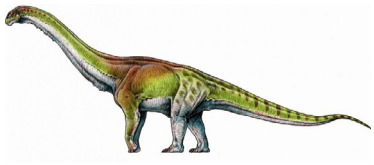
Giants from the Past

Middle School

NGSS: MS-LS4-1, MS-LS4-4



Background

Lesson Description

This investigation focuses on the fossils of a particular group of dinosaurs, the long-necked, herbivores known as sauropodomorphs. Students will gain an understanding of why certain body features provide advantages to survival through the use of models. Students will analyze and interpret data from fossils to synthesize a narrative for the evolution of adaptations that came to define a well-known group of dinosaurs.

Driving Phenomenon

Several traits, inherited and adapted over millions of years, provided advantages for a group of dinosaurs to evolve into the largest animals that ever walked the Earth. Giant dinosaurs called sauropods evolved over a period of 160 million years.

As paleontologists continue to uncover new specimens, they see connections across time and geography that lead to a better understanding of how adaptations interact with their environment to provide unique advantages depending on when and where animals lived. Several of the largest land animals ever found come from a region in South America known as Patagonia. The largest of these, Patagotitan mayorum also known as a titanosaur, is named after the region. **This creature reached a size fifteen times larger than an African elephant, the largest land animal living today.**

Driving Questions

- How could titanosaurs like Máximo have gotten so big?
  - What adaptation led to this ability?
  - How did these feature evolve over time?

Learning Objectives

- Students will demonstrate an understanding that particular traits provide advantages for survival by using models to test and gather data about the traits' functions.
- Students will demonstrate an understanding of ancestral traits by investigating how traits appear and change (or evolve) in the fossil record over time.
- Students will demonstrate an understanding of how traits function to provide advantages in a particular environment by inferring daily activities that the dinosaur would have performed for survival.

Time Requirements

- Four 40-45 minute sessions

Prerequisite Knowledge

- Sedimentary rocks form in layers, the newer rocks are laid down on top of the older rocks.
- In certain environments some traits provide an advantage for surviving and reproducing.

Teacher Resources

1. Titanosaur Infographic
2. Sauropodomorph Data Cards
3. Narrative Rubric
4. Habitat Map
5. Sauropodomorph Tree Diagram

Student Resources

1. Advantages and Challenges T-Chart
2. Testing Models of Grand Proportions
3. Graphic Organizer Examples
4. Advantages to Survival Claim
5. Non-fiction Narrative Elements

How could titanosaurs like Máximo have gotten so big?

Engage | 40 minutes	
Investigate the phenomena of the largest land animal ever known to science, and test the limits and abilities of long necks with models.	Notes
Teacher Resource: 1, 4, & Bigger They Are Video Student Resource: 1, 2	
Explore | 25 minutes	
Students will analyze and interpret data of many species of sauropodomorphs that lived over millions of years. Then, organize and develop graphical displays to communicate information from the data.	Notes
Teacher Resource: 2 Student Resource: 3	
Explain | 20 minutes	
Students will infer advantages to survival conferred by a particular trait, and then make a claim supported by evidence and reasoning as to how that trait provided a survival advantage.	Notes
Student Resource: 4	
Elaborate | 45 minutes	
Students write a non-fiction narrative that explains and describes milestones of saurpod evolution.	Notes
Student Resource: 5	
Evaluate | 40 minutes	
Students share their narratives with the class and evaluate one another's narratives based upon a rubric.	Notes
Teacher Resource: 3	

Pre-Lesson Preparation

Prepare stations prior to class. Students will use models to investigate the advantages and challenges of a sauropod body feature, the extremely long neck. Half of the class will start at the each station and then switch as stations do not need to be presented in a particular sequence. You may consider setting up multiple copies of the same station around your room to prevent crowding.

Materials

- Plastic straws (2-3 per student)
- Non-drying clay—6-8 palm-sized lumps
- Student Resource - One copy per student
- Teacher Resources - Copy and laminate as instructed on each document
- 1 pair of scissors
- Digital scale (<50g) or triple beam balance - One for each version of Station2 that is set-up
- Clamps or large binder clips 6-8
- Tape

Station Set-up Checklist

Station A: How does a long neck provide an advantage?
Materials: Teacher Resource 4.0: Habitat Map, String, Dry erase markers or wax pencils, Tape or binder clip

1. Cut string to three lengths: 6 in., 3 in., and 1.5 in. Cut enough pieces for each student at the station to have a set of the three lengths.
2. Teacher Resource 4.0: Habitat Map Print and laminate enough maps so that when a group is at the station, each student will have their own map to work on. For example if groups will have four students, you will want for maps per station.
3. Provide wax pencils/dry erase markers for use with laminated maps. (alternatively, if you don't want to laminate the maps make one copy per student, and they can use regular no. 2 pencils)

Station B: How does a long neck present a challenge?
Materials: Clay, Straws, Large binder clips or clamps, Digital scale (g) or triple-beam balance

1. Cut straws to three lengths: 1.5 in., 3 in., and Full length of straw. Cut enough straws so that each group has a set of each length.
2. Set out approximately 150 g of clay.
3. Set up the scale or balance.

Sauropods and Sauropodomorphs...What's in a Name?

Most people are familiar with the term Sauropod as referring to the long-necked, herbivorous giants of the dinosaur world. However, you may wonder, what is a sauropodomorph [SORE-oh-PO-doh-morf]? Sauropodomorphs include sauropods as well as a few prior and sister groupings or taxa that evolved prior to true sauropods. Some of these ancestors had shorter necks, some were small in comparison, and some walked on two legs instead of four. In this lesson we use the term sauropod quite a bit when referring to the well-known features or body traits of that group. We use the term sauropodomorph to refer to the major grouping that all of the dinosaurs in this lesson belong within.

Lesson Enrichment Resources

DO

Plan a trip to see the largest land animal yet discovered represented by Máximo the Titanosaur and the largest living land animal, the African Elephant, in the same room — Stanley Field Hall at the Field Museum. Students can also examine many of the sauropodomorph specimens used in this lesson, in person.

READ

These long-necked, elephant-sized dinos arose before Brachiosaurus
Newsela Article — adaptable to various reading levels
https://newsela.com/read/elem-first-giant-dinosaur-discovered/id/44856/

WATCH

Being Big on Land: The bigger they are, the harder they fall
Discover why being big isn't always an advantage. Learn what sets the rules on size limitations, and find out how mythic creatures like Godzilla and King Kong could have never carried their own weight.
https://vimeo.com/channels/1268513/86741231

Procedure

Engage

1 Present Teacher Resource 1.0: Patagotitan mayorum: the largest dinosaur to walk the Earth to students with the following background information.

> This is the largest land animal ever discovered. Fully grown it was the length of three city buses. Scientists, called paleontologists, found fossilized bones of this animal in southern Argentina. The largest bone, a leg bone, is more than eight feet long. Paleontologists have also discovered many different dinosaurs with bodies similar to this one. These dinosaurs, who walk on four legs, have large bodies, long necks, and long tails, are called sauropods. They grow from eight pound hatchlings. Why do you think these animals were so big? How did they get this way?

2 Assign students to groups of three to four, and invite them to propose ideas and additional questions about how the titanosaurs' size would have provided advantages and/or challenges in their everyday life. Have each group record their thoughts on Student Resource 1.0: Advantages and Challenges T-Chart.

3 Have students summarize their ideas by choosing one or two main points to share with the entire class. Record the responses from each group in a class t-chart that can be saved and referred to throughout the duration of the lesson.

4 Watch the video, "The Bigger They Are" (2 min 43 sec) from the Field Museum. When it is done ask students if they have any additional ideas or questions to add to the class version of the Advantages and Challenges T-chart.

5 Review the list and discuss how we could test these ideas.

a. If students need more support with this concept, encourage them to look back at one of the concepts that their group contributed and discuss the following questions in their small group.
b. Is this a question or an idea?
c. If it's a question can it be tested scientifically?
d. If it's an idea, what question would you ask to determine if the idea is true or not?

6 Now pass out Student Resource 2.0: Testing Models of Grand Proportions to each group along with the kits that you assembled previously.

Engage

7 Explain that sometimes scientists test questions they have by using models. They will now explore how some of the sauropods' body features offered both advantages and challenges to survival.

a. Station A prompts students to test how lengthening the neck increases the area for grazing while stationary.
b. Station B prompts students to test how increasing the length of the neck affects its ability to support a large head.

8 After the students have used the models to explore the advantages and challenges to having an extremely large body, revisit the advantages and challenges class t-chart. Ask students to share additional advantages and challenges from this activity.

9 Remind students that all animals face challenges to survival depending on the environment in which they live. Share that a trait or feature developed by an animal that provides an advantage to survival in a particular environment is called an adaptation. The titanosaurs' bodies represented an extreme example of traits (very long neck, and very small head) that adapted to help them better survive in their environment.

10 How did these traits become so extreme? Allow students to ponder this idea and share their thoughts with a partner. Elicit feedback from the class. Listen for students to mention ideas such as:

a. Traits that increase an organism's ability to survive and reproduce are passed to offspring.
b. Then that trait is present in more of the offspring in the next generations.
c. Traits tend change and adapt in an overall population over generations rather than in an individual organism over a single lifetime.
d. It takes extremely long amounts of time (>million years) for traits to become extreme.

11 If students seem perplexed here, or don't have all these answers, that's ok. These ideas will be explored throughout the rest of the lesson.

Engage

12 Share that when scientists, called paleontologists, study fossils of the titanosaurs and related dinosaurs they ask questions about the traits they see in the fossils such as:

a. Did these traits give the dinosaur and advantage in surviving and/or reproducing?
b. When did these traits first appear in the fossil record?
c. How does the trait vary from species to species?
d. How did the trait change over time?

13 Listen for students to say that they would look at data in fossils from many dinosaurs that were from different times and places on Earth so that they can compare and contrast the information.
You can further add that, to answer these questions, scientists especially have to compare animals that are related to one another or who all possess a certain set of traits.

14 Tell the students that they will have the opportunity to explore information from the fossils to try to determine how the titanosaurs became giants.

Explore

1. Remind students that scientists called paleontologists have found fossilized dinosaurs all over the world, and they have studied the bones, tracks, and impressions that make up fossils to identify traits of the once living animals. They have also been able to figure out when dinosaurs lived by testing the bones. Today they will take this research further by assembling, organizing, and analyzing this fossil data.

2. Give each group a set of fossil cards (Teacher Resource 2: Sauropodomorph Data Cards), and allow students a few minutes to become acquainted with the information on the fossil cards.

3. Ask the students to share features or data that they could use to organize the dinosaurs. Invite them to use the traits and information on their dinosaur cards as inspiration. Write their ideas on the board. If students have trouble coming up with categories, here are some recommendations:
    a. Order by size
    b. Categorize by traits that are either present or absent on the dinosaurs
    c. Categorize by types of traits (e.g. tooth shapes)

    Every group should also create a timeline based on the dates that the organisms lived.

4. Refer students to Student Resource 3: Graphic Organizer Examples where there are several types of graphic organizers that can be used to help organize the fossil data.
    a. Students can use the feature matrix to compare what features are present

5. Give the students time in their groups to organize the dinosaurs and create a graphic representation of how the traits range across the organisms as well as a timeline based upon when the dinosaurs lived. Then, they will determine as a group how to further illustrate the progression of the body feature (or trait) directly on or in conjunction with the dinosaur timeline.

Explain

1 Now students will analyze the data that they organized in the previous activity to help inform a claim about how certain traits came to be common and exaggerated in the sauropod dinosaurs.

2 Questions and prompts in Student Resource 4.0: Advantages to Survival Claim will guide groups to analyze the data that they chose to organize to investigate how and why the traits evolved over time.

3 Once students have made their claim they will also synthesize a narrative for how this advantage and/or challenge would have developed through time in the populations of dinosaurs that each fossil represents.

Elaborate

1 Have students write a nonfiction narrative of the evolutionary process for one of the features. Student Resource 5.0: Non-fiction Narrative Elements provides writing supports such as nonfiction text structures with example phrases as well as a checklist for developing a nonfiction narrative.

2 The narrative should be written and revised in a text format. However, if time provides students can enhance their narrative with graphics or comic-style of the narrative as well.

