- Proleg: A fleshy leg on many larvae of insects has independently evolved in several orders.[148]
- Parasitoid use of viruses: Parasitoid wasps lay their eggs inside host caterpillars, to keep the caterpillar's immune system from killing the egg, a virus is also "laid" with the eggs. Two unrelated wasps use this trick.[149]
- Short-lived breeders: Species that are in the juvenile phase for most of their lives. The adult lives are so short most do not have working mouth parts. Unrelated species: cicada, mayflies, some flies, dragonfly, silk moths, and some other moths.[150][151]

- Katydids and frogs both make loud sounds with a sound-producing organs to attract females for mating [152][dubious – discuss].
- Camouflage of two kinds: Twig-like camouflage independently in walking sticks and the larvae of some butterflies and moths; leaf camouflage is found independently in some praying mantises and winged moths.
- Dipteran flies and Strepsiptera insects independently came up with whirling drumsticks halteres that are used like gyroscopes in flight.[153]
- Carcinisation: A crustacean evolves into a crab-like form from a non-crab-like form. The term was introduced into evolutionary biology by L. A. Borradaile, who described it as "one of the many attempts of Nature to evolve a crab".[154]

Molluscs



Vertebrate
Octopus



In vertebrate eyes, the nerve fibers route *before* the retina, blocking some light and creating a blind spot where the fibers pass through the retina and out of the eye. In octopus eyes, the nerve fibers route *behind* the retina, and do not block light or disrupt the retina. In the example, **4** denotes the vertebrate blind spot, which is notably absent in the octopus eye. In both images, **1** denotes the retina and **2** the nerve fibers, including the optic nerve (**3**).

- Bivalves and the gastropods in the family Juliidae have very similar shells.[155]
- There are limpet-like forms in several lines of gastropods: "true" limpets, pulmonate siphonariid limpets and several lineages of pulmonate freshwater limpets.[156][157]
- Cephalopod (like in octopuses & squid) and vertebrate eyes are both lens-camera eyes with much overall similarity, yet are very unrelated species. A closer examination reveals some differences including embryonic development, extraocular muscles, number of lens parts, and the lack of a retinal blindspot in the cephalopod eye.[158][159]
- Swim bladders: Buoyant bladders independently evolved in fishes, the tuberculate pelagic octopus, and siphonophores such as the Portuguese man o' war.[160]
- Bivalves and brachiopods independently evolved paired hinged shells for protection. However, the anatomy of their soft parts is very dissimilar, which is why molluscs and brachiopods are put into different phyla.[161]
- Jet propulsion in squids and in scallops: these two groups of mollusks have very different ways of squeezing water through their bodies in order to power rapid movement through a fluid. (Dragonfly larvae in the aquatic stage also use an anal jet to propel them, and jellyfish have used jet propulsion for a very long time.). Sea hares (gastropod molluscs) employ a similar means of jet propulsion, but without the sophisticated neurological machinery of cephalopods they navigate somewhat more clumsily.[162][163] tunicates (such as salps),[164][165] and some jellyfish[166][167][168] also employ jet propulsion. The most

efficient jet-propelled organisms are the salps,[164] which use an order of magnitude less energy (per kilogram per metre) than squid.[169]
- The free-swimming sea slug *Phylliroe* is notable for being a pelagic hunter that resembles a fish in body plan and locomotion, with functional convergences.[170]

