

THE ULTIMATE PLAYDATE
65 MILLION
YEARS
IN THE
MAKING!



Earth's
**DINOSAUR
ZOO™**



STUDY GUIDE

www.DinosaurZooLive.us



INTRODUCTION

This publication was created as a study guide for students preparing to see *Erth's DINOSAUR ZOO Live™* which is touring theatres throughout North America beginning January 2014.

Erth's DINOSAUR ZOO Live™ takes the audience on a tour through pre-historic Australia, bringing an eye-popping array of ancient creatures to life on stage. They will observe and interact with extraordinarily life-like creatures, just like those that inhabited the Southern Hemisphere millions of years ago. And, they will meet a menagerie of insects, mammals and dinosaurs in their ancient environment, in this highly imaginative, entertaining and educational live show. From the sweetly curious baby *Dryosaur*, to the peaceful hulk *Titanosaur*, and even the teeth-gnashing *T-rex* -- *Erth's DINOSAUR ZOO Live™* is a unique interactive theater performance that stimulates the imagination in a way that connects children to their world. Erth's large-scale puppets were developed in consultation with paleontologists, based on current science and interpretations of fossil evidence. Employing sophisticated design and electronics, these giants are brought to life by skilled performers and puppeteers, made all the more real through the magic of theatre.



A scene from *Dinosaur Zoo Live*



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ABOUT EARTH

Erth Visual & Physical, Inc. is a highly creative 'visual and physical' theatre company based in Sydney, Australia. Since its beginnings in 1990, the company has created installations, site specific productions, performance artistry, and original live theatre -- always striving to provide audiences with eye popping visual experiences.

Giant puppetry, stiltwalkers, inflatable environments, aerial and flying creatures: Erth is all these things, and more. They have built an Australia-wide, and increasingly international reputation based on their exceptional work. In demand for events and festivals, Erth inspires audiences with their unique and dynamic vision.

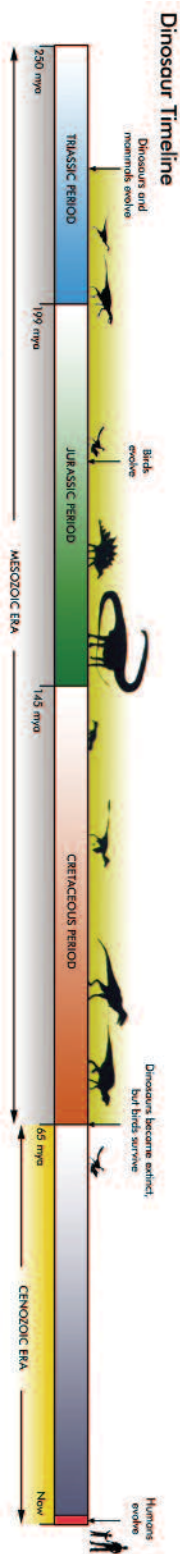
Erth's DINOSAUR ZOO Live™ is one of their favorite projects; it is a unique and exciting show where children have the opportunity to get up close and personal with ancient life-sized dinosaurs in the form of puppets, to learn about their lives in the world of prehistoric Australia.



Titanosaur puppet created by Erth Visual & Physical, Inc.



INTRODUCTION TO THE TIME OF DINOSAURS



Between 230 and 65 million years ago, some of the most amazing creatures ever to have lived, ruled our planet. The most successful of these creatures were a group of *terrestrial* reptiles called dinosaurs. Not all the dinosaurs lived at the same time, nor did they all live in the same part of the world, but they existed on the earth for over 165 million years.

Terrestrial: living on land rather than in the sea.

No other single group of animals has been dominant on earth for such a long period of time. It can be difficult to imagine just how long they dominated, but we can try to understand by comparing the era of dinosaurs to human existence: The earliest known human genus evolved on earth about 2.4 million years ago and modern humans (Homo Sapiens) only originated about 200,000 years ago! One reason for the dinosaur's success was their ability to *evolve*.

Evolve: develop and change very quickly.

Dinosaurs lived during a period of the Earth's history called the *Mesozoic (mez-oh-zoe-ick) Era*. The *Mesozoic Era* spans 183 million years and is divided into three time periods:

- The *Triassic* Period (try-ass-ick)
- The *Jurassic* Period (jur-ass-ick)
- The *Cretaceous* Period (crest-ace-us)

These terms will be used throughout this guide to describe the time periods that different dinosaurs evolved and existed in.



INTRODUCTION TO THE TIME OF DINOSAURS

DID YOU KNOW: The history of the Earth is divided into many different time periods?

Click [HERE](#) to learn more about the history of the earth.

DID YOU KNOW: The name Mesozoic Era is derived from the Greek language and means 'Middle Life'?

The world the dinosaurs inhabited looked vastly different from how it does today. During the *Triassic* period, all of the land masses were grouped together in one huge 'super continent' named *Pangaea* (meaning 'All Earth') and many continents we recognize today did not exist, or at least they were not in the locations that they are now!



The *Triassic* dinosaurs spread throughout *Pangaea* and over time, the *Pangaea* landmass began to split. By the *Jurassic* period, it had split into two enormous continents named *Laurasia* and *Gondwana*. These two land masses also began to break up, and over millions of years they split into smaller continents each with different climates and plants, and groups of dinosaurs, which then evolved into new species to suit each new continent.

Click [HERE](#) to see an animated depiction of *Pangaea* breaking apart.



INTRODUCTION TO THE TIME OF DINOSAURS

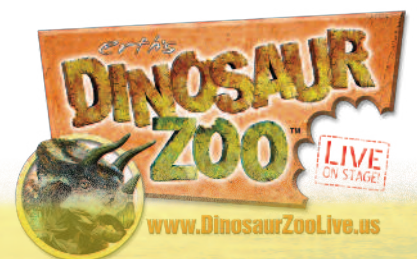
By the time of the *Cretaceous* period, the continents looked much as they do today.



DID YOU KNOW: *Pangaea* was the biggest landmass there has ever been? This allowed the dinosaurs to spread far and wide across the planet.

DID YOU KNOW: *The world is constantly changing? The land moves slowly over vast amounts of time and landscapes become dramatically different.*

To watch a video from the BBC about the movement of the continents **Click this link:** http://www.bbc.co.uk/science/earth/earth_timeline/pangaea#p00fztwb



WHAT IS A DINOSAUR?

