Alles Introductory Biology: Illustrated Lecture Presentations

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Part Three: The Integration of Biological Knowledge

Vertebrate Evolution in the Late Paleozoic and Mesozoic Eras

Vertebrate Evolution in the Late Paleozoic and Mesozoic

• Amphibians to Reptiles

Internal Fertilization, the Amniotic Egg, and a Water-Tight Skin

• The Adaptive Radiation of Reptiles

from Scales to Hair and Feathers

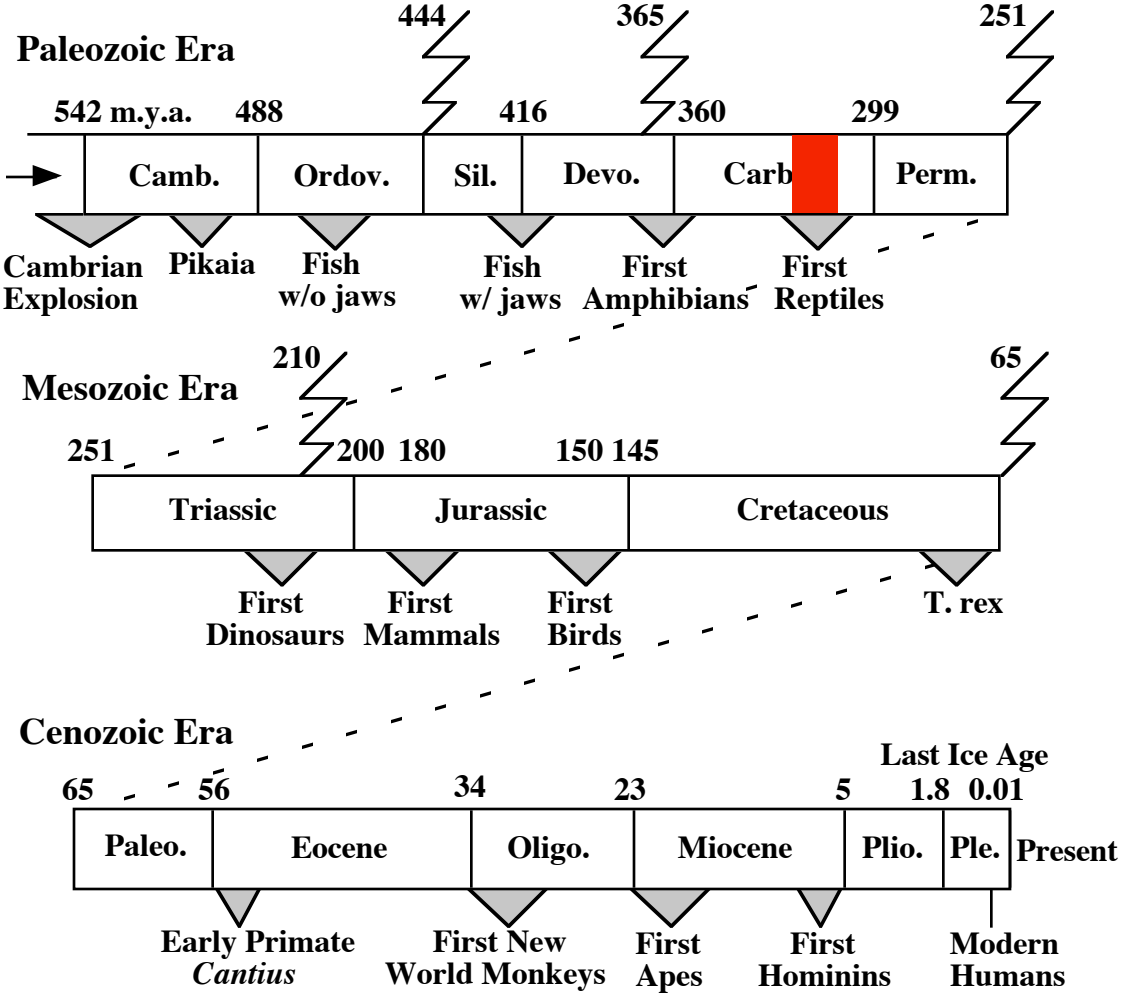
• Therapsids to Mammals

• Dinosaurs to Birds

Ectothermy to Endothermy