Evaluate

1 Students present their narrative projects to the class, sharing, comparing, and discussing ideas as in a scientific conference.

2 Share Teacher Resource 3.0: Narrative Rubric with the students to help them evaluate their work and the work of others.

3 Allow other groups to ask questions and comment on what they notice in the various narratives.

From Student Resource 4.0: Advantages to Survival Claim

2.1 Looking at the graphic organizer(s) you developed during the previous investigation, identify which dinosaurs exhibit the first appearance of the sauropod body feature that you were researching (e.g. four-legged/ two-legged, neck length, tail length, body size).

2.2 Which dinosaurs, that came later in time, possess this feature in a different form? How did it change over time?

2.3 Looking back to the information about when and where these organisms lived, what would the environment have been like? Was it very hot because it's close to the equator, or would there have been seasonal differences in weather that happens in regions closer to the poles of the Earth?

2.4 What role might this trait have allowed the dinosaurs to play in their environment?

2.5 What other organisms (plants or animals) would they have interacted with or relied upon in their environment?

2.6 Make a claim about how the trait that you've researched would have provided advantages or challenges to the dinosaurs' survival and reproduction.

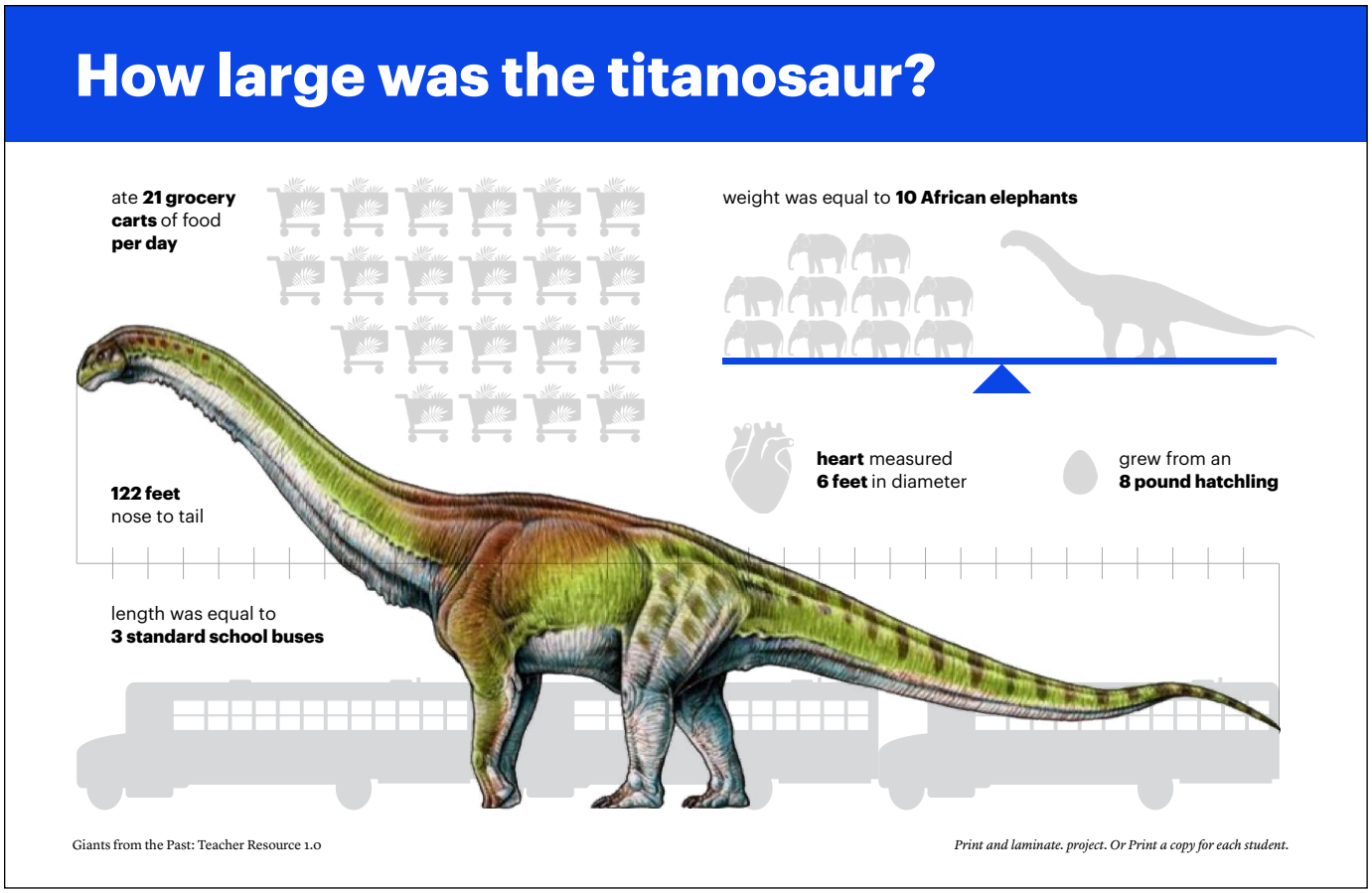
2.7 Utilize evidence from how this trait appeared and developed over time to support your claim.

2.8 Show how the evidence connects to the claim using logic and reasoning.

Titanosaur infographic

Teacher Resource 1.0

Please refer to the end of this document for the full-size poster.



Panphagia protos | [pan-fay-gee-uh]

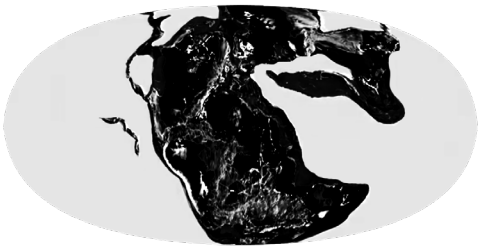
(first eater of everything)

WHERE IT WAS FOUND

Fossils found in Northwest Argentina

WHEN IT LIVED

Late Triassic (230 mya)



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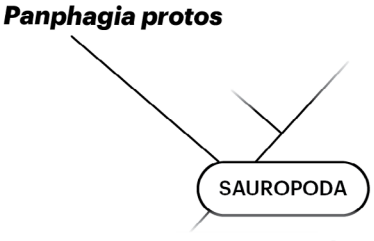


FEEDING HABITS

Omnivorous

MOVING HABITS

Bipedal (two-legged walking)

BODY FEATURES

Length

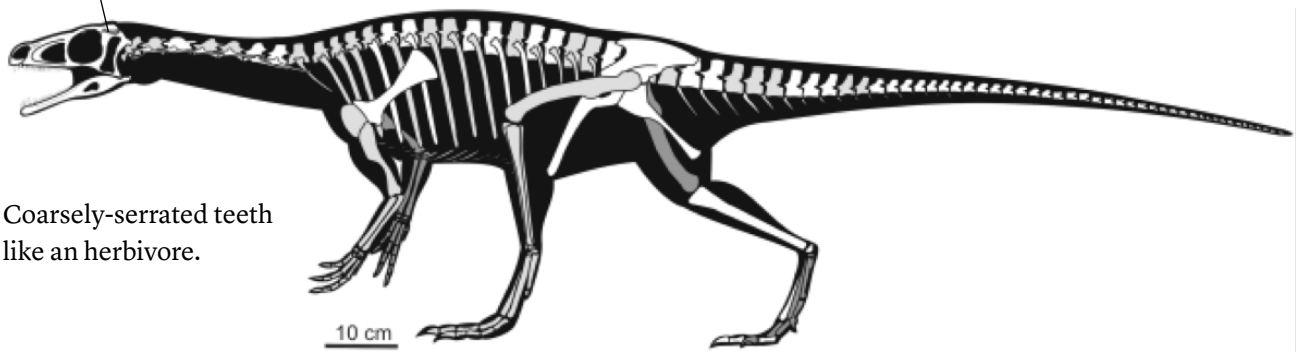
1.6 meters (7.2 feet)

Weight

7-8 kg (15-18 lbs.)

Larger head, like a carnivore.

Coarsely-serrated teeth like an herbivore.



Plateosaurus engelhardti | [PLAH-tee-oh-SORE-us]

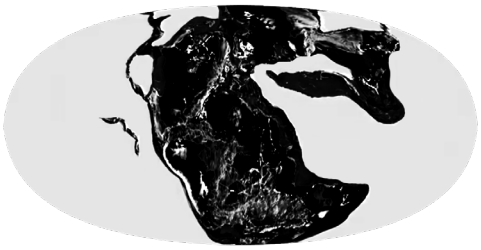
(flat lizard)

WHERE IT WAS FOUND

Europe (Fr, De, Swi)

WHEN IT LIVED

Late Triassic (219-210 mya)



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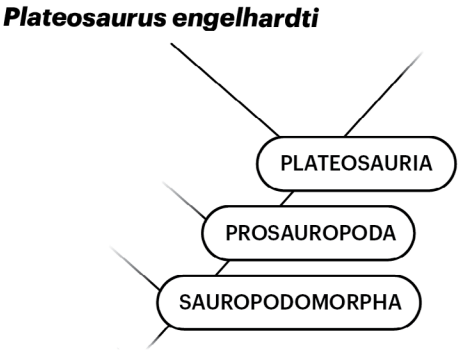


FEEDING HABITS

Herbivorous

MOVING HABITS

Quadrupedal (four-legged walking)
Reared up to two legs to reach food

BODY FEATURES

Length
5-10 meters
(16-33 feet)

Weight
4,000 kg
(4.4 tons)

Had three sacral vertebrae which made for a stronger hip structure.

Skull indicates that it may have had cheek pouches which would help keep food inside its mouth.

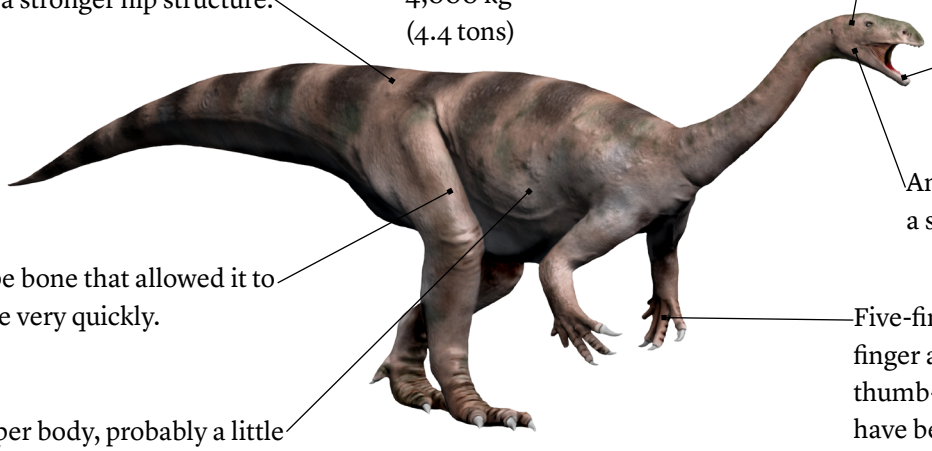
Teeth were serrated and leaf-shaped.

Angle of jaw hinge indicates a strong bite.

Had a type bone that allowed it to grow large very quickly.

Five-fingered hands with long finger and hand bones, and a thumb-like claw, which may have been able to grab for food.

Bulky upper body, probably a little front heavy from food weight in digestive system.



Pantydraco caducus | [pan-tee-DRAY-koh]

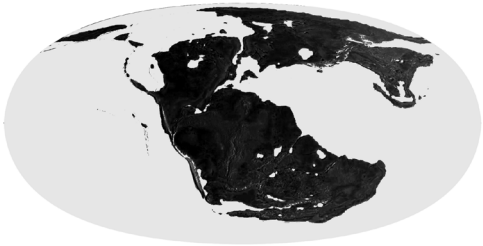
(Dragon of Pantyffynnon)

WHERE IT WAS FOUND

United Kingdom

WHEN IT LIVED

Early Jurassic (208-201 mya)



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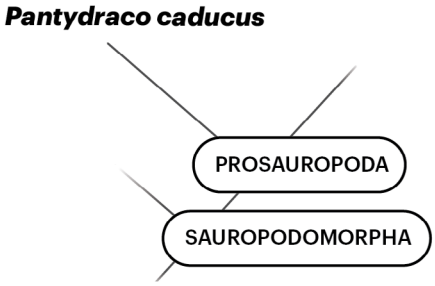


FEEDING HABITS

Herbivorous

MOVING HABITS

Bipedal (two-legged walking)

BODY FEATURES

Length
3 meters (10 feet)

Weight
50 kg (110 lbs.)