Dinosaur bones have been around for millennia, but it was not until 1842 that the term 'dinosaur' was first coined. The first dinosaur to be described and named was presented as the *Megalosaurus* or 'Great Fossil Lizard of Stonesfield'. The bones and fossilized remains of this animal were found in the Oxfordshire village of Stonesfield.

William Buckland, Professor of Geology at Oxford, presented descriptions of the *Megalosaurus* discovery in a written paper, which was the first full account of a fossil dinosaur.

DID YOU KNOW: *Several of the first dinosaur discoveries were made in Oxfordshire?*

Click HERE to find out more about William Buckland

In 1842 the word 'dinosaur' was invented by *Richard Owen*, following the discovery of several more creatures that shared common features with *Megalosaurus*. Owen was a distinguished professor of anatomy and he based this new Dinosauria grouping on the shared features of the recently discovered large terrestrial (living on land) reptiles *Megalosaurus*, *Iguanodon* and *Hylaeosaurus*. He saw that they shared certain features (including hollow limb bones, and five-fused vertebrae where the spine fastens to the pelvis) and recognized that they were more than just the overgrown lizards the others had seen them to be.

DID YOU KNOW: *The word dinosaur, is a combination of two Greek words 'Deinos' (terrible) and 'sauros' (lizard)?*

Click HERE to find out more about Richard Owen.

Prior to the 1800's, scientists struggled to interpret early findings of large bones that were occasionally dug from quarries. In 1677, before the discovery of dinosaurs, English Naturalist and Oxford Professor *Robert Plot* wondered if some of the large bones found could have been evidence of an elephant brought to Britain by the Romans. He finally concluded they were too



WHAT IS A DINOSAUR?

large and so must be the remains of a giant! Dinosaurs are a large, yet very specific group of creatures. The word 'dinosaur' is often used incorrectly: Many people lump together all of the ancient reptiles (including the flying reptiles and marine reptiles) and call them dinosaurs.

Richard Owen's skill as an anatomist enabled him to begin creating a classification system for dinosaurs. He identified key common features and criteria which classed an animal as a dinosaur. Below are the 4 main features:

1. It must have lived during the *Mesozoic* Era
2. It must be a reptile (although not all reptiles are dinosaurs, for example lizards are reptiles, but they are not dinosaurs).
3. Its legs must be located below its body, as opposed to sticking out from the sides like the legs of a crocodile.
4. It must have lived on land, not in the water like swimming reptiles, or in the air like the *pterosaurs*. (However, the fossil record indicates that birds evolved from theropod dinosaurs during the *Jurassic* period, and consequently birds are now considered a type of dinosaur in modern classification systems.)

There are a number of other characteristics that many dinosaurs share:

- A large hole in the bottom of their basin-shaped hip socket
- A secondary palate (uncharacteristic of reptiles) that permits dinosaurs to eat and breathe at the same time
- A fairly straight thigh bone with an inwardly-turned head
- Two pair of holes in the temporal region of the skull
- Backward-pointing knees (or elbows) of the front legs
- Forward-pointing knees of the rear legs (rather than pointing sideways)
- Front legs shorter and lighter than the rear legs (in almost every case)
- A special bone at the chin, capping the front of the bottom jaw in some dinosaurs



WHAT IS A DINOSAUR?

Dinosaurs evolved and adapted themselves rapidly during their 165 million year reign. Early in their evolutionary history, dinosaurs split into two major groups, defined (and named) by their different hip structures:

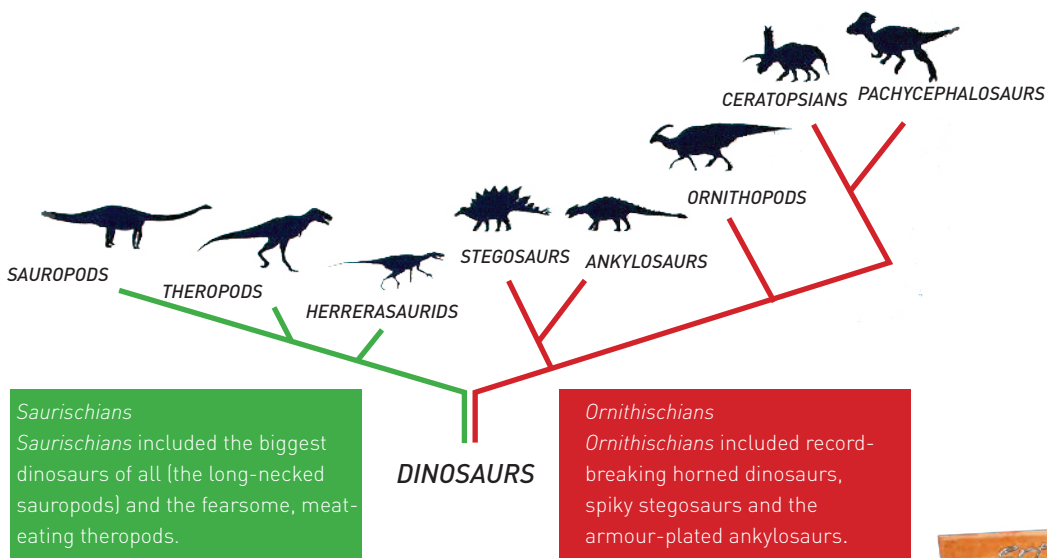
Saurischians (sore-iss-key-ans) means 'lizard-hipped' dinosaurs

Ornithischians (or-nith-iss-key-ans) means 'bird-hipped' dinosaurs

If that is not confusing enough, each group has several subgroups too! And within each subgroup are several different species of dinosaur.

Have a look at the Family tree below. It shows the two major groups along with their subgroups, along with a small sample of each subgroup (it does not show all the individual species!) It is impossible to tell exactly how many species of dinosaurs there were since the fossil remains of new species are still being found each year. Approximately 700 species have been named so far.

Even if all 700 named species are valid, their number is still less than one-tenth the number of currently known living bird species, less than one-fifth the number of currently known mammal species, and less than one-third the number of currently known spider species -- which shows potentially how many more types of dinosaur there are still to discover.



WHAT IS A DINOSAUR?

It can take a long time for scientists and paleontologists to classify dinosaurs. Sometimes, new dinosaurs are discovered and named, but *paleontologists* realize later that the dinosaur is actually a species of dinosaur already known to them!

The most famous case of mistaken identity is possibly that of the *Brontosaurus*. *Brontosaurus* used to be one of the most well-known dinosaurs until *paleontologists* realized that *Brontosaurus* was actually the same creature as *Apatosaurus*. Since *Apatosaurus* was discovered first, this is the name that was used going forward and the name *Brontosaurus* stopped being used.