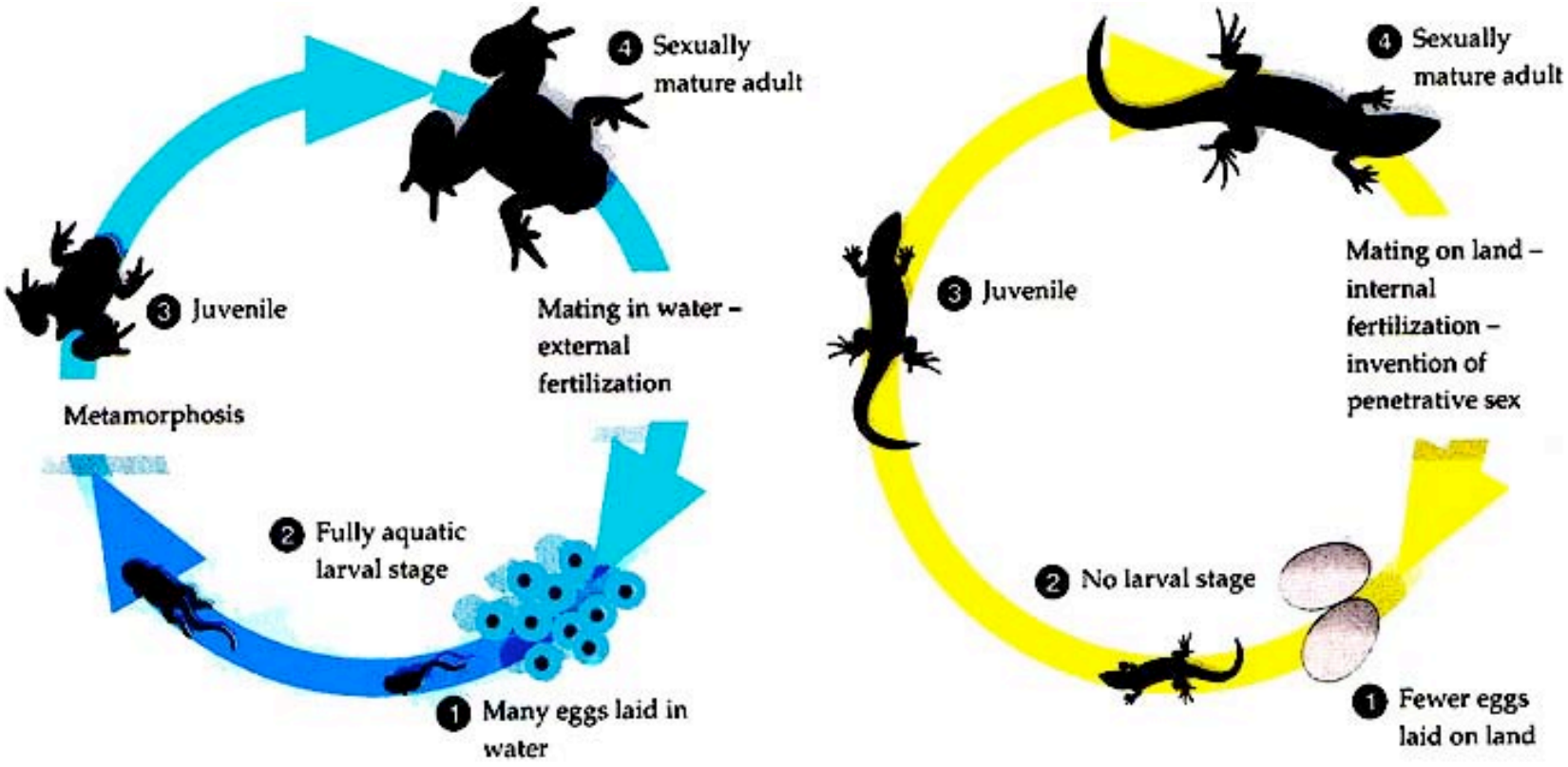
The Evolution of Reptiles

The Phanerozoic Eon

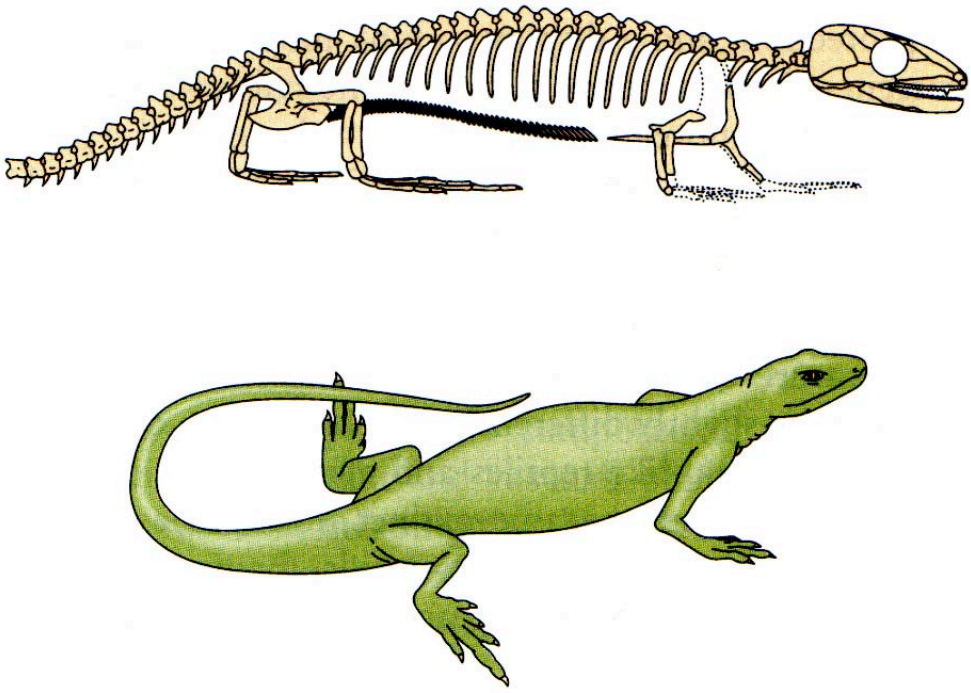


A modern Amphibian—the toad

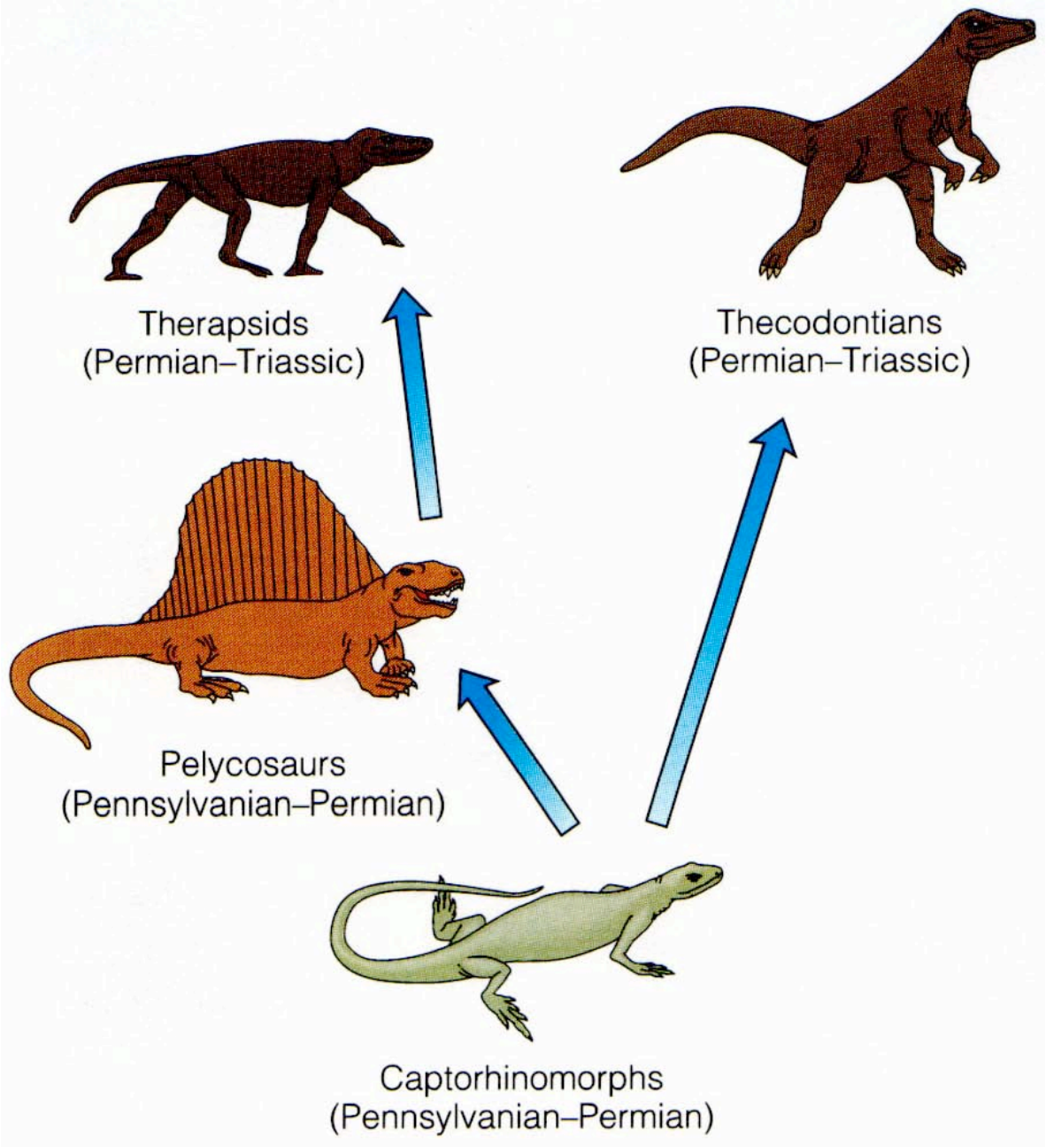
A modern day Reptile—a skink, note the finely outlined scales.