Neck vertebrae contain pits that correspond to pneumatic holes of giant sauropod vertebrae.

Closely related to Thecodontosaurus.

Aardonyx celestae | [ar-don-ix]

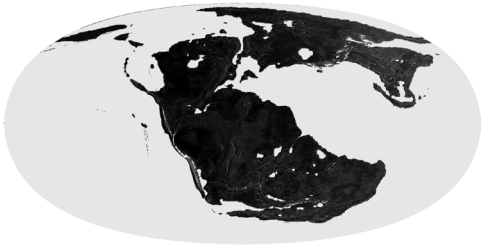
(earth claw)

WHERE IT WAS FOUND

South Africa

WHEN IT LIVED

Early Jurassic (199-189 mya)



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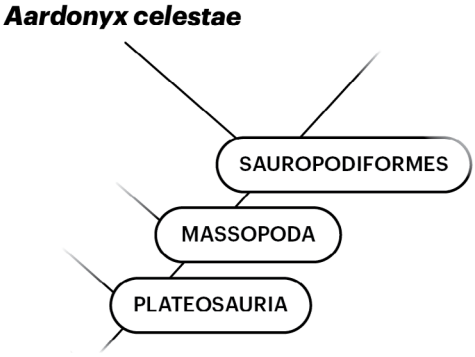


FEEDING HABITS

Herbivorous

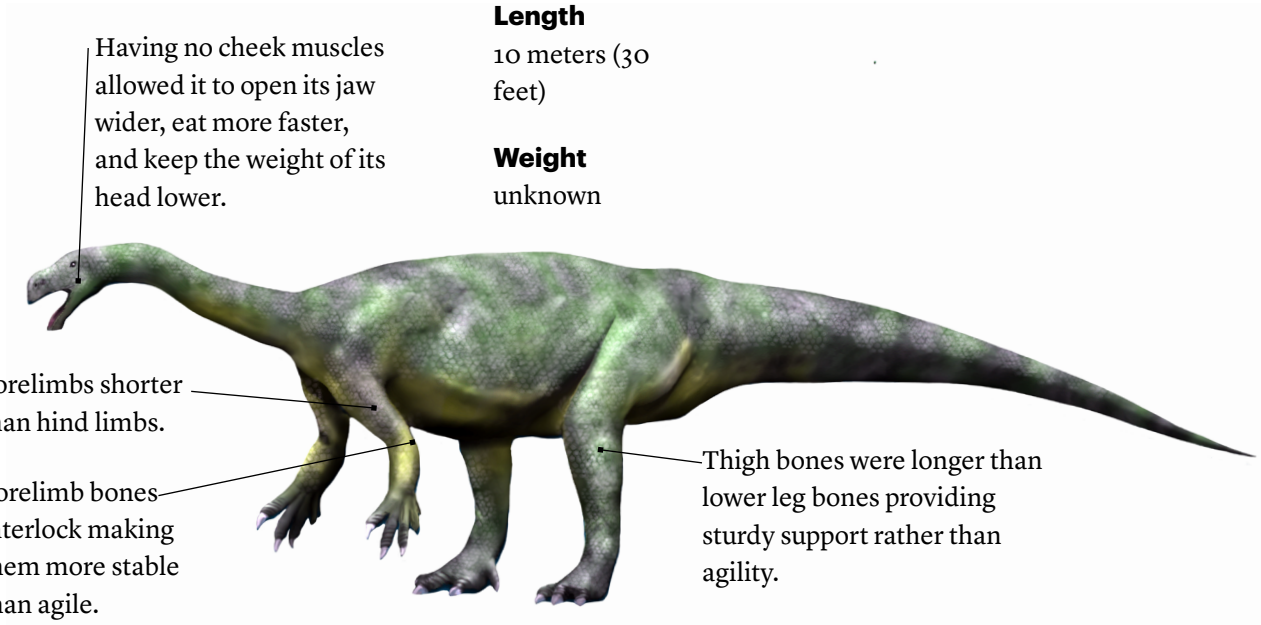
MOVING HABITS

Bipedal (two-legged walking)

BODY FEATURES

Length
10 meters (30 feet)

Weight
unknown



Riojasaurus incertus | [REE-oh-ha-SORE-us]

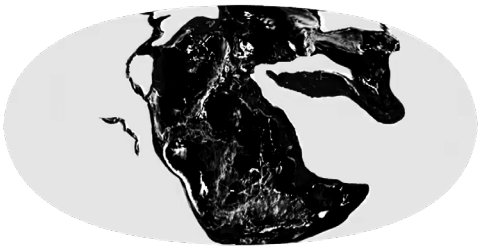
(Lizard of Rioja)

WHERE IT WAS FOUND

Argentina

WHEN IT LIVED

Late Triassic (228-209 mya)



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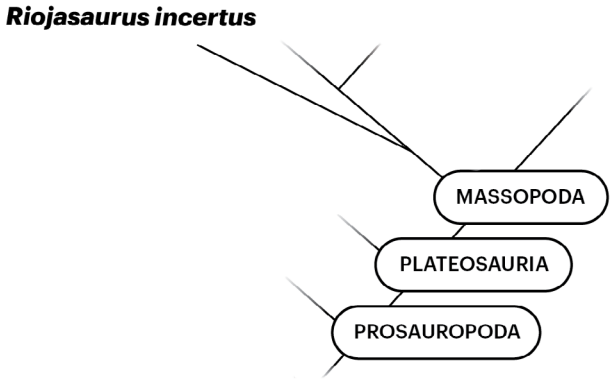


FEEDING HABITS

Herbivorous

MOVING HABITS

Quadrupedal (four-legged walking)

BODY FEATURES

Length
11 meters
(36 feet)

Weight
63 metric tons
(70 tons)

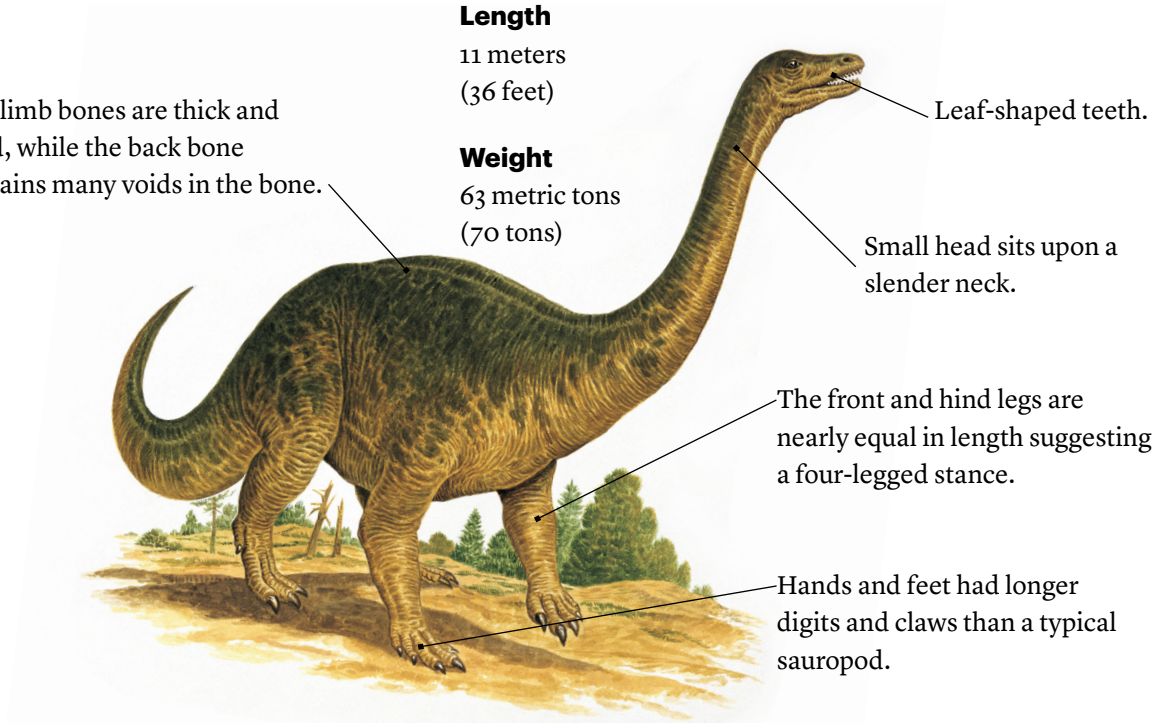
The limb bones are thick and solid, while the back bone contains many voids in the bone.

Leaf-shaped teeth.

Small head sits upon a slender neck.

The front and hind legs are nearly equal in length suggesting a four-legged stance.

Hands and feet had longer digits and claws than a typical sauropod.



De Agostini Picture Library/Science Source

Lufengosaurus huenei | [loo-FUNG-oh-sore-us]

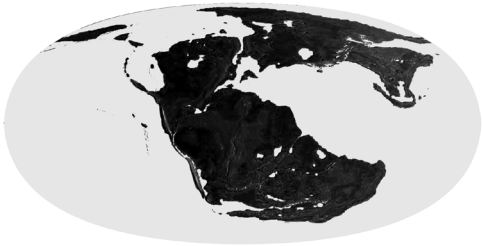
(Lufeng lizard)

WHERE IT WAS FOUND

China (Lufeng region)

WHEN IT LIVED

Early Jurassic (200-195 mya)



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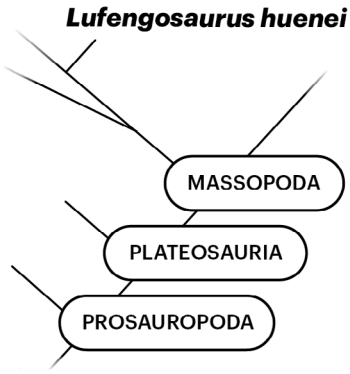


FEEDING HABITS

Herbivorous

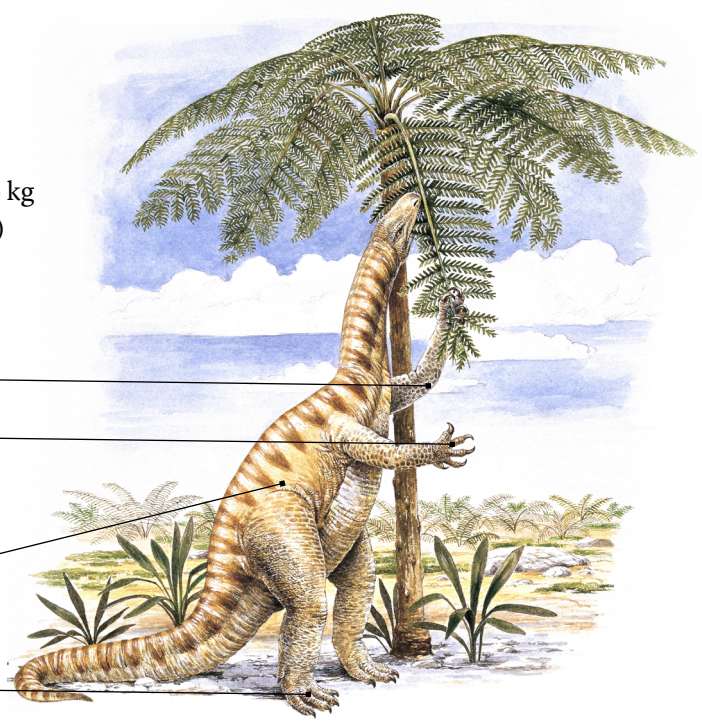
MOVING HABITS

Quadrupedal (four-legged walking)
Could rear up on hind legs

BODY FEATURES

Length
6 meters
(20 feet)

Weight
900-2,500 kg
(0.5-3 tons)



Teeth were widely spaced and shaped like pointy leaves.

Forelimbs shorter than hind limbs.

Long fingers on front limbs with thumb-like digit to aid grabbing food.

Stout prosauropod skeleton.