Other

- The notochords in chordates are like the stomochords in hemichordates.[171]
- Gastrotrichs, despite being in 2 different superphyla, resemble the kinorhynchids
- Elvis taxon in the fossil record developed a similar morphology through convergent evolution.[172]
- Venomous sting: To inject poison with a hypodermic needle, a sharppointed tube, has shown up independently 10+ times: jellyfish, spiders, scorpions, centipedes, various insects, cone shell, snakes, some catfish, stingrays, stonefish, the male duckbill platypus, Siphonophorae and stinging nettles plant.[173]
- Bioluminescence: Symbiotic partnerships with light-emitting bacteria developed many times independently in deep-sea fish, jellyfish, fireflies, Rhagophthalmidae, *Pyrophorus* beetles, pyrosome, *Mycena*, *Omphalotus nidiformis* mushrooms, *Vargula hilgendorfii*, *Quantula striata* snail, googly-eyed glass squid, stiptic fungus, *Noctiluca scintillans*, *Pyrocystis fusiformis*, vargulin, sea pen, ostracod, Siphonophorae and glow worms. Bioluminescence is also produced by some animals directly.[174][175]
- Parthenogenesis: Some lizards and insects have independent the capacity for females to produce live young from unfertilized eggs. Some species are entirely female.[176]
- Several worm phyla have evolved an eversible proboscis, with examples being acanthocephalans, priapulids, kinorhynchs, and some polychaete worms.
- Extremely halophile archaeal family Halobacteriaceae and the extremely halophilic bacterium *Salinibacter ruber* both can live in high salt environment.[177]
- Jellyfish-form Hydrozoans have evolved many times, including the Portuguese man-o' war, and the crystal jelly.
- In the evolution of sexual reproduction and origin of the sex chromosome: Mammals, females have two copies of the X chromosome (XX) and males have one copy of the X and one copy of the Y chromosome (XY). In birds it is the opposite, with males have two copies of the Z chromosome (ZZ) and females have one copy of the Z and one copy of the W chromosome (ZW).[178]
- Multicellular organisms arose independently in brown algae (seaweed and kelp), plants, and animals.[179]
- Origins of teeth have happened at least two times.[180]
- Winged flight is found in unrelated species: birds, bats (mammal), insects, pterosaur and *Pterodactylus* (reptiles). Flying fish do not fly, but are very good at gliding flight.[181]
- Hummingbird, dragonfly and hummingbird hawk-moth can hover and fly backwards.[182]
- Neuroglobins are found in vertebrate neurons, (deuterostomes), and are found in the neurons of unrelated protostomes, like photosynthesis acoel and jelly fish.[183]
- Siphonophorae and Praya dubia resemble and act like jellyfish, but are Hydrozoa, a colony of specialized minute individuals called zooids.[184][185] Salp, a Chordata, also is very much like jellyfish, yet completely different.[186]
- Eusociality colonies in which only one female (queen) is reproductive and all other are divided into a castes system, all work together in a coordinate system. This system is used in many unrelated animals: ants, bees, and wasps, termites, naked mole-rat, Damaraland mole-rat, Synalpheus regalis shrimp, certain beetles, some gall thrips and some aphids.[187]
- Oxygenate blood came about in unrelated animals groups: vertebrates use iron (hemoglobin) and crustaceans and many mollusks use copper (hemocyanin).[188]
- Biomineralization the secrete protective shells or carapaces made out of organically made hard materials like mineral carbonates and organic chitins came about in unrelated species all at the same time during the cambrian Explosion in: mollusks, brachiopods, arthropods, bryozoans, echinoderms, tube worms.[189][a]
- Reef builders, a number of unrelated species of sea life build rocky like reefs: some types of bacteria make stromatolites, various sponges build skeletons of calcium carbonate, like: Archaeocyath sponges, and stromatoporoid sponges, corals, some anthozoan cnidarians, bryozoans, calcareous algae and some bivalves (rudist bivalves).[190][191][192]
- Magnetite for orientation, magnetically charged particles of magnetite for directional sensing have been found in unrelated species of salmon, rainbow trout, some butterflies and birds.[193]

- Hydrothermal vent adaptations like the use of bacteria housed in body flesh or in special organs, to the point they no longer have mouth parts, have been found in unrelated hydrothermal vent species of mollusks and tube worms (like the giant tube worm).[194]
- Lichens are partnerships of fungi and algae. Each "species" of lichen is make of different fungi and algae species, thus each has to come about independently.[195][196][197]
- Parental care came about independently in: mammals, most birds, some insects, some fish and crocodilians.[198][199]
- Regeneration, many different unrelated species can grow new limbs, tail or other body parts, if body parts are lost.[200][201]
- The Statocyst is a balance sensory receptor independently found in different organisms like: some aquatic invertebrates, including bivalves,[202] cnidarians,[203] echinoderms,[204] cephalopods,[205] and crustaceans.[206] Also found in single-cell ciliate. A similar structure is also found in *Xenoturbella*.[207]
- Hearing came about in many different unrelated species with the: Tympanal organ, Johnston's organ and mammals/bird ears. Also the simpler hearing found in reptiles, with only the stapes bone.
- Pincushion-form starfish have evolved over 3 times
- Infrared vision is in many different unrelated species: Pit viper snakes (rattlesnakes), pythons, vampire bats, and wood-boring wasps and fire beetles