A Comparison of Amphibian and Reptile Reproduction

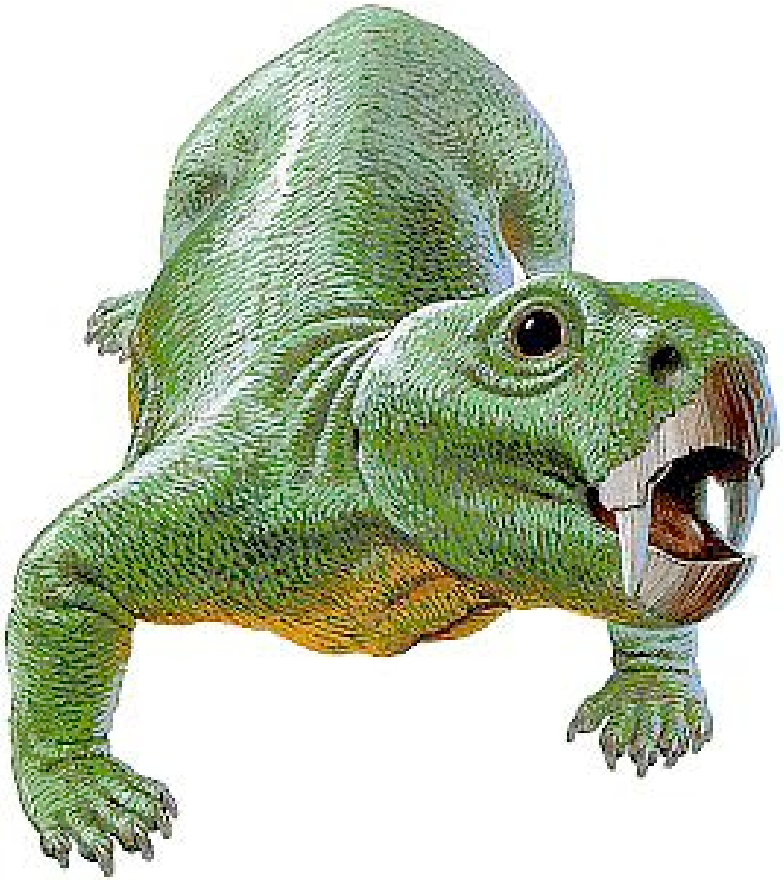


The oldest known reptile is *Hylonomus lyelli* dating to ~ 320 m.y.a..