The toes on the hind feet were long, also.

De Agostini Picture Library/Science Source

Rapetosaurus krausei | [ruh-PAY-toh-SORE-us]

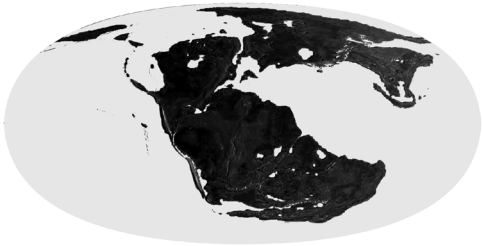
(lizard of Rapeto god)

WHERE IT WAS FOUND

Madagascar

WHEN IT LIVED

Early Jurassic (200-195 mya)



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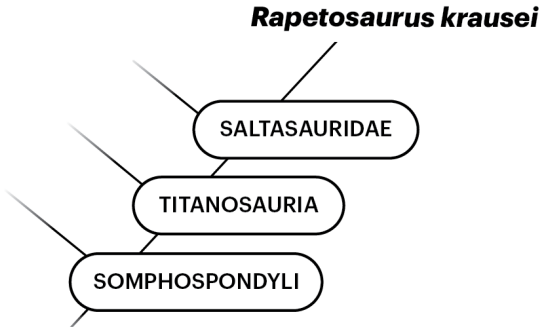


FEEDING HABITS

Herbivorous

MOVING HABITS

Quadrupedal (four-legged walking)

BODY FEATURES

Length
10 meters
(30 feet)

Weight
unknown

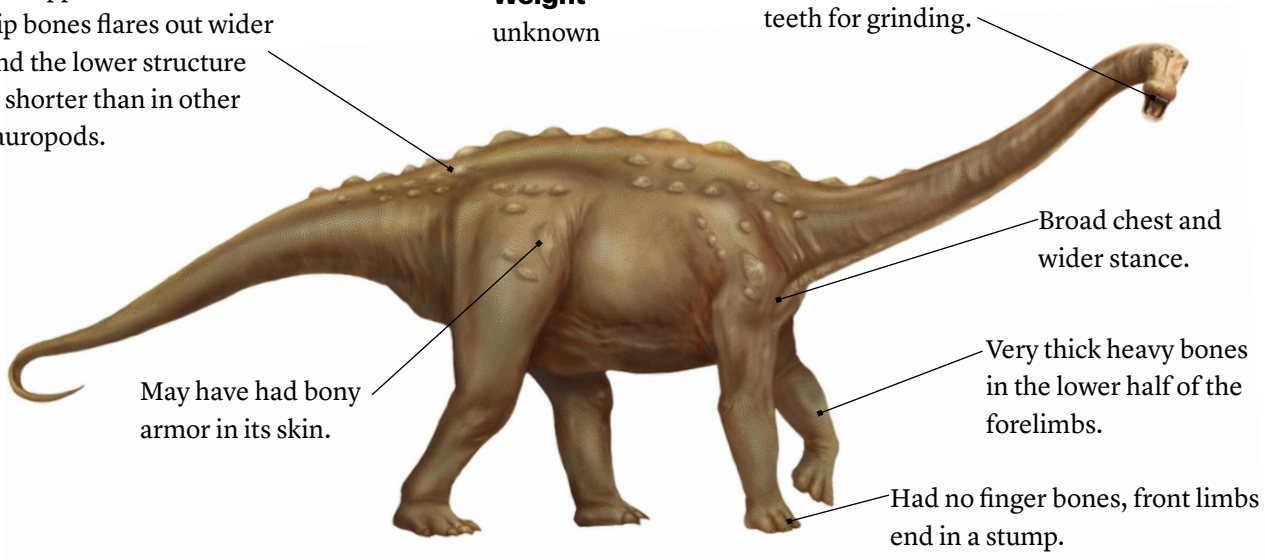


Illustration by Karen Carr. © The Field Museum.

Apatosaurus excelsus | [uh-PAT-uh-SORE-us]

(deceptive lizard)

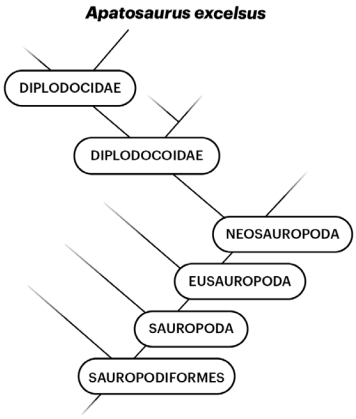
WHERE IT WAS FOUND

United States

WHEN IT LIVED

Late Jurassic (154-145 mya)

EVOLUTIONARY HISTORY



FEEDING HABITS

Herbivorous

MOVING HABITS

Quadrupedal (four-legged walking)

BODY FEATURES

Skeleton has many similarities to diplodocus, but is more stocky and thick leading to the heavier weight estimate.

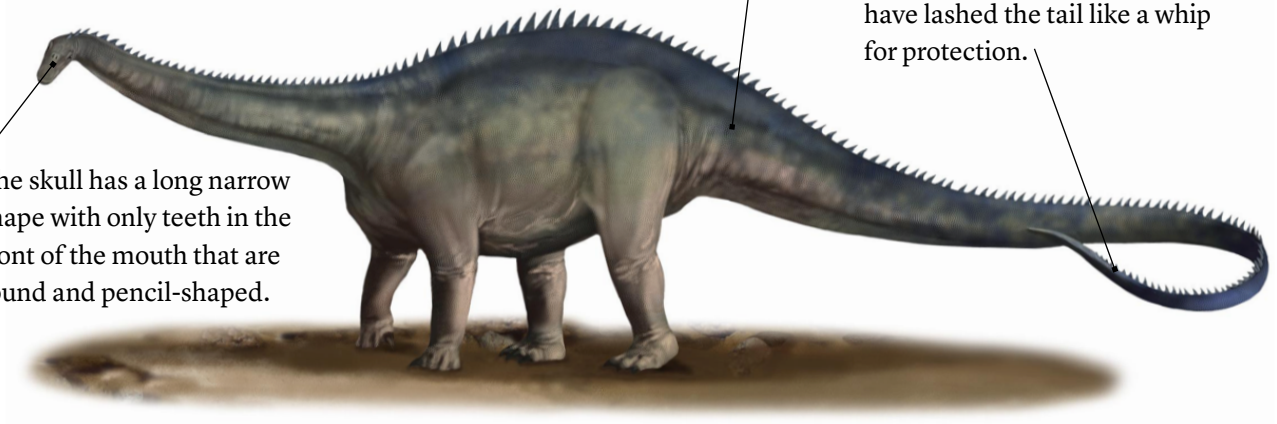
Skull similar to the size of a horse,but the body is about 30 times bigger.

Length
22 meters
(72 feet)

Weight
27 metric tons
(30 tons)

A strong ligament ran down the back to help support its massive weight like a giant suspension bridge.

Its tail makes up more than half of the length, and it consists of 80 bones. Paleontologists think it may have lashed the tail like a whip for protection.



The skull has a long narrow shape with only teeth in the front of the mouth that are round and pencil-shaped.

Brachiosaurus alithorax | [BRACK-ee-oh-SORE-us]

(arm lizard)

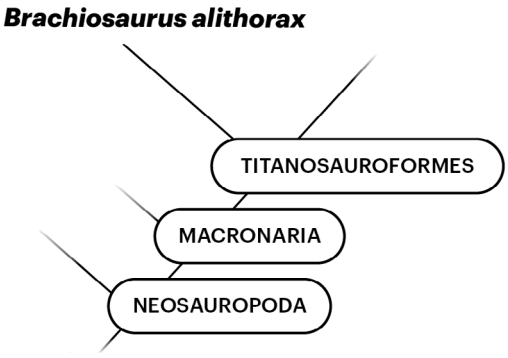
WHERE IT WAS FOUND

United States (Colorado)

WHEN IT LIVED

Late Jurassic (154-140 mya)

EVOLUTIONARY HISTORY



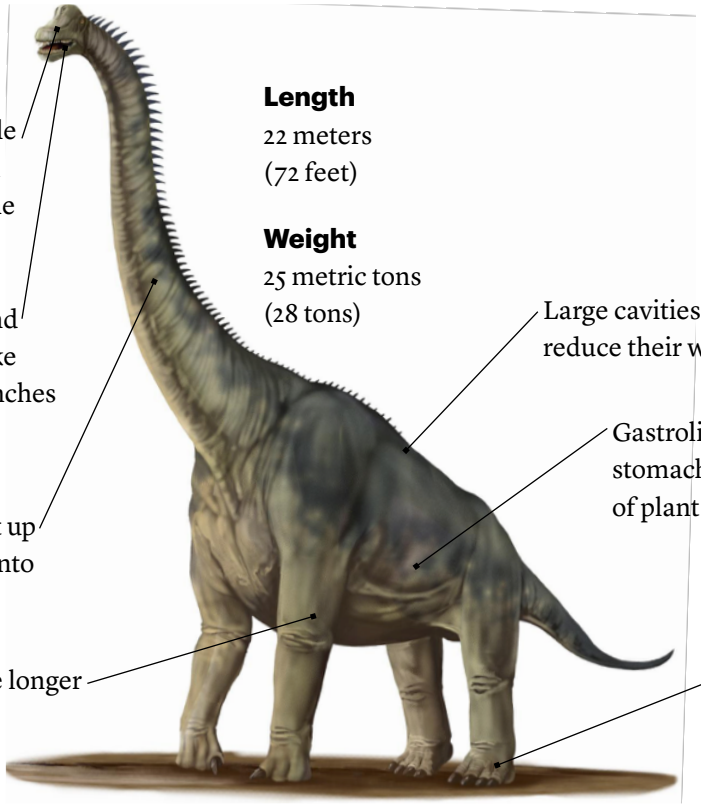
FEEDING HABITS

Herbivorous

MOVING HABITS

Quadrupedal (four-legged walking)

BODY FEATURES



Length
22 meters
(72 feet)

Weight
25 metric tons
(28 tons)

The skull had very little weight to it with small bony struts framing the eyes and nostrils.

Teeth were straight and strong with a blade-like edge for shearing branches of vegetation.

Neck and went up about 40 feet into the air.

Front legs were longer than back legs.

Large cavities in the back bones reduce their weight.

Gastroliths in the stomach aided digestion of plant material.

The column-like legs ended in feet with clawed toes.

Illustration by Karen Carr. ©2006 Field Museum.

Rebbechiasaurus garasbae | [re-BASH-eh-SORE-us]

(Rebbach territory lizard)

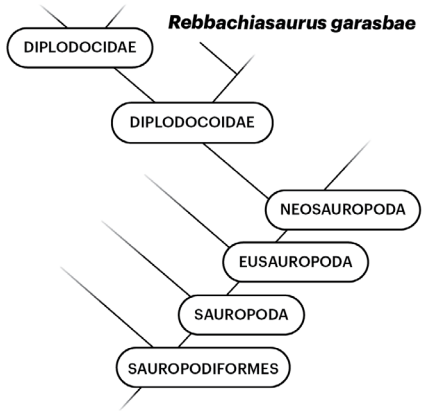
WHERE IT WAS FOUND

Morocco (Rebbach region)

WHEN IT LIVED

Late Jurassic (154-145 mya)

EVOLUTIONARY HISTORY



FEEDING HABITS

Herbivorous

MOVING HABITS

Quadrupedal (four-legged walking)

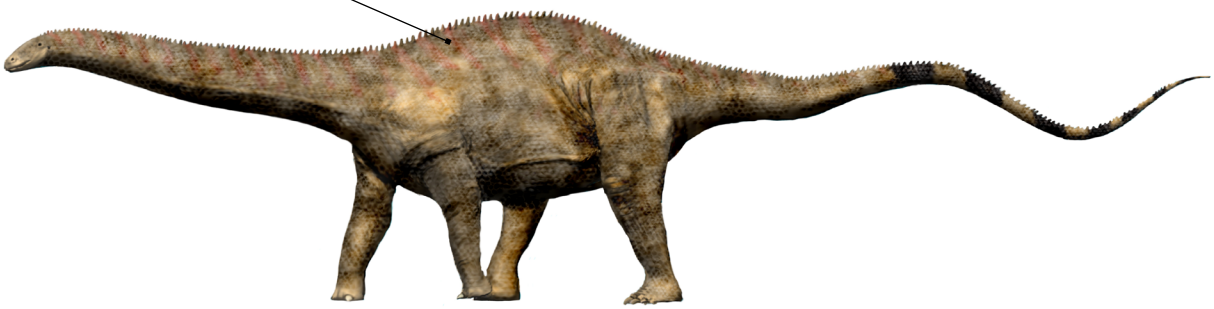
BODY FEATURES

Length
22 meters
(72 feet)

Weight
27 metric tons
(30 tons)

Spines on backbones possibly supported a sail or tall ridge on its back. The purpose of which may have been to help it cool down.