In plants

- Leaves have evolved multiple times - see Evolutionary history of plants. They have evolved not only in land plants, but also in various algae, like kelp.[208]
- Prickles, thorns and spines are all modified plant tissues that have evolved to prevent or limit herbivory, these structures have evolved independently a number of times.[209]
- Stimulant toxins: Plants which are only distantly related to each other, such as coffee and tea, produce caffeine to deter predators.[210]
- The aerial rootlets found in ivy (*Hedera*) are similar to those of the climbing hydrangea (*Hydrangea petiolaris*) and some other vines. These rootlets are not derived from a common ancestor but have the same function of clinging to whatever support is available.[211]
- Flowering plants (*Delphinium*, *Aerangis*, *Tropaeolum* and others) from different regions form tube-like spurs that contain nectar. This is why insects from one place sometimes can feed on plants from another place that have a structure like the flower, which is the traditional source of food for the animal.[212]
- Casuarinas are flowering plants with fruit and leaves resembling those of the gymnosperm pines
- Some dicots (*Anemone*) and monocots (*Trillium*) in inhospitable environments are able to form underground organs such as corms, bulbs and rhizomes for reserving of nutrition and water until the conditions become better.
- Carnivorous plants: Nitrogen-deficient plants have in at least 7 distinct times become carnivorous, like: flypaper traps such as sundews and butterworts, spring traps-Venus fly trap, and pitcher traps in order to capture and digest insects to obtain scarce nitrogen.[213][214]
- Pitcher plants: The pitcher trap evolved independently in three eudicot lineages and one monocot lineage.[215][216]
- Similar-looking rosette succulents have arisen separately among plants in the families Asphodelaceae (formerly Liliaceae) and Crassulaceae.[217]
- The orchids, the birthwort family and Stylidiaceae have evolved independently the specific organ known as gynostemium, more popular as column.[218]
- The *Euphorbia* of deserts in Africa and southern Asia, and the Cactaceae of the New World deserts have similar modifications (see picture below for one of many possible examples).[219]
- Sunflower: some types of sunflower and *Pericallis* are due to convergent evolution.[220]
- Crassulacean acid metabolism (CAM), a carbon fixation pathway that evolved in multiple plants as an adaptation to arid conditions.[221]
- C4 photosynthesis is estimated to have evolved over 60 times within plants,[222] via multiple different sequences of evolutionary events.[223] C4 plants use a different metabolic pathway to capture carbon dioxide but also have differences in leaf anatomy and cell biology compared to most other plants.
- Trunk, a single woody stem came about in unrelated plants: paleozoic tree forms of club mosses, horsetails, and seed plants.
- The marine animals sea lily crinoid, looks like a terrestrial palm tree.[224]
- Palm trees form are in unrelated plants: cycads (from Jurassic period) and older tree ferns.[225]
- Flower petals came about independently in a number of different plant lineages.[226]
- Bilateral flowers, with distinct up-down orientation, came about independently in a number of different plants like: violets, orchids and peas.[227][228]
- United petals, petals that unite into a single bell shape came about independently in blueberries, Ericaceae and other plants.[229]