Palaeontologist (*pay-lee-on-toll-oh-jist*) is the name given to someone who studies the forms of life existing in prehistoric or geologic times, through analysis of the fossils of plants, animals, and other organisms.



WELL KNOWN DINOSAURS THROUGHOUT THE WORLD

Have a look at our 'dinosaur hall of fame' over the next few pages to see a collection of the world's best known dinosaurs and to learn all about them.

There are so many dinosaurs that most of us have never even heard of the majority of them: Many interesting dinosaurs have not quite made it to the hall of fame, but perhaps in time, they will capture our imaginations in the way that T-rex and other popular dinosaurs have.

Do you have a favorite dinosaur?

See if you can draw your favorite dinosaur or find out a new fact about it.

MY FAVORITE DINOSAUR IS:

I JUST LEARNED THAT...



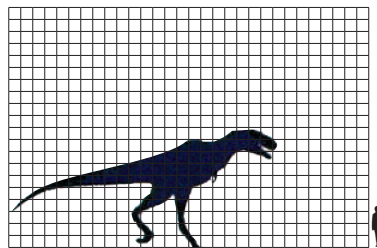
TYRANNOSAURUS

T-rex is probably the most well-known dinosaur. It was first discovered by *Barnum Brown* in 1902 and soon captured the public imagination.

T-rex is a type of *theropod* dinosaur and was one of the first giant, meat-eating dinosaurs to be put on display in a museum. At the time, it was thought to be the largest, but since its discovery, even larger *carnivorous* dinosaurs have been discovered!



Lifelike feathered T-rex puppet created by Erth Visual & Physical, Inc



FACT FILE

How to say it:
Tie-ran-o-sore -us

Name means:
Tyrant Lizard King

Family group:
Tyrannosaur

Period:
Late cretaceous 66 -70 MYA

Where found:
North America

1st Discovered:
1902

Height:
13 feet

Length:
46 feet

Weight:
7.7 tons

Food:
Meat

Special Features:
Large, sharp teeth and powerful jaws



TRICERATOPS

Triceratops is a very large and distinctive dinosaur because of the three sharp horns on its head which give it its name.

Triceratops is classified as a cerapod and was one of the last dinosaurs to live on the earth.



Triceratops puppet created uniquely for the North American tour of Dinosaur Zoo Live.



FACT FILE

How to say it:
Tri-ser-ra-tops

Name means:
Three-horned face

Family group:
Ceratopidae

Period:
Late Cretaceous 66 -70 MYA

Where found:
North America

1st Discovered:
1889

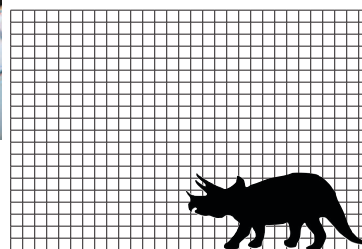
Height:
11 feet

Length:
29 1/2 feet

Weight:
6 tons

Food:
Plants

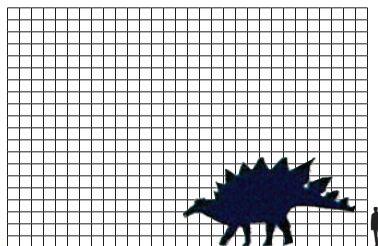
Special Features:
Horns and frill



STEGASAUROS

Stegosaurus is the largest member of the Stegosaur family but has one of the smallest brains -- comparative to its body size -- of all known dinosaurs.

The most impressive feature of Stegosaurus is the large plates running along its back. Paleontologists used to think these were for defense, but current thinking is that they were used to regulate temperature in some way.



FACT FILE

How to say it:
Ste-go-sore-ru s

Name means:
Roof Lizard

Family group:
Stegosauridae

Period:
Late Jurassic 146 - 154 MYA

Where found:
North America

1st Discovered:
1877

Height:
9 feet

Length:
29 ½ feet

Weight:
3 tons

Food:
Plants

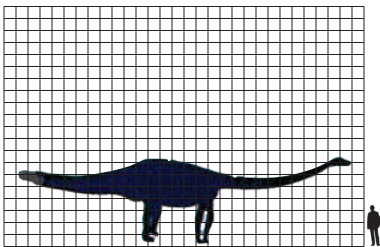
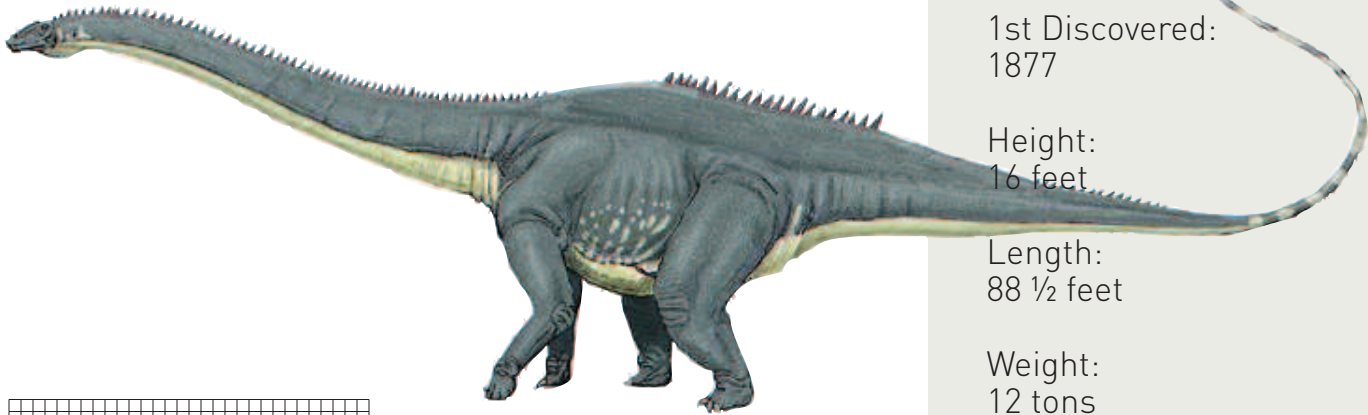
Special Features:
Double row of distinctive
plates along its back



DIPLODOCUS

Diplodocus was one of the dominant plant-eating dinosaurs during the late Jurassic era.

Diplodocus falls in the Sauropod category of dinosaur.