Closely related to *Diplodocus* of North America.

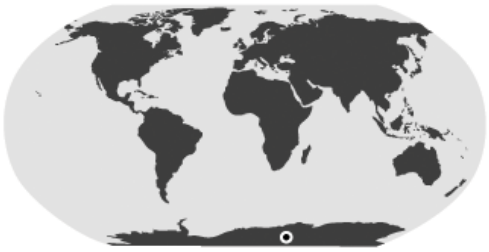


Glacialisaurus hammeri | [GLAY-see-AL-ah-sore-us]

(glacier lizard)

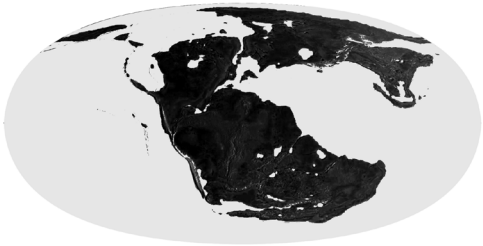
WHERE IT WAS FOUND

Antarctica (Beardmore Glacier)

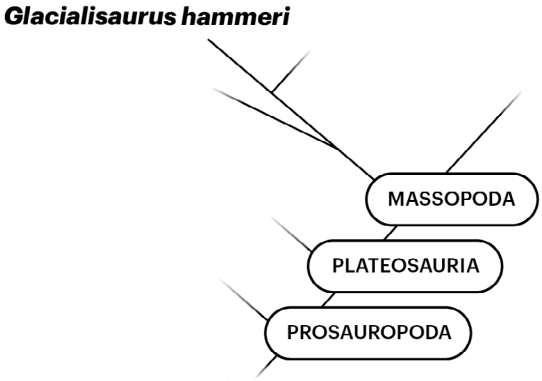


WHEN IT LIVED

Early Jurassic (189-1863 mya)



EVOLUTIONARY HISTORY



FEEDING HABITS

Herbivorous

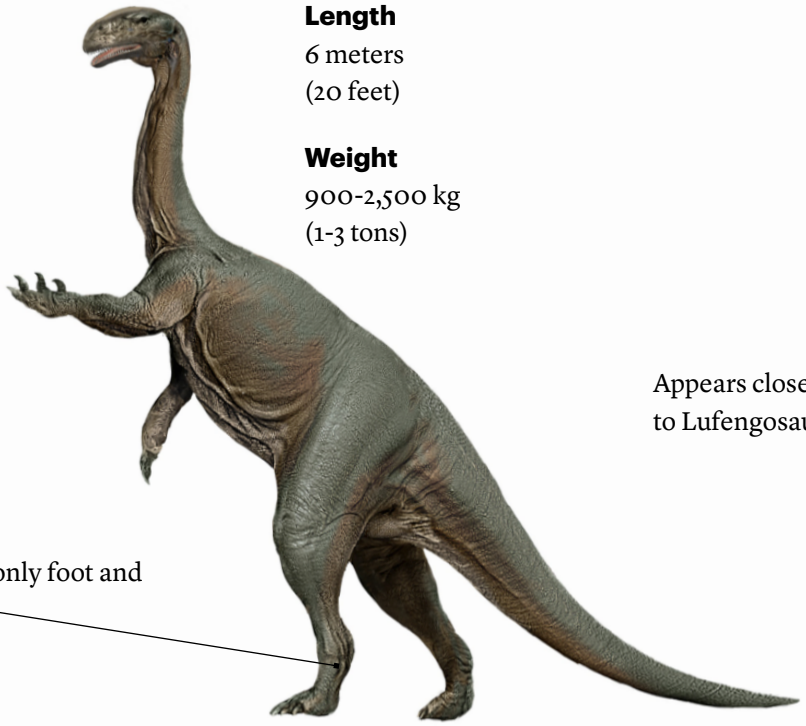
MOVING HABITS

Quadrupedal (four-legged walking)
Could rear up on back legs

BODY FEATURES

Length
6 meters
(20 feet)

Weight
900-2,500 kg
(1-3 tons)



Appears closely related to Lufengosaurus.

Known from only foot and ankle fossils.

Illustration by Velizar Simeonovski. ©2018 Field Museum.

Diplodocus longus | [dih-PLOD-oh-kus]

(double beam)

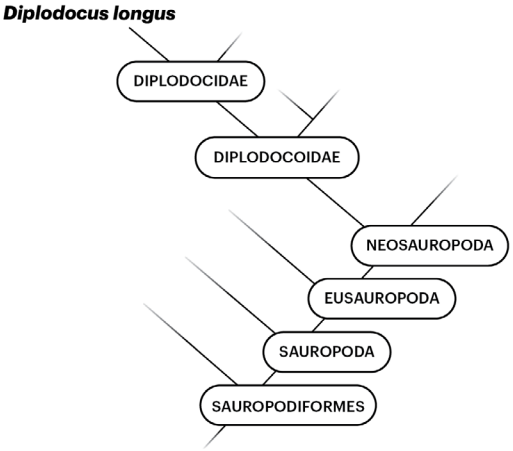
WHERE IT WAS FOUND

United States

WHEN IT LIVED

Late Jurassic (154-145 mya)

EVOLUTIONARY HISTORY



FEEDING HABITS

Herbivorous

MOVING HABITS

Quadrupedal (four-legged walking)

BODY FEATURES

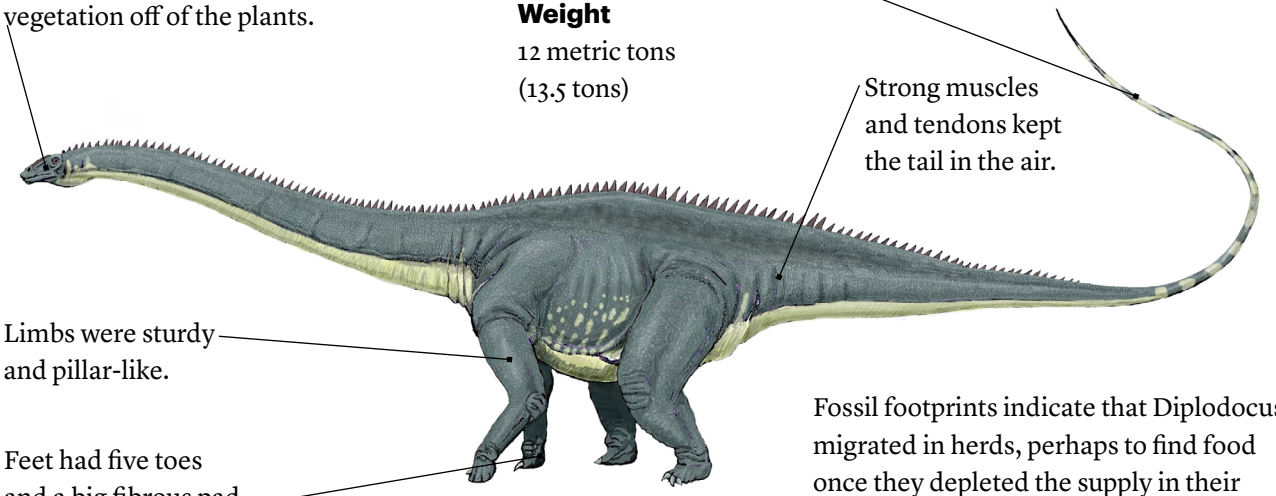
Long, slender skull with slender teeth only in the very front of the mouth that acted as a rake to scrape vegetation off of the plants.

Length
27 meters
(87 feet)

Weight
12 metric tons
(13.5 tons)

Extremely long tail contributed to the long length of this animal. Tail was extremely thin and whip-like and may have been used in defense.

Strong muscles and tendons kept the tail in the air.



Limbs were sturdy and pillar-like.

Feet had five toes and a big fibrous pad similar to the pad inan elephant's foot.

Fossil footprints indicate that Diplodocus migrated in herds, perhaps to find food once they depleted the supply in their immediate area.

Camarasaurus grandis | [KAM-ar-uh-SORE-us]

(chambered lizard)

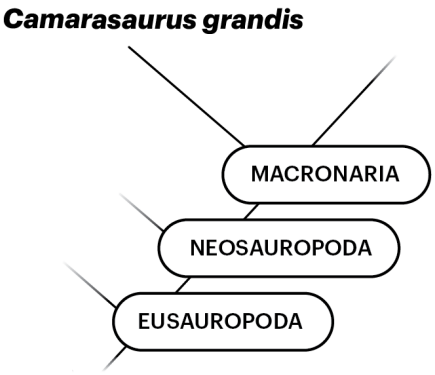
WHERE IT WAS FOUND

United States (Colorado)

WHEN IT LIVED

Late Jurassic (154-145 mya)

EVOLUTIONARY HISTORY



FEEDING HABITS

Herbivorous (high plants)

MOVING HABITS

Quadrupedal (four-legged walking)

BODY FEATURES

Length
20 meters
(66 feet)

Weight
25 metric tons
(28 tons)

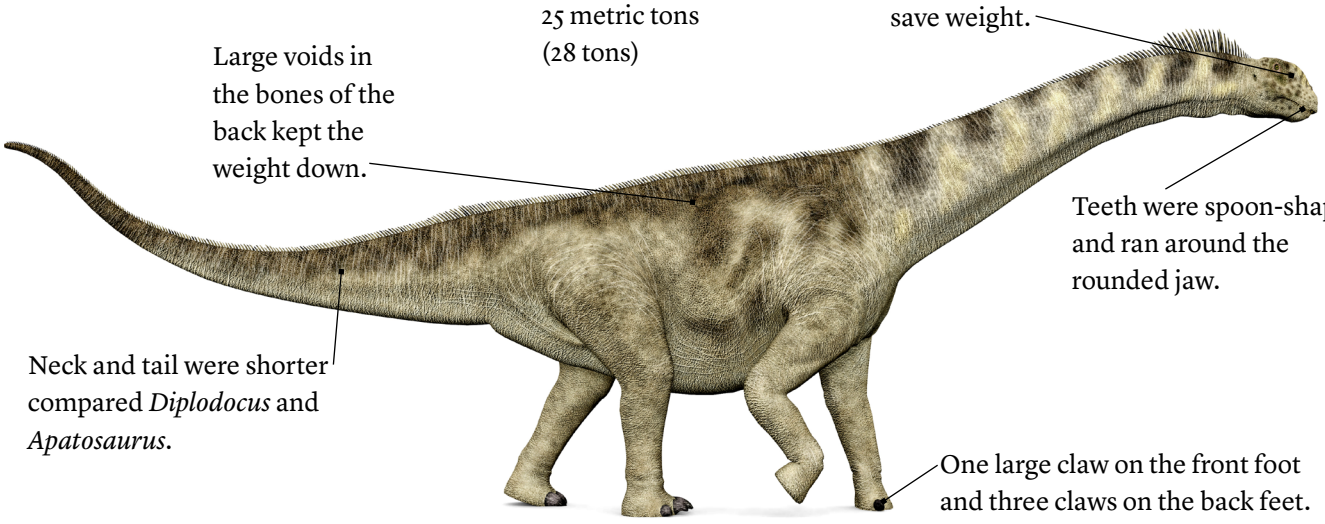


Image by Michael Rosskothen. Licensed via Shutterstock.