- Hummingbird flowers are scentless tubular flowers that have independently came about in at least four plant families. They attract nectar-feeding birds like: hummingbirds, honey eaters, sunbirds. Remote Hawaii also has hummingbird flowers.[230]
- Carrion flower type flowers that smell like rotting meat have independently came about in: pawpaw (family Annonaceae), the giant Indonesian parasitic flower Rafflesia, and African milkweed (*Stapelia gigantea*).[231]
- Fruit that develops underground, after the upper part is pollinated the flower stalk elongates, arches downward and pushes into the ground, this has independently came about in: peanut, legume, Florida's endangered burrowing four o'clock and Africa's *Cucumis humifructus*.[232]
- Plant fruit the fleshy nutritious part of plants that animal dispense by eating independently came about in flowering plants and in some gymnosperms like: ginkgo and cycads.[233]
- Water transport systems, like vascular plant systems, with water conducting vessels, independently came about in horsetails, club mosses, ferns, and gymnosperms.[234]
- Wind pollination independently came about in pine trees, grasses, and wind pollinated flower.
- Wind dispersal of seeds independently came about in dandelions, milkweed, cottonwood trees, and others tufted seeds like, impatiens sivarajanii, all adapted for wind dispersal.[235]
- Hallucinogenic toxins independently came about in: peyotecactus, Ayahuasca vine, some fungi like psilocybin mushroom.[236]
- Plant toxins independently came about in: solauricine, daphnin, tinyatoxin, ledol, protoanemonin, lotaustralin, chaconine, persin and more.[237]
- Venus flytrap sea anemone is an Animalia and Venus flytrap plant. Both look and act the same.[238]
- Digestive enzymes independently came about in carnivorous plants and animals.[239]

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Euphorbia obesa

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Astrophytum asterias

In fungi

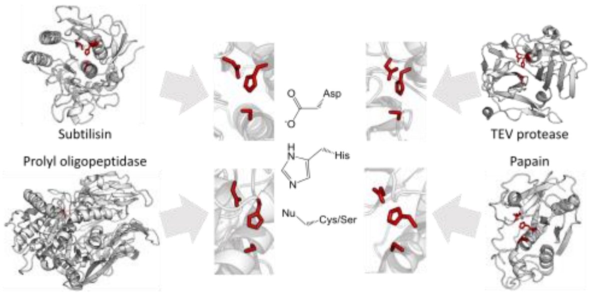
- There are a variety of saprophytic and parasitic organisms that have evolved the habit of growing into their substrates as thin strands for extracellular digestion. This is most typical of the "true" fungi, but it has also evolved in Actinomycetota (Bacteria), oomycetes (which are part of the stramenopile grouping, as are kelp), parasitic plants, and rhizocephalans (parasitic barnacles).[240][241][242]
- Slime molds are traditionally classified as fungi, but molecular-phylogeny work has revealed that most slime molds are not very close to Fungi proper and similar organisms, and that their slime-mold habit has originated several times. Mycetozoa (Amoebozoa), Labyrinthulomycetes (Stramenopiles), Phytomyxea and *Guttulinopsis vulgaris*[243] (Rhizaria), Acrasidae (Excavata), *Fonticula alba* (Opisthokonta), and

Myxobacteria (Bacteria). Mycetozoa itself contains myxogastrids, dictyostelids, and protostelids, likely with separate origins, with protostelids themselves likely originating several times.[244][245][246]

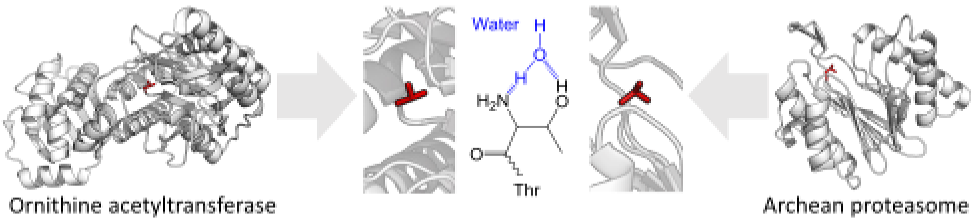
- Specialized forms of osmotrophy are found in unrelated fungi and animals.[247]

In proteins, enzymes and biochemical pathways

Functional convergence



Evolutionary convergence of serine and cysteine protease towards the same catalytic triads organisation of acid-base-nucleophile in different protease superfamilies. Shown are the triads of subtilisin, prolyl oligopeptidase, TEV protease, and papain.