FACT FILE

How to say it:
Di-plo-doh-kus

Name means:
Double Beam Lizard

Family group:
Diplodocidae

Period:
Late Jurassic 145 – 161 MYA

Where found:
North America

1st Discovered:
1877

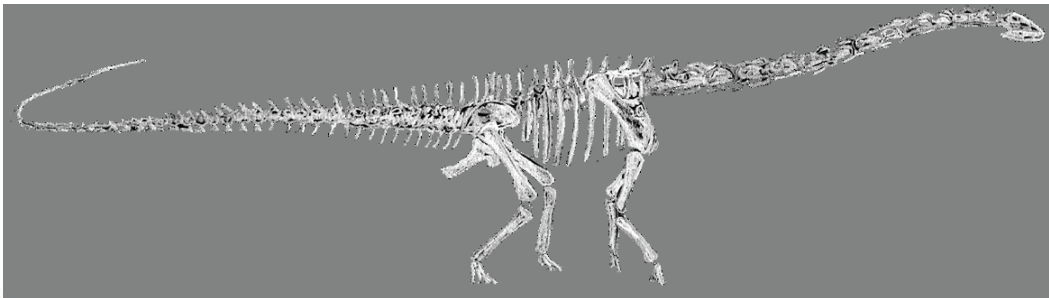
Height:
16 feet

Length:
88 ½ feet

Weight:
12 tons

Food:
Plants

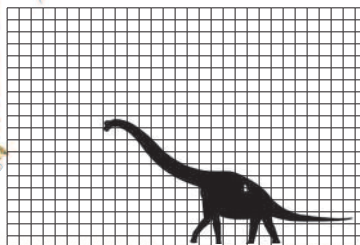
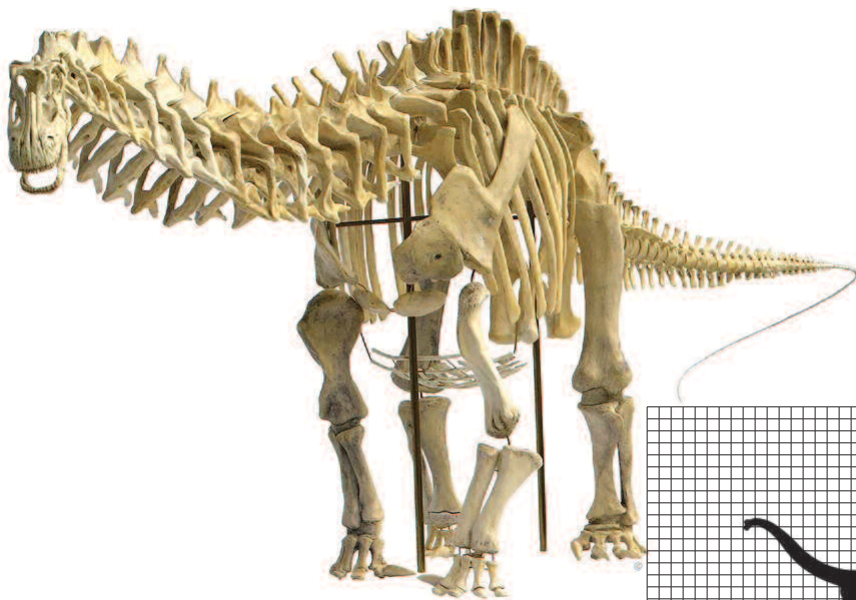
Special Features:
Tall with a very long neck



APATOSAURUS

Apatosaurus is a large sauropod.

For many years, the most complete skeleton of an Apatosaurus was thought to be a different species and was named Brontosaurus. In the 1970's, it was finally proven that Apatosaurus and Brontosaurus were the same creature.



FACT FILE

How to say it:
A-pat-oh-sore-rus

Name Means:
Deceptive Lizard

Family Group:
Diplodocidae

Period:
Late Jurassic 145 – 161 MYA

Where found:
North America

1st Discovered:
1877

Height:
13 feet

Length:
69 feet

Weight:
33 tons

Food: Plants

Special Features:
Enormous size and weight



VELOCIRAPTOR

Velociraptor was an agile, fast-running hunter. It was not the largest of predators but its keen intelligence and teamwork made it a very successful killer.



FACT FILE

How to say it:
Vel-oss-ah-rap-tor

Name Means:
Fast robber

Family Group:
Dromaeosauridae

Period:
Late Cretaceous 65 – 70 MYA

Where found:
Mongolia

1st Discovered:
1924

Height:
3 feet, 3 inches

Length:
6 ½ feet

Weight:
33 lbs

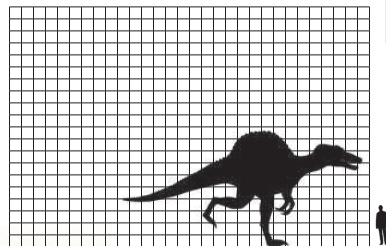
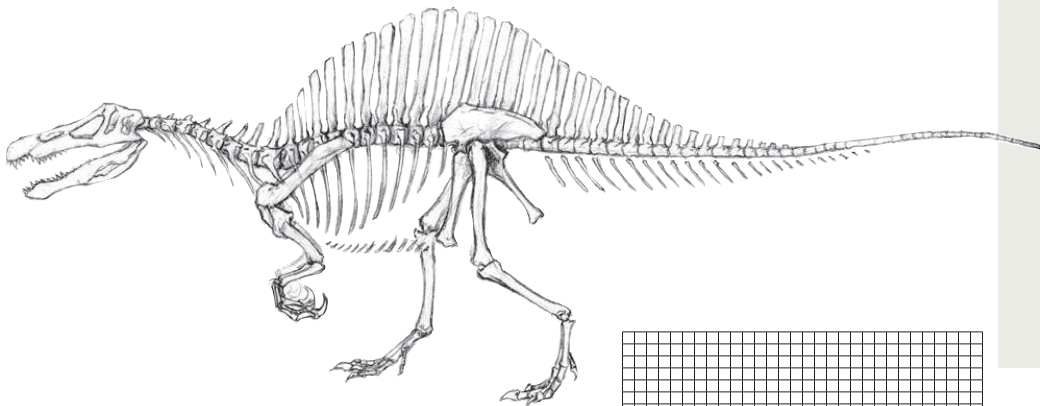
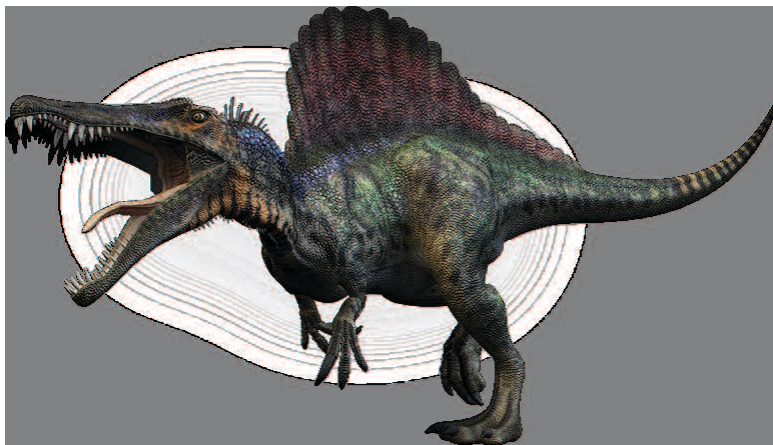
Food:
Meat

Special Features:
Intelligence
and deadly claws



SPINOSAURUS

Spinosaurus is a very large carnivore. Significantly larger than T-rex and with a skull about three feet longer than most T-rex skulls.