Patagotitan mayorum | [PAT-uh-go-TIE-ton]

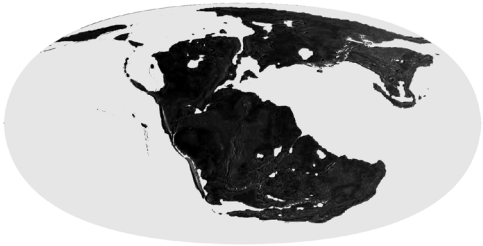
(giant of Patagonia)

WHERE IT WAS FOUND

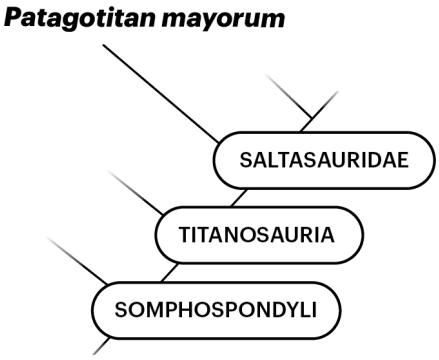
Southern Argentina

WHEN IT LIVED

Early Cretaceous (104 mya)



EVOLUTIONARY HISTORY



FEEDING HABITS

Herbivorous (high plants)

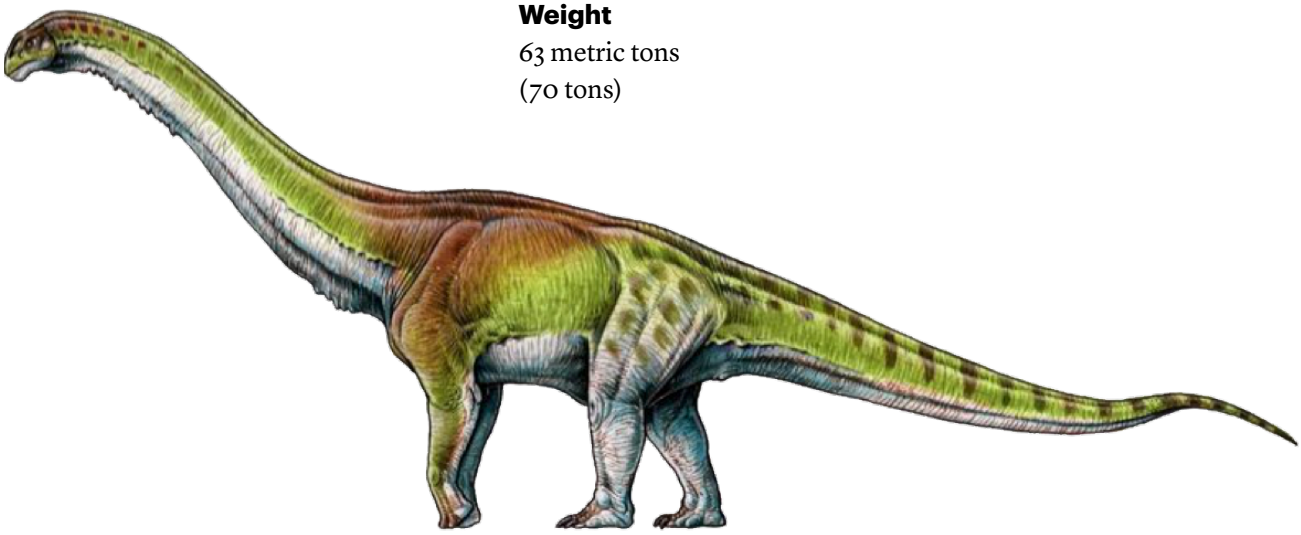
MOVING HABITS

Quadrupedal (four-legged walking)

BODY FEATURES

Length
37 meters
(122 feet)

Weight
63 metric tons
(70 tons)



Saltasaurus loricatus | [SALT-uh-SORE-us]

(Salta lizard)

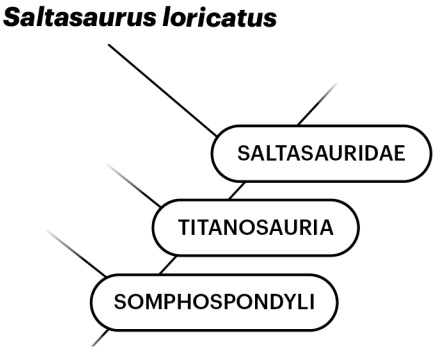
WHERE IT WAS FOUND

Argentina and Uruguay

WHEN IT LIVED

Late Cretaceous (83-70 mya)

EVOLUTIONARY HISTORY



FEEDING HABITS

Herbivorous

MOVING HABITS

Quadrupedal (four-legged walking)

BODY FEATURES

Smaller than predecessors in titanosaur group.

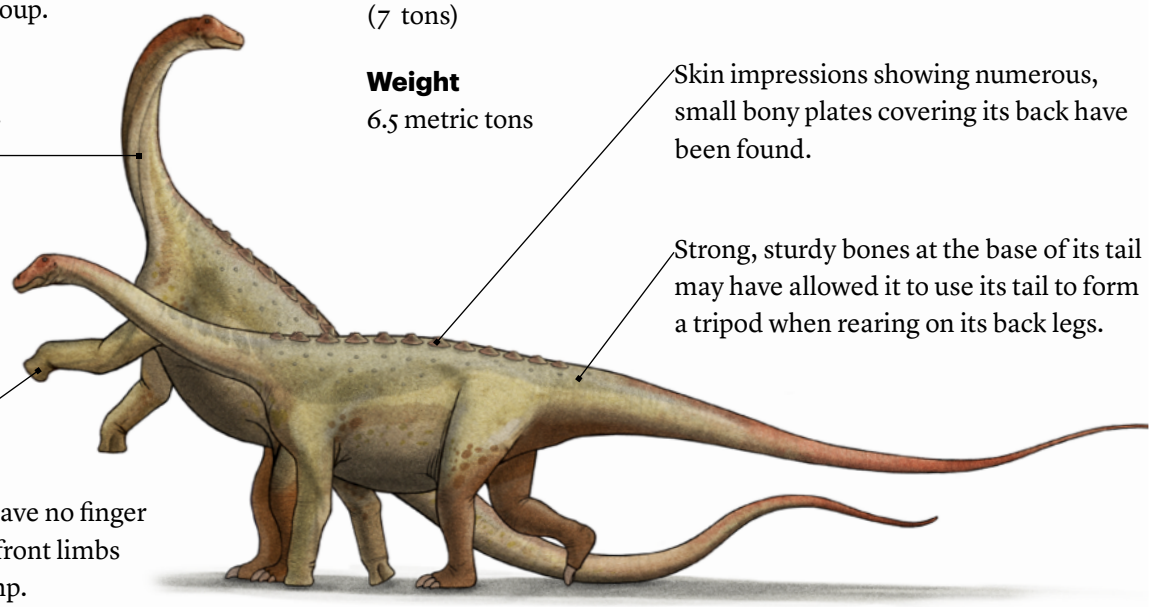
Length
12 meters (37 feet)
(7 tons)

Weight
6.5 metric tons

Neck shorter than tail.

Skin impressions showing numerous, small bony plates covering its back have been found.

Strong, sturdy bones at the base of its tail may have allowed it to use its tail to form a tripod when rearing on its back legs.



Thought to have no finger bones, their front limbs end in a stump.

Cetiosaurus oxoniensis | [SEE-TEE-oh-SORE-us]

(whale lizard)

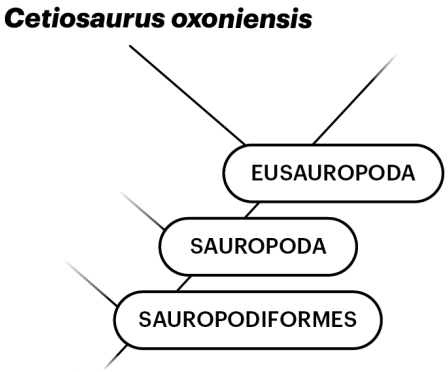
WHERE IT WAS FOUND

Europe and Northern Africa

WHEN IT LIVED

Middle Jurassic (180-170 mya)

EVOLUTIONARY HISTORY



FEEDING HABITS

Herbivorous

MOVING HABITS

Quadrupedal (four-legged walking)

BODY FEATURES

Length
18 meters
(60 feet)

Weight
9 metric tons
(10 tons)

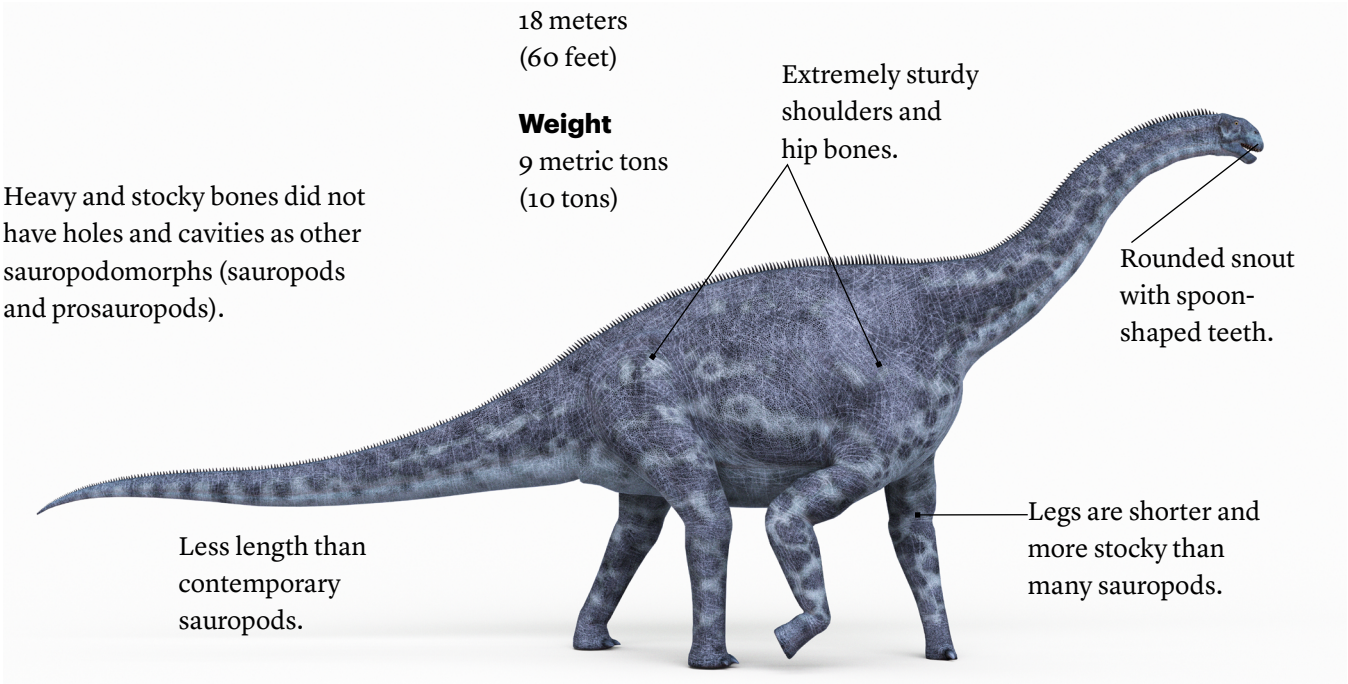


Illustration by Sebastian Kaulitzki. Licensed via Shutterstock.