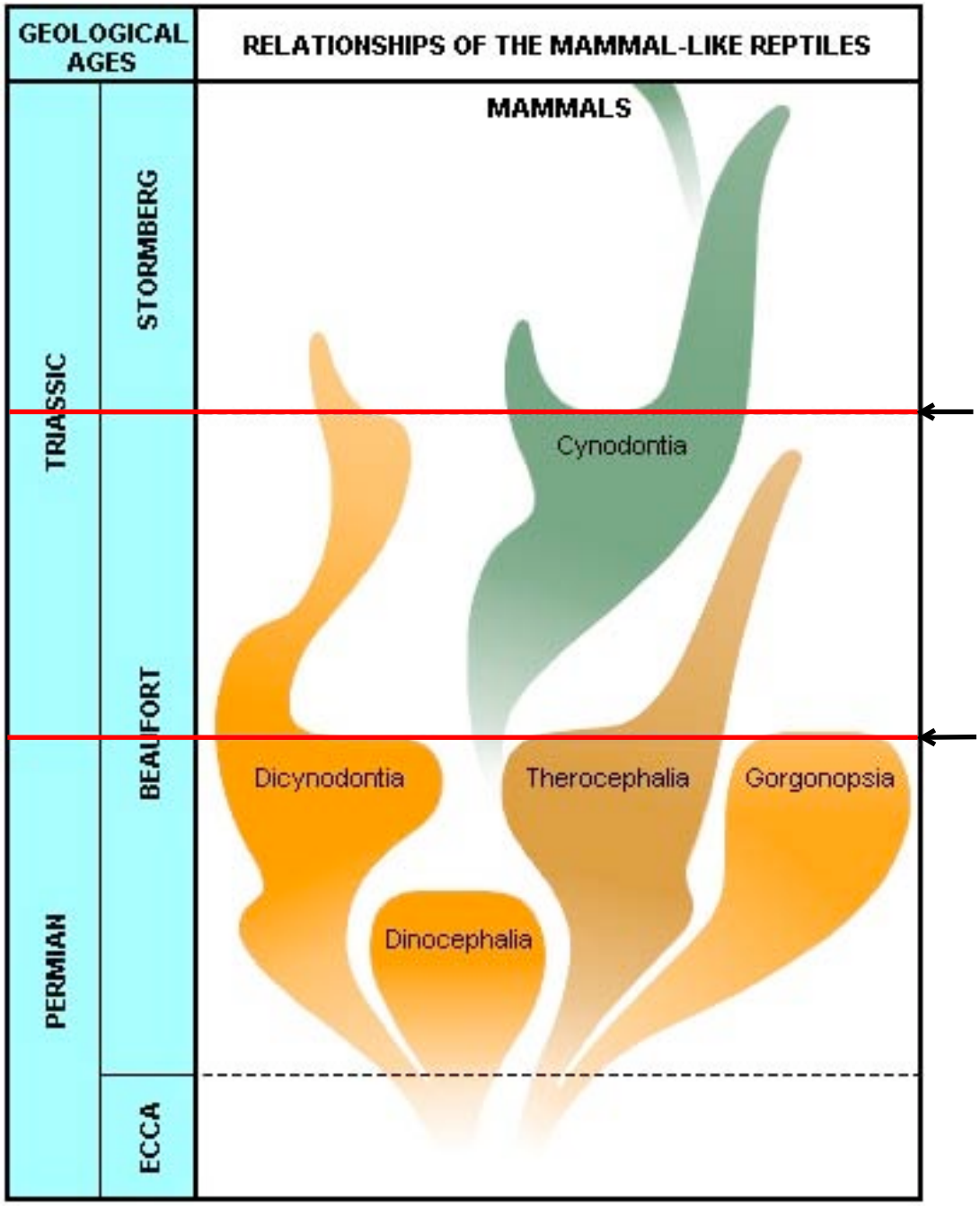
The earliest or stem reptiles radiated into therapsids leading to mammals, and archosaurs leading to all the other reptile groups including the thecodontians, ancestors of the dinosaurs.