FACT FILE

How to say it:
Spine-oh-sore-rus

Name Means:
Thorn lizard

Family Group:
Spinosauridae

Period:
Late Cretaceous 90 – 135 MYA

Where found:
North Africa

1st Discovered:
1915

Height:
16 feet 5 inches

Length:
52 ½ feet

Weight:
4 tons

Food:
Meat

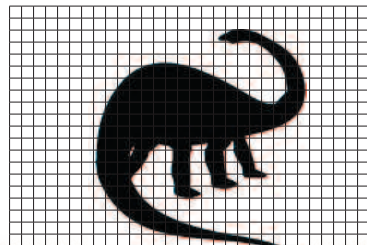
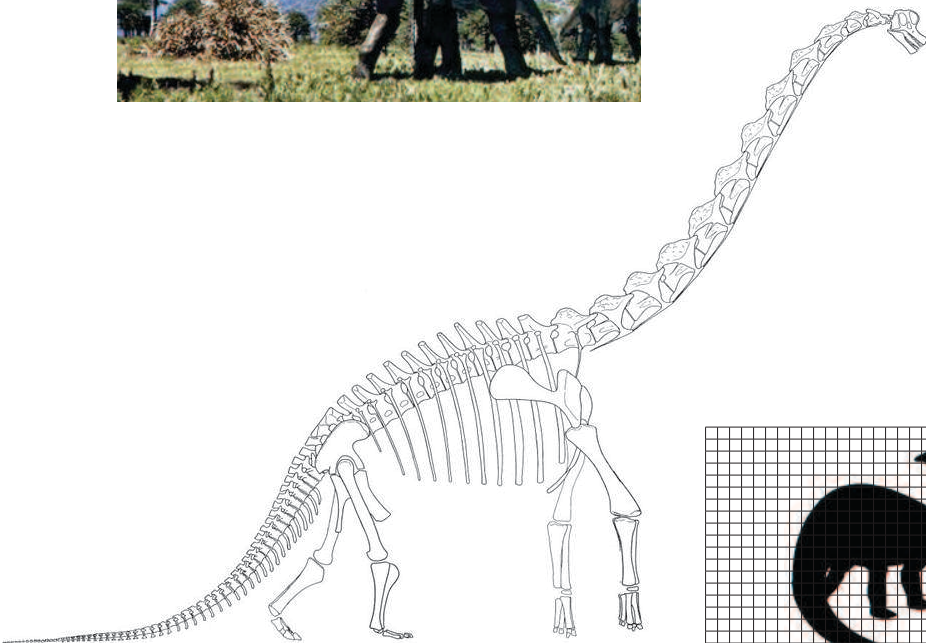
Special Features:
Large, sail-like crest along its back



BRACHIOSAURUS

Brachiosaurus is one of the largest known land animals. Its large nostrils were located on top of its head, which caused speculation that Brachiosaurus might have spent time submerged in water.

However, recent studies have shown that a creature as large as Brachiosaurus could not have inhaled and inflated its lungs against the water pressure at depths of total submergence.



FACT FILE

How to say it:
Brak-ee-o-sore-us

Name Means:
Arm Lizard

Family Group:
Brachiosauridae

Period:
Late Jurassic 146 – 161 MYA

Where found:
North Africa / North America

1st Discovered:
1900

Height:
52 feet 6 inches

Length:
98 feet 5 inches

Weight:
88 tons

Food:
Plants

Special Features:
Extreme height
and weight



MEGANEURA

Meganeura was a gigantic primitive dragonfly with a wingspan over 2 feet. Meganeura were predatory, they fed on other insects and even small amphibians. Meganeura flew by beating two pairs of wings stiffened by “veins”. It flew to hunt flying insects above tropical forests, and had swiveling, multifaceted eyes like headlamps which were quick to spot movement and sharp enough to allow it to pounce on flying prey. It dashed to and fro in forests, changing speed and direction almost instantly, grabbing insects with its legs and bringing them up to the mouth to feed. Meganeura were around in the late Carboniferous period, but not in either the Jurassic or the Cretaceous period. However, there were still large dragonflies in both these periods, and present day dragonflies are descended from these.



Meganeura puppet in Dinosaur Zoo Live

FACT FILE

How to Say it:
Meg-a-NEW-ra

Name Means:
Large -Nerved

Family Group:
Meganeuridae

Period:
Carboniferous 300 MYA

Where Found:
World wide

1st Discovered:
France, 1880

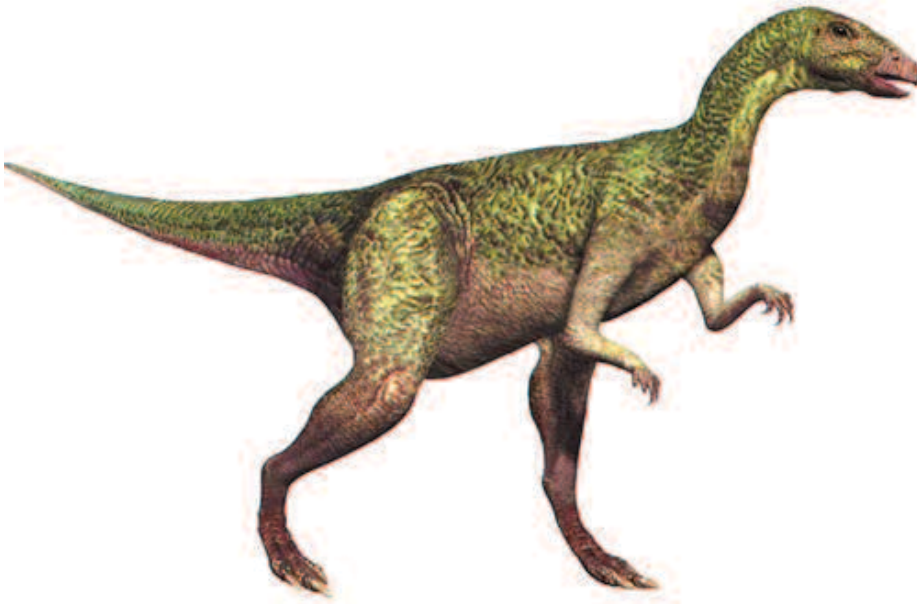
Wingspan:
Over 2 feet and perhaps larger