Evolutionary convergence of threonine proteases towards the same N-terminal active site organisation. Shown are the catalytic threonine of the proteasome and ornithine acetyltransferase.

Here is a list of examples in which unrelated proteins have similar functions with different structure.

- The convergent orientation of the catalytic triad in the active site of serine and cysteine proteases independently in over 20 enzyme superfamilies.[248]
- The use of an N-terminal threonine for proteolysis.
- The existence of distinct families of carbonic anhydrase is believed to illustrate convergent evolution.
- The use of (*Z*)-7-dodecen-1-yl acetate as a sex pheromone by the Asian elephant (*Elephas maximus*) and by more than 100 species of Lepidoptera.
- The biosynthesis of plant hormones such as gibberellin and abscisic acid by different biochemical pathways in plants and fungi.[249][250]
- The protein prestin that drives the cochlea amplifier and confers high auditory sensitivity in mammals, shows numerous convergent amino acid replacements in bats and dolphins, both of which have independently evolved high frequency hearing for echolocation.[27][28] This same signature of convergence has also been found in other genes expressed in the mammalian cochlea[29]
- The repeated independent evolution of nylonase in two different strains of *Flavobacterium* and one strain of *Pseudomonas*.
- The myoglobin from the abalone *Sulculus diversicolor* has a different structure from normal myoglobin but serves a similar function — binding oxygen reversibly. "The molecular weight of Sulculus myoglobin is 41kD, 2.5 times larger than other myoglobins." Moreover, its amino acid sequence has no homology with other invertebrate myoglobins or with hemoglobins, but is 35% homologous with human indoleamine dioxygenase (IDO), a vertebrate tryptophan-degrading enzyme. It does not share similar

function with IDO. "The IDO-like myoglobin is unexpectedly widely distributed among *gastropodic molluscs*, such as *Sulculus*, *Nordotis*, *Battilus*, *Omphalius* and *Chlorostoma*."[251]

- The hemocyanin from arthropods and molluscs evolved from different ancestors, tyrosinase and insect storage proteins, respectively. They have different molecular weight and structure. However, the proteins both use copper binding sites to transport oxygen.[252]
- The hexokinase, ribokinase, and galactokinase families of sugar kinases have similar enzymatic functions of sugar phosphorylation, but they evolved from three distinct nonhomologous families since they all have distinct three-dimensional folding and their conserved sequence patterns are strikingly different.[253]
- Hemoglobins in jawed vertebrates and jawless fish evolved independently. The oxygen-binding hemoglobins of jawless fish evolved from an ancestor of cytoglobin which has no oxygen transport function and is expressed in fibroblast cells.[254]
- Toxic agent, serine protease BLTX, in the venom produced by two distinct species, the North American short-tailed shrew (*Blarina brevicauda*) and the Mexican beaded lizard, undergo convergent evolution. Although their structures are similar, it turns out that they increased the enzyme activity and toxicity through different way of structure changes. These changes are not found in the other non-venomous reptiles or mammals.[255]
- Another toxin BgK, a K+ channel-blocking toxin from the sea anemone *Bunodosoma granulifera* and scorpions adopt distinct scaffolds and unrelated structures, however, they have similar functions.[256]
- Antifreeze proteins are a perfect example of convergent evolution. Different small proteins with a flat surface which is rich in threonine from different organisms are selected to bind to the surface of ice crystals. "These include two proteins from fish, the ocean pout and the winter flounder, and three very active proteins from insects, the yellow mealworm beetle, the spruce budworm moth, and the snow flea."[257]
- RNA-binding proteins which contain RNA-binding domain (RBD) and the cold-shock domain (CSD) protein family are also an example of convergent evolution. Except that they both have conserved RNP motifs, other protein sequence are totally different. However, they have a similar function.[258]
- Blue-light-receptive cryptochrome expressed in the sponge eyes likely evolved convergently in the absence of opsins and nervous systems. The fully sequenced genome of *Amphimedon queenslandica*, a demosponge larvae, lacks one vital visual component: opsin-a gene for a light-sensitive opsin pigment which is essential for vision in other animals.[259]
- The structure of immunoglobulin G-binding bacterial proteins A and H do not contain any sequences homologous to the constant repeats of IgG antibodies, but they have similar functions. Both protein G, A, H are inhibited in the interactions with IgG antibodies (IgGFc) by a synthetic peptide corresponding to an 11-amino-acid-long sequence in the COOH-terminal region of the repeats.[260]
- The evolution of cardiotonic steroid (CTS) resistance via amino acid substitutions at well-defined positions of the Na^+,K^+-ATPase α-subunit in multiple insect species spanning 6 orders.[261][262][263]