Sauroposeidon proteles | [SORE-oh-poh-SIE-don]

(God of thunder and sea lizard)

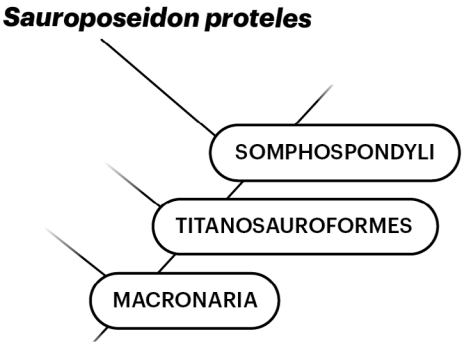
WHERE IT WAS FOUND

United States (Oklahoma)

WHEN IT LIVED

Early Cretaceous (113-100 mya)

EVOLUTIONARY HISTORY



FEEDING HABITS

Herbivorous (high plants)

MOVING HABITS

Quadrupedal (four-legged walking)

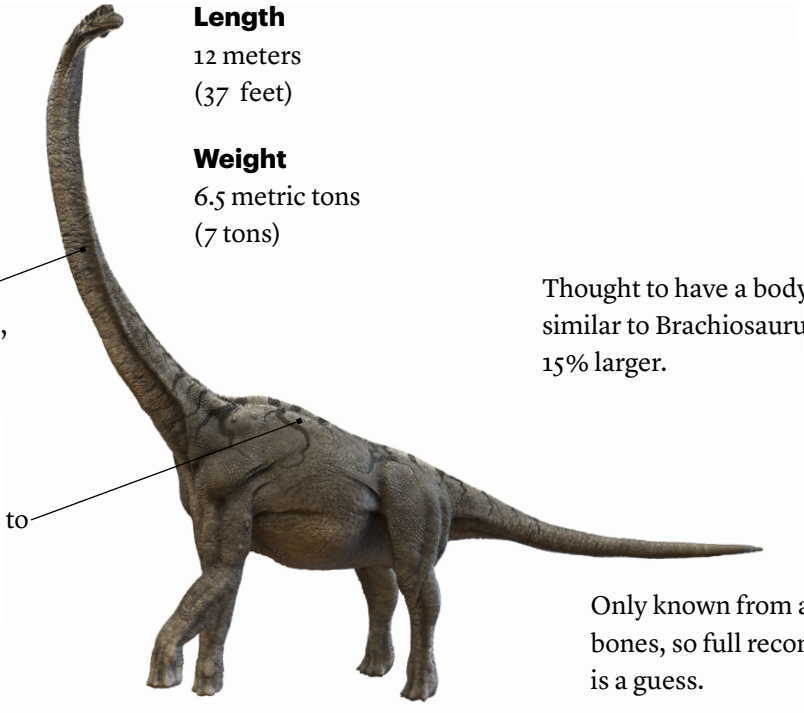
BODY FEATURES

Length
12 meters
(37 feet)

Weight
6.5 metric tons
(7 tons)

Neck could possibly reach upright to leaves in tall trees, up to 20 meters in the air.

Vertebrae are full of air cells to make them lighter weight.



Thought to have a body form similar to Brachiosaurus but 15% larger.

Only known from a few neck bones, so full reconstruction is a guess.

Illustration by Herschel Hoffmeyer. Licensed via Shutterstock.

Vulcanodon karibaensis | [vul-KAN-oh-don]

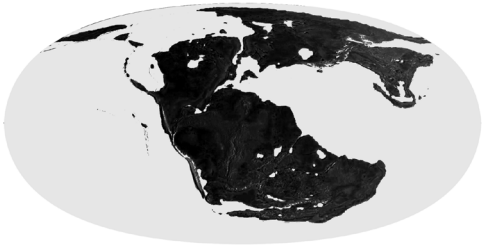
(volcano tooth)

WHERE IT WAS FOUND

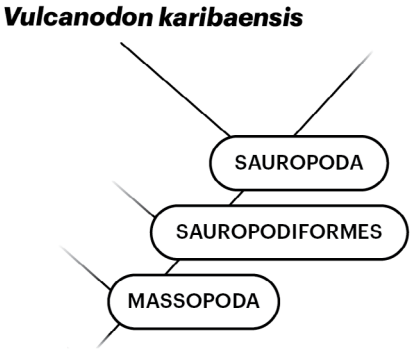
Zimbabwe

WHEN IT LIVED

Early Jurassic (219-192 mya)



EVOLUTIONARY HISTORY



FEEDING HABITS

Herbivorous

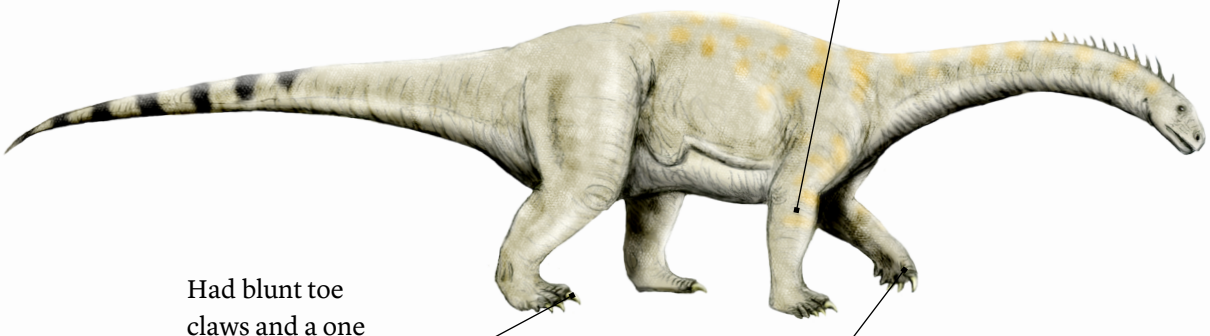
MOVING HABITS

Quadrupedal (four-legged walking)

BODY FEATURES

Length
12 meters
(37 feet)

Weight
1,800 kg
(2 tons)



Front legs are proportionally longer than most sauropods.

Fossil evidence is lacking for teeth, skull and neck.

Had blunt toe claws and a one enlarged toe on each front foot.

Toe bones are wider than they are long.

Amargasaurus cazaui | [ah-MAR-gah-SORE-us]

(La Amarga region lizard)

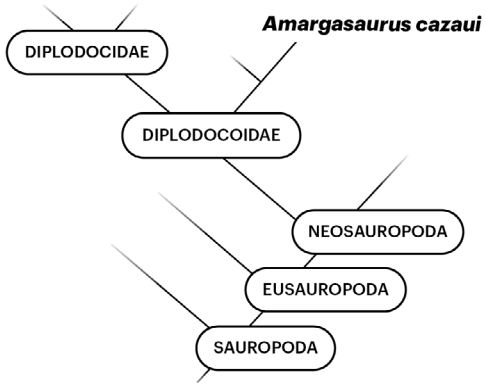
WHERE IT WAS FOUND

Argentina (La Amarga region)

WHEN IT LIVED

Early Cretaceous (134-125 mya)

EVOLUTIONARY HISTORY



FEEDING HABITS

Herbivorous

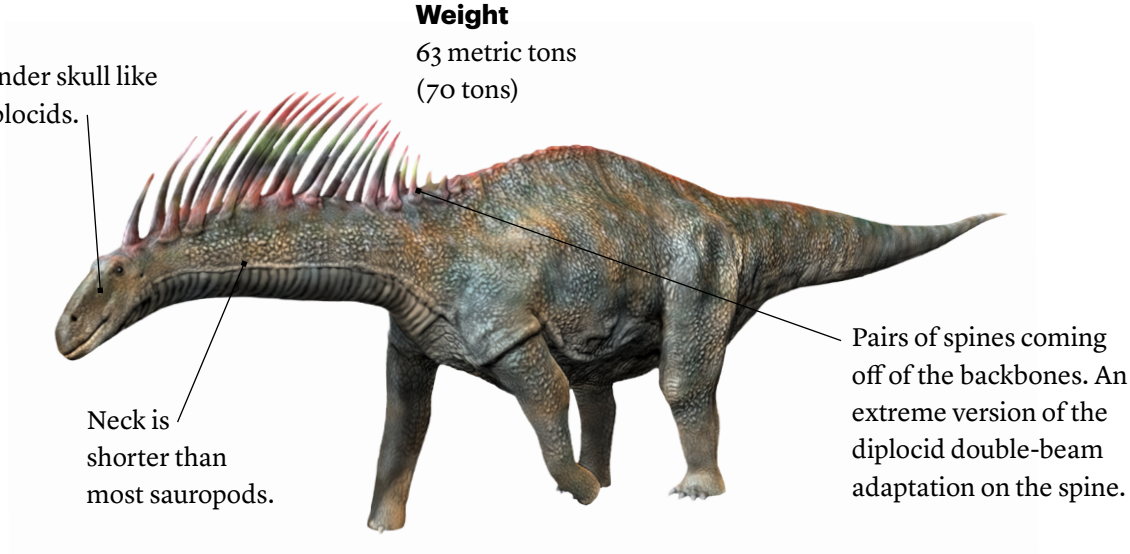
MOVING HABITS

Quadrupedal (four-legged walking)

BODY FEATURES

Length
12 meters
(39 feet)

Weight
63 metric tons
(70 tons)



Non-fiction Narrative Rubric

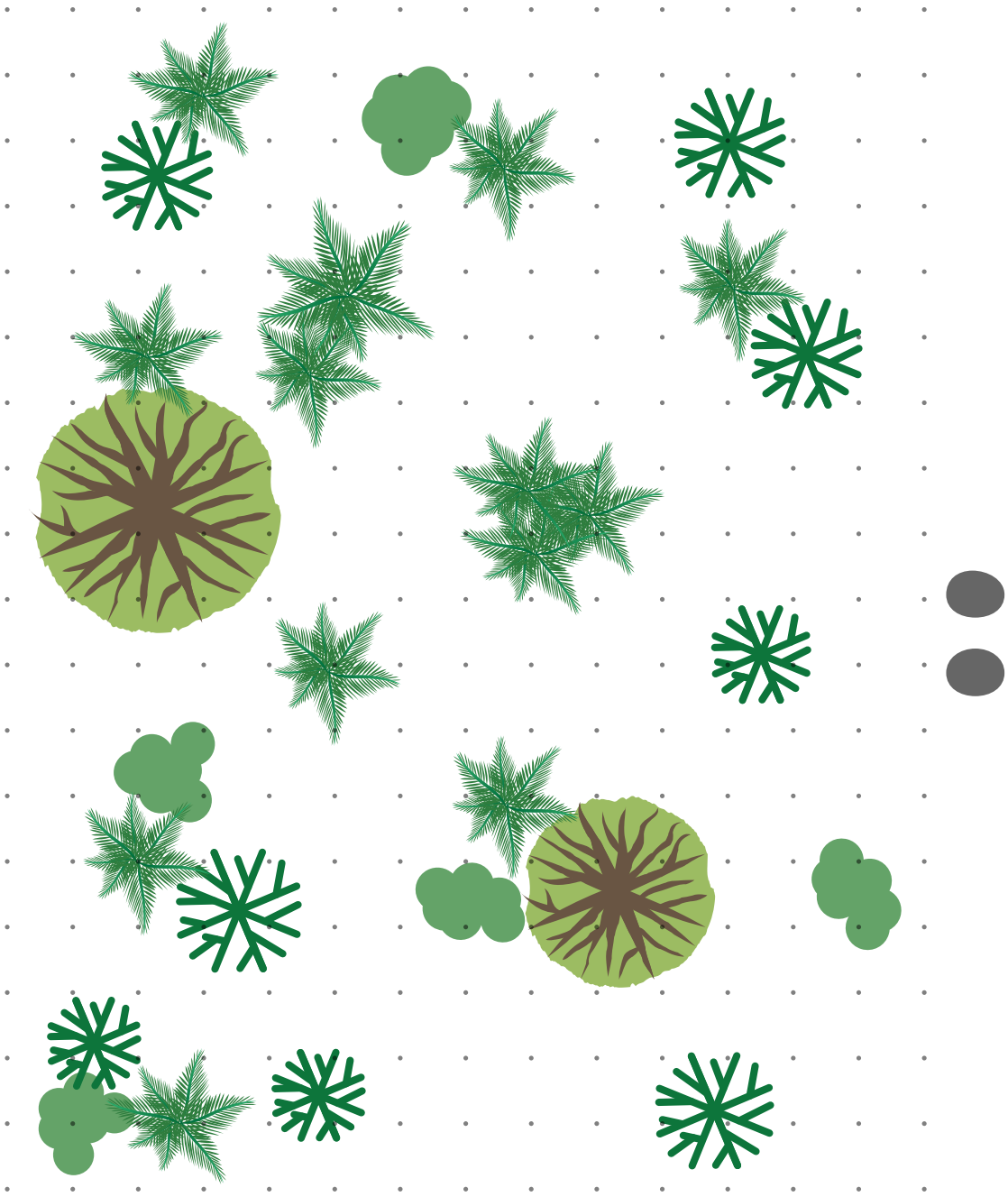
Teacher Resource 3.0

	Exemplary	Good	Acceptable	Needs work
Focus	Clear, precise topic based upon scientific claim.	Focused topic based upon a reasonable idea.	Focused topic is presented.	Introduces a flawed claim, or does not introduce a focused topic.
Organization	• Clear introduction orients the reader • Transitions help link ideas throughout narrative • Conclusion provides summary and closure	• Introduction brings in main topic. • Supporting points are positioned logically. • Conclusion provides summary or closure.	• Supporting points are positioned logically. • Conclusion provides summary or closure.	Missing one or more of the three main elements of organizational structure.
Evidence and Substantiation	• Evidence is presented in a logical and coherent manner. • Evidence provided is based on fact and sources are cited properly.	• Evidence is connected relevantly with the main topic. • Evidence provided from reliable sources.	Evidence presented supports the main topic.	Evidence is missing or chosen from inappropriate sources.
Voice and Style	Strategic use of pertinent vocabulary Writing is appropriate to audience.	• Varies sentence structure throughout the narrative. • Writing is engaging to the audience. • Minimal grammar mistakes	• Uses correct sentence structure. • Some grammar mistakes distract from writing quality.	Numerous grammatical mistakes.