Food:
Other insects, small amphibians

Special Features:
One of the largest flying insects to have existed. Older than the dinosaurs

DRYOSAUR

Dryosaurs were bipedal and had powerful back legs, so it is likely they were fast runners. Their stiff tail balanced the body while standing or moving.



Dryosaurs were *herbivores*, using their hard beak to cut leaves and plants, and their oak leaf-shaped teeth at the back of their mouth to grind them up. Dryosaur fossils have been found in the Western United States, Tanzania and in New Zealand.



*Baby Dryosaurus puppet
in Dinosaur Zoo Live*

FACT FILE

How to Say it:
Dry-O-sore

Name Means:
Oak Reptile or Tree Lizard

Family Group:
Dryosauridae

Period:
Late Jurassic 145 - 161 MYA

Where Found:
North America and
Southern Hemisphere

1st Discovered:
North America, 1880's

Height:
5 feet

Length:
12 feet

Weight:
One ton

Food:
Plants

Special Features:
Beak. Five fingers for
gripping food

LEAELLYNASAURA

Leaellynasaura is one of many dinosaurs whose partial remains have been dug (and blasted) out of the solid rocks at Dinosaur Cove in Southeastern Australia. Leaellynasaura is a relatively recent dinosaur discovery and is known from several specimens including two nearly complete skeletons and two fragmentary skulls.

Its body was roughly turkey-sized (with a long tail) and it was an herbivorous ornithomimid. In the early Cretaceous period, areas of current day Australia were within the Antarctic Circle where the climate was extreme, with limited sun visible much of the year. Its skull has unusually large eye sockets, which suggests that Leaellynasaura adapted to the long winter darkness of the Antarctic and could withstand low, perhaps even subzero, temperatures. To do this, it would have needed a way of generating body heat, which some people have taken as evidence that dinosaurs were in fact warm-blooded.



Both images are Leaellynasaura puppets in Dinosaur Zoo Live

FACT FILE

How to Say it :
Lee-el-in-a-sore-rah

Name Means:
Leaellyn's Lizard

Family Group:
Undecided!

Period:
Early Cretaceous 104 - 112 MYA

Where Found:
Australia

1st Discovered:
Australia, 1989

Height:
Unknown

Length:
6-1/2 feet

Weight:
Unknown

Food:
Plants

Special Features:
Long tail compared to
body size



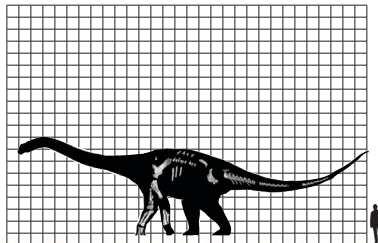
TITANOSAUR

Titanosaurs were the largest animals ever to roam on land; they were sauropod dinosaurs that survived to the end of the Cretaceous period (most sauropods went extinct at the end of the Jurassic period). Titanosaurs grew to sizes far in excess of their earlier relatives; hence they are named after the mythological Titans, who were Gods of ancient Greece.

The biggest Titanosaur that we can factually estimate the size is Argentinosaurus, it grew up to 114 feet 9 inches in length! Titanosaurs discovered in Australia include Wintonotitan Wattsi and Diamantinasaurus Matildae.



Titanosaur puppet in Dinosaur Zoo Live



FACT FILE

How to Say it:
Tie-tan-O-sore

Name Means:
Titanic Lizard

Family Group:
Titanosauridae

Period: Cretaceous
65 - 96 MYA

Where Found:
All continents

1st Discovered:
South America and
India in 1877

Height:
Up to 60 feet

Length:
Up to 115 feet

Weight:
Up to 100 tons

Food:
Plants

Special Features:
Very Large!
Last surviving sauropod



SCALES, SPIKES FEATHER OR FUR?

No one knows exactly what colors or patterns most of the dinosaurs were. Coloring and pattern are suited to the functions that an organism needs to survive. Some dinosaurs were likely camouflaged in order to hide from predators or to sneak up on prey. Some may have been colored in a particular way to attract mates, and some may even have been brightly colored to ward off predators. Different colors are also important for temperature regulation because different colors absorb, or reflect sunlight. Fossilized skin impressions have only been found for a small fraction of the known dinosaurs. Not much is known about dinosaur skin and there is some debate among paleontologists on this topic.

Most skin fossils show bumpy skin; only the huge plant-eaters appear to have had scaly skin. Some of the bird-like dinosaurs even had feathers.

DID YOU KNOW *there are dinosaurs flying in our skies today?*

Despite almost 100 hundred years of disagreements, most scientists now acknowledge that birds today are the ancestors of small meat-eating dinosaurs. The development of feathers turned dinosaurs that could run or climb into birds that could fly.

The earliest true bird is *Archeopteryx*, which lived during the late Jurassic period. When *Archaeopteryx* remains were first unearthed, paleontologists quickly realized this was one of the most important dinosaur discoveries ever made because *Archaeopteryx* was the first feathered dinosaur ever found.



SCALES, SPIKES FEATHER OR FUR?

Other dinosaurs developed feathers but were flightless like several types of bird known today, such as ostriches, emus and kiwis, to name just a few.

Click *HERE* to find out more about the feathered dinosaurs.



FACT FILE

How to say it:
Ar-kee-op-ter-riks

Name means:
Ancient Wing

Family Group:
Coeluridea

Period:
Late Jurassic

Where found:
Germany

First discovered:
1861 (but not
classified as a dinosaur)

Height :
About a foot

Length:
1 foot 8 inches

Weight: 1 lb 1.67 oz

Food:
Meat

Special features:
Feathers

IN THE AIR

At the time of the dinosaurs, there were a group of winged reptiles known as *Pterosaurs*. *Pterosaurs* are related to dinosaurs but are not classified as dinosaurs themselves. They had wings made of skin that stretched between long finger bones and the legs. They did not evolve to have feathers. Pterosaurs died out at the end of the Cretaceous period at the same time as the dinosaurs and did not evolve into modern day birds.