Structural convergence

Here is a list of examples in which unrelated proteins have similar tertiary structures but different functions. Whole protein structural convergence is not thought to occur but some convergence of pockets and secondary structural elements have been documented.

- Some secondary structure convergence occurs due to some residues favouring being in α-helix (helical propensity) and for hydrophobic patches or pocket to be formed at the ends of the parallel sheets.[264]
- ABAC is a database of convergently evolved protein interaction interfaces. Examples comprise fibronectin/long chain cytokines, NEF/SH2, cyclophilin/capsid proteins.[265]

Mutational convergence

The most well-studied example is the Spike protein of SARS-CoV-2, which independently evolved at the same positions regardless of the underlying sublineage.[266] The most ominent examples from the pre-Omicron era were E484K and N501Y, while in the Omicron era examples include R493Q, R346X, N444X, L452X, N460X, F486X, and F490X.

Notes

1. Biomineralization is a process generally concomitant to *biodegradation* [?].[189]

References

Recall please: See the Original Article for All the References:
https://en.wikipedia.org/wiki/List_of_examples_of_convergent_evolution

For Wikipedia: "This page was last edited on 28 May 2023, at 23:34 (UTC)." (Retrieved 19 and 21 June 2023).

POSTSCRIPT:

Full mail by evolutionary biologist Michael D'Emic of 26 June 2023 to W.-E. L. on my question "Concerning the following 20 long-necked sauropod genera [which I had subsequently listed in my mail]: Did they all – without exception – arise independently of each other? All by convergence?":

His answer: "Hello – nearly all did arise independently, a few of the diplodocoids and titanosaurs may have been each others' closest relatives, in extremely large bodied clades."

I would like to add that this may also be true for *Mamenchisaurus* and *Omeisaurus* mentioned at the beginning of this article: As for genetical species and genera concepts *cf*. http://www.weloennig.de/Artbegriff.html (622 pp. 1986/2001/2002), and in paleontology see additionally http://www.weloennig.de/Rhinoceros.pdf (2023) especially pp. 42/**43**. However, it is not so easy to perform and study hybridization experiments with sauropod dinosaurs nowadays to elucidate the genetic situation.

5 July 2023

Objection: But consider the effect of time – in millions of years anything was possible. However, as M. Eden remarked on that point: "The length of time is relevant only when the probabilistic structure of events and changes occurring in this time are also known." Or J. H. Fabre: "When the difficulties become too great, one takes refuge behind the mists of centuries [and millions of years], one hides, as far as one's imagination allows, in the darkness of the past, one invokes time, this factor about which we have so few assets [or so little power] and which is precisely therefore so well suited to veiling phantasies."

See also on this topic some further comments at http://www.weloennig.de/AuIINeBe.html and http://www.weloennig.de/Gesetz_Rekurrente_Variation.html http://www.weloennig.de/AuIn.html

Moreover, the probability calculations on the basis of careful experimental molecular research by Douglas Axe[87], well summed up by Stephen C. Meyer in his books *Signature of the Cell*[88]and *Darwin's Doubt*[89], have shown that the evolutionary refuge to time is unfounded. See also the *Waiting Time* problem[90].

To be continued (and refined).

Back to Internet Library

[87] Estimating the Prevalence of Protein Sequences Adopting Functional Enzyme Fold https://www.sciencedirect.com/science/article/abs/pii/S0022283604007624 or his contributions in *BIO-Complexity* as for example https://bio-complexity.org/ojs/index.php/main/article/view/BIO-C.2011.1 or https://bio-complexity.org/ojs/index.php/main/article/view/BIO-C.2014.4

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