Teacher Resource

Habitat Map

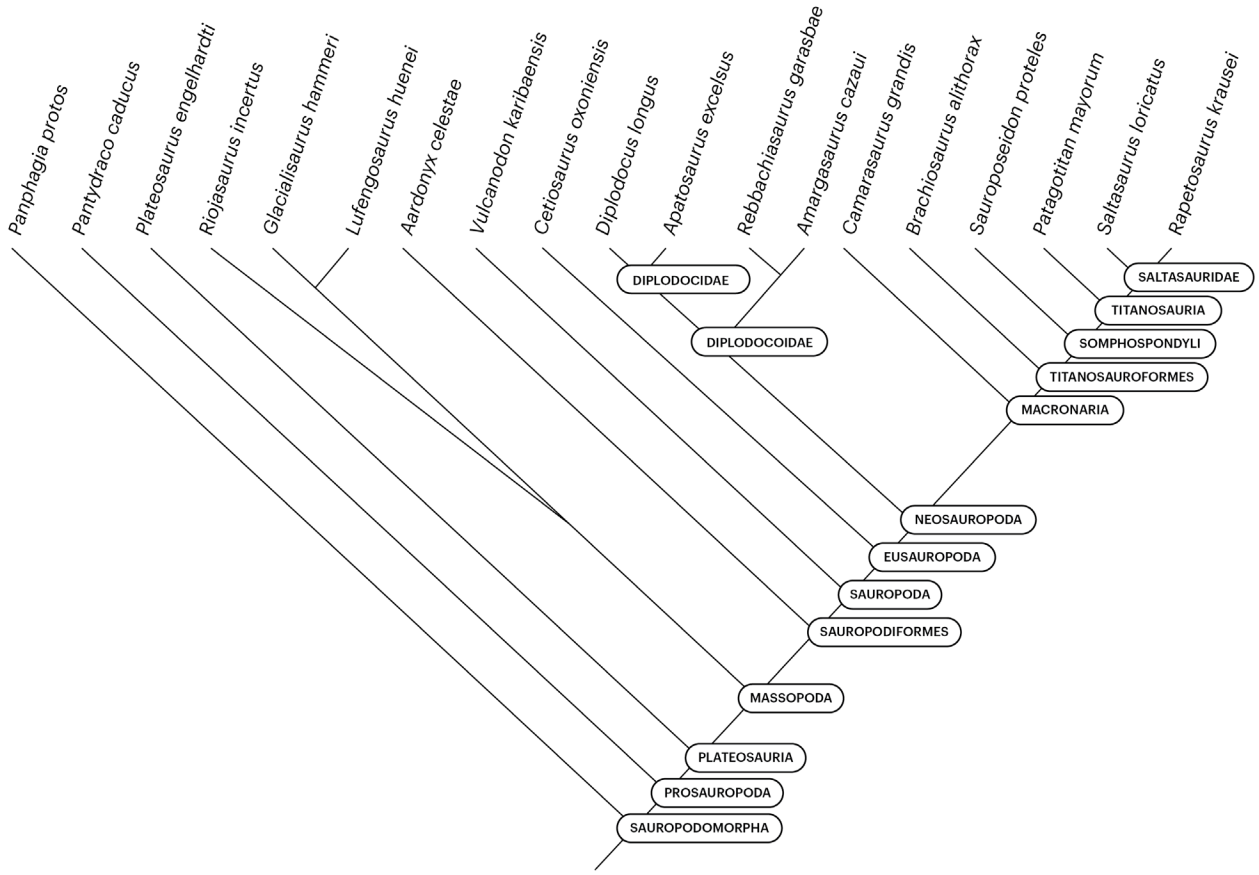
Teacher Resource 4.0



= 2 meters

Sauropodomorph Tree Diagram

Teacher Resource 5.0



Teacher Resource

Advantages and Challenges T-Chart

Student Resource 1.0

1. What challenges would the titanosaur face being 10 times the size of an African elephant?
2. How would being large provide advantages for survival?

Testing Models of Grand Proportions

Student Resource 2.0

Station A: How does a long neck provide an advantage to survival?

Since we cannot observe them in nature, we are going to use models to gather data about the habits of dinosaurs. The test sample includes three dinosaurs; Plateosaurus (neck length 3m), Cetiosaurus (neck length 7 meters), and Titanosaur (neck lenght 14 meters).

Use the scale on the map to convert dinosaur neck length to string length. Show your work in the box below. Procedure

1. Cut string to three lengths based upon you calculations above.
2. Secure one end of the string to the footprints of the front of the dinosaur with tape.
3. Stretch out string, and draw an arc across the habitat.
4. Use the area formula in the table below to determine the area inside the arc.
5. Repeat this process with each piece of string at the station and record all data in the table below.

String Length (cm)	Area Under Arc ($A=\pi r^2 \div 2$)	Number of trees in area for grazing

What did the string represent in this model?

Based on the data you've collected and what you know about the titanosaur's (Patagotitan mayorum) body. Explain why a long neck would have provided an advantage to survival.

Graphic Organizer Examples

Student Resource 3.0

Feature Matrix

The matrix below can help you analyze several traits at one time. This can be a good way to compare different traits that members of your group are interested in to see which one would be best to research further.

Aardonyx								
Plateosaurus								
Rebbechiasaurus								
Pantydraco								
Panphagia								
Brachiosaurus								
Rapetosaurus								
Apatosaurus								
Lufengosaurus								

Student Resource

Student Resource 3.0: Graphic Organizer Examples (continued)

Diplodocus								
Camarasaurus								
Aardonyx								
Glacialisaurus								
Vulcanodon								
Riojasaurus								
Amargasaurus								
Cetiosaurus								
Sauroposeidon								
Saltasaurus								
Patagotitan								

Feature Detail Comparison

Choose two features to investigate across all of the dinosaurs in this sample.
Write features in the top row that you want to compare across the different dinosaurs.
Record observations from the data in each row.
Review the observations to begin to identify patterns across multiple organisms.

	Feature A	Feature B
Aardonyx		
Plateosaurus		
Rebbechiasaurus		
Pantydraco		
Panphagia		
Brachiosaurus		
Rapetosaurus		
Apatosaurus		
Lufengosaurus		

Diplodocus		
Camarasaurus		
Aardonyx		
Glacialisaurus		
Vulcanodon		
Riojasaurus		
Amargasaurus		
Cetiosaurus		
Sauroposeidon		
Saltasaurus		
Patagotitan		

Student Resource 3.0: Graphic Organizer Examples (continued)

Size Graphic Organizer

You can use the length or weight data to list the dinosaurs from smallest to largest.

Mesozoic Timeline

Record the names of the dinosaurs in their appropriate time periods. Compare this graphic organizer with the other feature that you investigated to see how your feature developed over time.

Period	Epoch	Date Range (millions of years ago)	Dinosaurs
Cretaceous	Late	66	
	Early	100	
Jurassic	Late	145	
	Middle	154	
	Early	174	
Triassic	Late	201	
	Middle	237	
	Early	247	

Advantages to Survival Claim

Student Resource 4.0

Discuss the following prompts with your group. Choose one person to record your group's answers.

1. Looking at the graphic organizer(s) you developed during the previous investigation, identify which dinosaurs exhibit the first appearance of the sauropod body feature that you were researching (e.g. four-legged/two-legged, neck length, tail length, body size).

   Feature researched: _____

   Feature first appeared in which dinosaur? _____

2. Which dinosaurs, that came later in time, possess this feature in a different form? How did it change over time?

Dinosaur	How feature evolved

3. Looking back to the information about when and where these organisms lived, what would the environment have been like? Was it very hot because it's close to the equator, or would there have been seasonal differences in weather that happens in regions closer to the poles of the Earth?

   _____

   _____

   _____

4. Each organism has a role to play in their environment. What role might this trait have allowed the dinosaurs to play in their environment?

Dinosaur	Feature	Possible role in environment

5. What other organisms (plants or animals) would they have interacted with or relied upon in their environment?

Now that you've spent some time thinking and discussing the trait and its effect on the life and survival of the dinosaurs. You will make a scientific claim about the trait as instructed below.

6. Make a claim about how the trait that you've researched would have provided advantages or challenges to the dinosaurs' survival and reproduction.

7. Utilize evidence from how this trait appeared and developed over time to support your claim.

8. Show how the evidence connects to the claim using logic and reasoning.

Non-fiction Narrative

Student Resource 5.0

Write a nonfiction narrative describing the evolutionary process of the feature you researched. You will describe how the feature changed over time, and the evidence from the fossil record that shows this change. Utilize the table and checklist on the following pages to assist your group in developing the narrative.

Student Resource 5.0

Checklist of elements to develop in your narrative

	The beginning sets the narrative in motion, and it includes details that will later be important to understanding.
	Use transitional phrases when moving from one organism or time period to the next.
	The ending gives the reader a sense of closure by clearly showing how body feature has changed over time.
	The overall narrative structure is sequential, and the order of events is clear.
	Other nonfiction text structures are used to enrich supporting details and evidence.
	Precise details were used to describe body features and explain changes.
	Evidence from fossil data is used to support the descriptions.
	Use resources available to check spelling, and all eyes in the group have double-checked punctuation.

Student Resource 5.0

Chart of Text Structures

Non-fiction Text Structures	Definition	Example Phrases
Description	Portray a topic by sharing features, examples, characteristics, and attributes.	specimens show one example illustrated by characteristics similar to
Sequence	List events in chronological order or items in numerical order.	first initially next later then before followed by subsequent to derived from
Compare/Contrast	Explain how two or more things or ideas are alike or different.	like unlike simillar to different than unique from homologous to
Cause & Effect	Present a phenomena or fact and the agent or prior event that triggers or influences it.	due to this led to since, for this reason as a result of
Problem/Solution	Outline a challenge or dilemma and the fix or remedy.	challenged by one problem concerned with solved by answer to approach to take advantage of

THE GRIFFIN DINOSAUR EXPERIENCE

FIELD MUSEUM

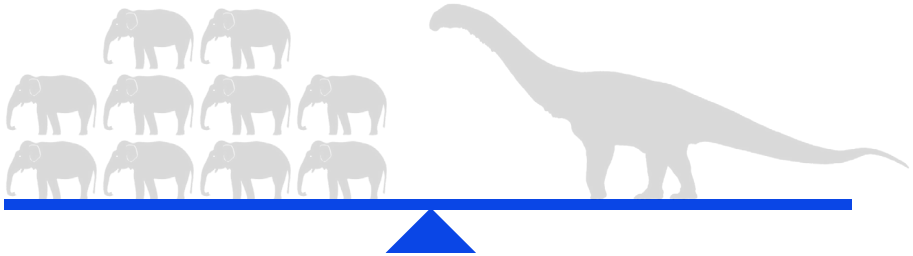
The Educator Toolkit is part of the Griffin Dinosaur Experience, made possible by the generous support of the Kenneth C. Griffin Charitable Fund.

Sponsor

How large was the titanosaur?

ate **21 grocery carts** of food **per day**

weight was equal to **10 African elephants**



heart measured **6 feet** in diameter

grew from an **8 pound hatchling**

122 feet nose to tail

length was equal to **3 standard school buses**

Print and laminate. project. Or Print a copy for each student.