Click [HERE](#) to find out more about Pterosaurs

BELOW THE WAVES

While dinosaurs ruled the land and pterosaurs (and eventually flying dinosaurs like *Archaeopteryx*) ruled the air, the ocean was home to many species of marine reptiles such as *Nothosaurs*, *Ichthyosaurs*, *Pliosaurus*, *Plesiosaurs*, *Mosasaurus* and *Elasmosaurus*. Most were fierce carnivores survived preying on other sea creatures -- and on each other. Although they lived in the sea, many of these prehistoric creatures breathed air (like whales do).

Click [HERE](#) to find out more about prehistoric sea life.



Plesiosaurs from Dinosaur Zoo Live



FOSSILS

Dinosaurs are a great part of our world history. We know that dinosaurs (and other extinct animals and plants) existed because of the fossils they left behind.

DID YOU KNOW: Fossils are the preserved remains or traces of animals, plants, and other organisms from the remote past?

Fossils offer physical evidence of life prior to human history. This prehistoric evidence includes the remains of living organisms, prints and molds of their physical form, and marks/traces created in the sediment by their activities. Dinosaur fossils come in many types, from preserved bones, to tracks and more. Some fossils are better preserved than others and show impressions of skin and other soft tissues. Fossil remains left by dinosaurs prove that they existed, and we are able to use the fossil evidence to recreate their skeletons and then start to create pictures of what they might have looked like.



There is still so much to learn about dinosaurs and new fossil discoveries are being made all the time. Click on the links below to watch some short BBC videos all about fossils.



Click HERE to watch a brief clip about how fossils formed in mud

Click HERE to watch a brief clip about fossilized bones

Click HERE to watch a brief clip about formation of fossils, limestone and slate

IMPORTANT NAMES IN PALEONTOLOGY

The following people played a key role in early dinosaur paleontology:

Gideon Mantell (1790 - 1852) was an English doctor from Sussex. Gideon was a paleontologist throughout his life and contributed greatly to the field through his discovery and analysis of many fossilized remains. One of the stories told about Mantell is that his wife found a tooth that looked like a very large Iguana tooth and it was many years before Mantell managed to complete the skeleton which turned out to be Iguanodon.

Mary Anning (1799 - 1847) was a fossil collector who gained a reputation as a paleontologist. She lived in Lyme Regis and made many important prehistoric discoveries. She started fossil collecting to earn money and although women and the lower classes were not usually respected in scientific circles, Mary managed to make an impact.

Sir Richard Owen (1809 - 1892) was an English anatomy professor and paleontologist. He's best known for inventing the term Dinosaur (meaning Terrible Lizard). Owen was a central character during the early days of dinosaur discovery.

(Benjamin) Waterhouse Hawkins (1807 - 1894) was an English sculptor and artist with an interest in natural history. He built the life-size Crystal Palace dinosaurs under the scientific direction of Richard Owen. Unfortunately, later discoveries revealed that many of the assumed body positions of the dinosaurs were actually incorrect. For example, we now know Megalosaurus was bipedal, though it was originally depicted on all fours.



IMPORTANT NAMES IN PALEONTOLOGY

Bipedal is the word used to describe any creature that walks on its two back limbs.

Can you imagine how difficult it is for *paleontologists* to reconstruct a dinosaur from fossils and bones, and try to imagine what it looked like just by this little and incomplete evidence?

Paleontologists need to be able to identify which bones belong to what type of creature, and they need to separate all the bones that might be found all together into the different species of dinosaur. They also must identify which part of the body each bone belongs to. It must be very difficult and so it is understandable that sometimes mistakes are made identifying and classifying dinosaurs.

Would you like to attempt to assemble some prehistoric creatures?

Click HERE to play the BBC's fantastic fossil game on the BBC science website

And, ***click HERE*** to play a similar game (made by The Online Dinosaur Museum)



WHERE ARE THEY NOW?

65 million years ago, at the end of the *Cretaceous* period, one of the most devastating mass extinctions of all time took place on earth. It wiped out between 60 and 80 percent of all living things and ended the dinosaurs' lengthy reign on earth. Many other groups of animals also became extinct at this time, including *ammonites*, *mosasaurs*, *plesiosaurs*, *pterosaurs* and many groups of *mammals*. Virtually all life on earth was affected. On land, no animal weighing over 55 lbs survived.

The most common theory is that the mass extinction was caused by the impact of a giant asteroid or comet hitting the earth. Other theories suggest sudden volcanic eruptions may have been the cause of the extinction, or that dinosaurs simply failed to adapt to changing conditions.

Extinction is when a whole species or group of organisms is wiped out and ceases to exist. The moment of extinction is generally considered to be the death of the last individual of the species.

The discovery that birds are a type of dinosaur shows that dinosaurs in general are not extinct as is commonly stated. However, all non-bird dinosaurs, as well as many groups of birds and other life did suddenly become extinct approximately 65 million years ago.



ABOUT THE PUPPETS

In *Erth's DINOSAUR ZOO Live™*, the dinosaurs are portrayed by puppets. A puppet is a figure whose movements are controlled by someone through strings, rods or hand/body actions.

The main style of puppetry used in *DINOSAUR ZOO Live* is a modified style of *Bunraku* (pronounced bun-rah-koo) puppetry, a form of puppetry that originated in Japan over 400 years ago. In *Bunraku*, there are usually several puppeteers who manipulate the puppet directly and are visible throughout the play rather than being hidden. Usually three puppeteers will operate one puppet, and usually one puppeteer is responsible for moving a different part of the body. Puppetry in Japan is highly regarded. *Bunraku* is directly related to the *kabuki*, a mime theatre tradition and at one time was considered the highest form of theatre in Japan. The greatest writers and actors of the day created work exclusively for *Bunraku* performances. Many plays were written that are similar to Shakespearean dramas, with detailed language and complex plots. *Bunraku* plays are still performed today in Japan; a master puppeteer spends a lifetime perfecting manipulation of his puppet.

So how much do you think you have learned about dinosaurs?



T-rex puppet and puppeteer from Dinosaur Zoo Live



Meganeura puppet in Dinosaur Zoo Live

QUIZ

Answer these quiz questions!

1. In which country was the first dinosaur discovered?
2. Who invented the name dinosaur?
3. What does the name dinosaur mean?
4. Which era of the earth's history did dinosaurs live in?
5. How long did dinosaurs live on the earth?
6. What is the special name given to someone who studies dinosaurs and prehistoric life?
7. What should you feed a Tyrannosaurus Rex-- plants or meat?
8. Which creatures of today are direct ancestors of the dinosaurs and are classified as dinosaurs?
9. What is the name given to preserved remains of animals, plants and other organisms from the past?
10. What word is used to describe a whole species being wiped out and ceasing to exist?

Answers, see page 35



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This study guide as appended from the original by Norwich Puppet Theatre in partnership with Norfolk and Norwich Festival (2012) and Erth Visual and Physical Inc. It was researched and compiled by: Gemma Khawaja

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GLOSSARY

Ammonites -- an extinct group of marine invertebrate animals in the subclass Ammonoidea of the class Cephalopoda, more closely related to living coleoids (i.e. octopuses, squid, and cuttlefish). The name was inspired by the spiral shape of their shells, resembling tightly coiled rams' horns.

Apatosaurus -- a genus of sauropod dinosaur that lived during the Jurassic Period, which included the popular but scientifically redundant dinosaur Brontosaurus. It was one of the largest land animals known to have ever existed, with an average length of 75 ft and a mass of 18 short tons.

Archeopteryx -- the earliest true bird which lived during the late Jurassic period.

Bipedal -- any creature that walks on its two back limbs.

Brontosaurus -- used to be one of the most well known dinosaurs until paleontologists realized it was actually the same creature as Apatosaurus.

Buckland, William -- Professor of Geology at Oxford who presented descriptions of the Megalosaurus discovery in a written paper, which was the first full account of a fossil dinosaur.

Bunraku -- a form of puppetry that originated in Japan over 400 years ago. Usually there are several puppeteers who manipulate the puppet directly and are visible rather than being hidden.

Carnivorous -- meat-eating, flesh-eating, feeding on other animals.

Cretaceous Period -- a geologic period and system from circa 145 to 66 million years ago. In the geologic timescale, the Cretaceous follows the Jurassic period and is followed by the Paleogene period of the Cenozoic era. It is the last period of the Mesozoic Era, and, spanning 79 million years.

Elasmosaurs -- genus of plesiosaur with an extremely long neck that lived in the Late Cretaceous period, 80.5 million years ago.

Evolve -- develop and change very quickly

Extinction -- when a whole species or group of organisms is wiped out and ceases to exist.

Gondwana -- the southernmost of the two supercontinents (the other being Laurasia) that formed part of the Pangaea supercontinent from approximately 300 to 200 million years ago.

Herivore -- an animal that gets its energy from eating plants, and only plants.

Ichthyosaurs -- Greek for "fish lizard" they were giant marine reptiles that resembled dolphins and thrived during much of the Mesozoic era; They evolved from a group of land reptiles that moved back into the water, in a development parallel to that of the ancestors of modern-day dolphins and whales.

Jurassi Period -- a geologic period and system that extends from 201.3 to 145 million years ago; from the end of the Triassic to the beginning of the Cretaceous: The middle period of the Mesozoic Era.

Kabuki -- a mime theatre tradition in Japan that was at one time considered the highest form of theatre in Japan.

Laurasia -- the northernmost of two supercontinents (the other being Gondwana) that formed part of the Pangaea supercontinent from approximately 300 to 200 million years ago.

Mammals -- any of various warm-blooded vertebrate animals of the class Mammalia, including humans, characterized by a covering of hair on the skin and, in the female, milk-producing mammary glands for nourishing the young.

Megalosaurus -- the first dinosaur to be described and named, it was presented as the Great Fossil Lizard of Stonesfield by Professor William Buckland, Professor of Geology at Oxford.



GLOSSARY

Mesozoic Era -- an interval of geological time from about 252 to 66 million years ago.

Mosasaurs -- large, extinct, marine reptiles that probably evolved from semiaquatic squamates known as aigialosaurs, which were more similar in appearance to modern-day monitor lizards.

Nothosaur -- Triassic marine sauropterygian reptiles that may have lived like seals of today, catching food in water but coming ashore on rocks and beaches. They averaged about 10 ft in length, with a long body and tail.

Owen, Richard -- an English anatomy professor and paleontologist who is known for inventing the term 'dinosaur' (terrible lizard).

Ornithischians -- 'Bird-hipped' dinosaurs - one of two major defining groups of dinosaurs, the other being Saurischians, or 'lizard-hipped' dinosaurs.

Paleontologist -- a specialist in the study of paleontology.

Paleontology -- the study of the forms of life existing in prehistoric or geologic times, as represented by the fossils of plants, animals, and other organisms.

Pangaea -- a supercontinent surrounded by a single global ocean that existed during the late Paleozoic and early Mesozoic eras, forming approximately 300 million years ago. It began to break apart around 200 million years ago.

Plesiosaurs -- meaning "near lizard" were flippered marine reptiles from the Mesozoic Era - they were not dinosaurs. They ranged in size from 8-46 feet long and had four flippers, sharp teeth in strong jaws, and short, pointed tails.

Pliosaur -- short-necked plesiosaurs with large heads and massive toothed jaws. These swimming reptiles were not dinosaurs, but distant cousins of modern lizards.

Plot, Robert -- English Naturalist and Oxford Professor engaged in early paleontologic study, who initially (and erroneously) concluded that dinosaur bones found in Briton were actually the bones of elephants that were brought by the Romans.

Pterosaur -- flying reptiles of the order Pterosauria. They existed from the late Triassic to the end of the Cretaceous Period 220 to 65 million years ago. Pterosaurs are the earliest vertebrates known to have evolved powered flight.

Saurischians -- 'Lizard-hipped' dinosaurs - one of two major defining groups of dinosaurs, the other being Ornithischians, or 'bird-hipped' dinosaurs.

Terrestrial -- living on land rather than in the sea.

Triassic Period -- a geologic period and system that extends from about 252.2 to 201.3 million years ago. It is the first period of the Mesozoic Era.

Vrown, Barnum -- Scientist and paleontologist who first discovered fossils of Tyrannosaurus or T-rex, which soon captured public imagination to become one of the most well-known and popular dinosaurs.

QUIZ ANSWERS

- | | |
|----------------------|-------------------|
| 1. England | 6. Paleontologist |
| 2. Richard Owen | 7. Meat |
| 3. Terrible Lizard | 8. Birds |
| 4. Mesozoic Era | 9. Fossil |
| 5. 165 million years | 10. Extinction |