Dimetrodon, a Mammal-like Reptile of the Early Permian

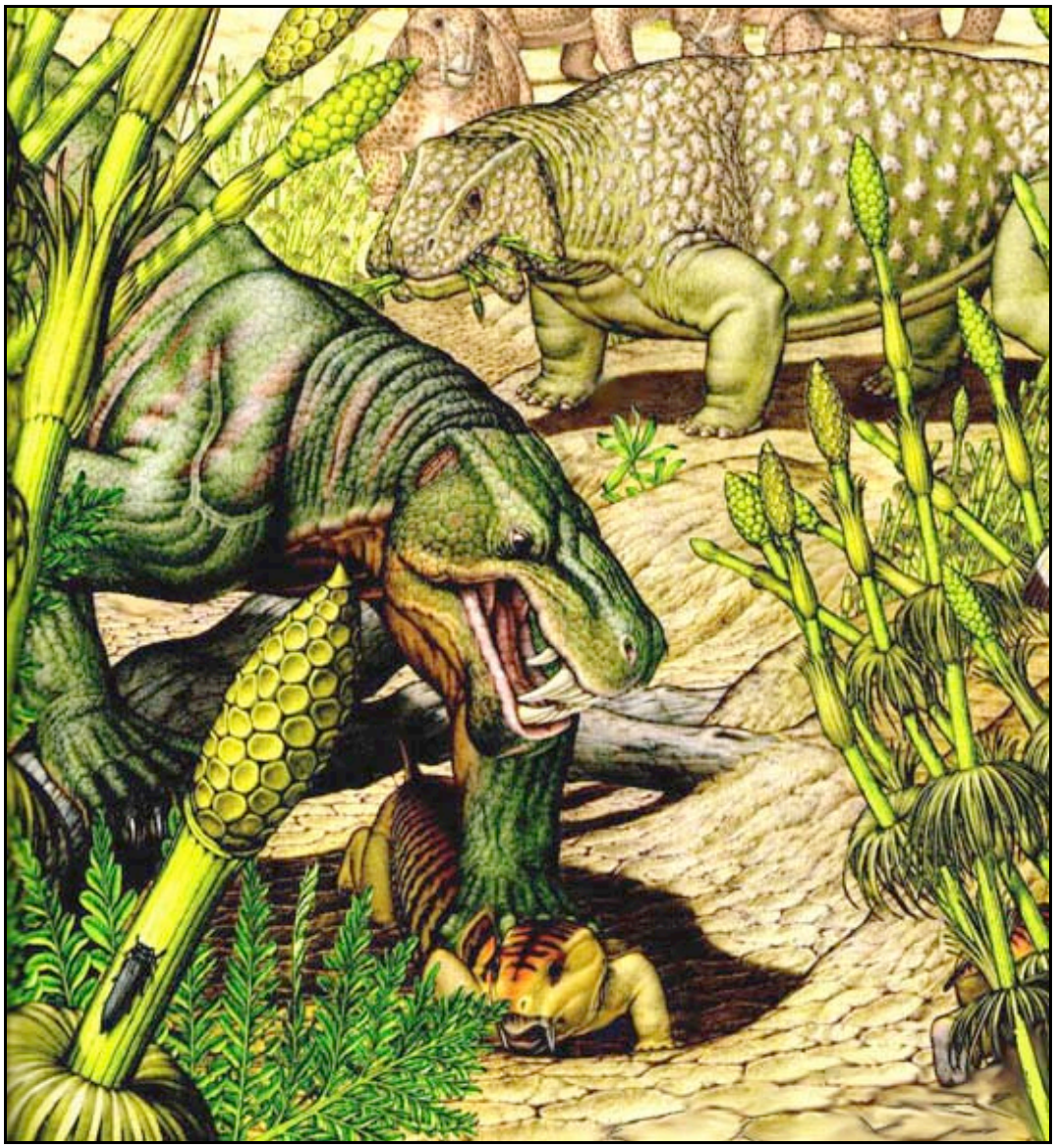


Dicynodonts were a group of therapsids of the late Permian.

Web Reference
http://www.museums.org.za/sam/resource/palaeo/cluver/index.html



Therapsids experienced an adaptive radiation during the Permian, but suffered heavy extinctions during the end Permian mass extinction.



Shown above is a *Gorgonopsian* predator attacking a *Dicynodont*, with the herbivores *Ischigualastia* and *Lystrosaurus* looking on. Therapsids, as a group, also suffered heavy extinctions during the Triassic mass extinction, setting the stage for the adaptive radiation of dinosaurs in the Jurassic.

The Five Mass Extinction Events of the Phanerozoic Eon
(after Benton 2003)

1. End Ordovician ~ 444 m.y.a. with a loss of at least 50% percent of species.

2. Late Devonian 370 to 360 m.y.a. with a loss of at least 50% percent of species.

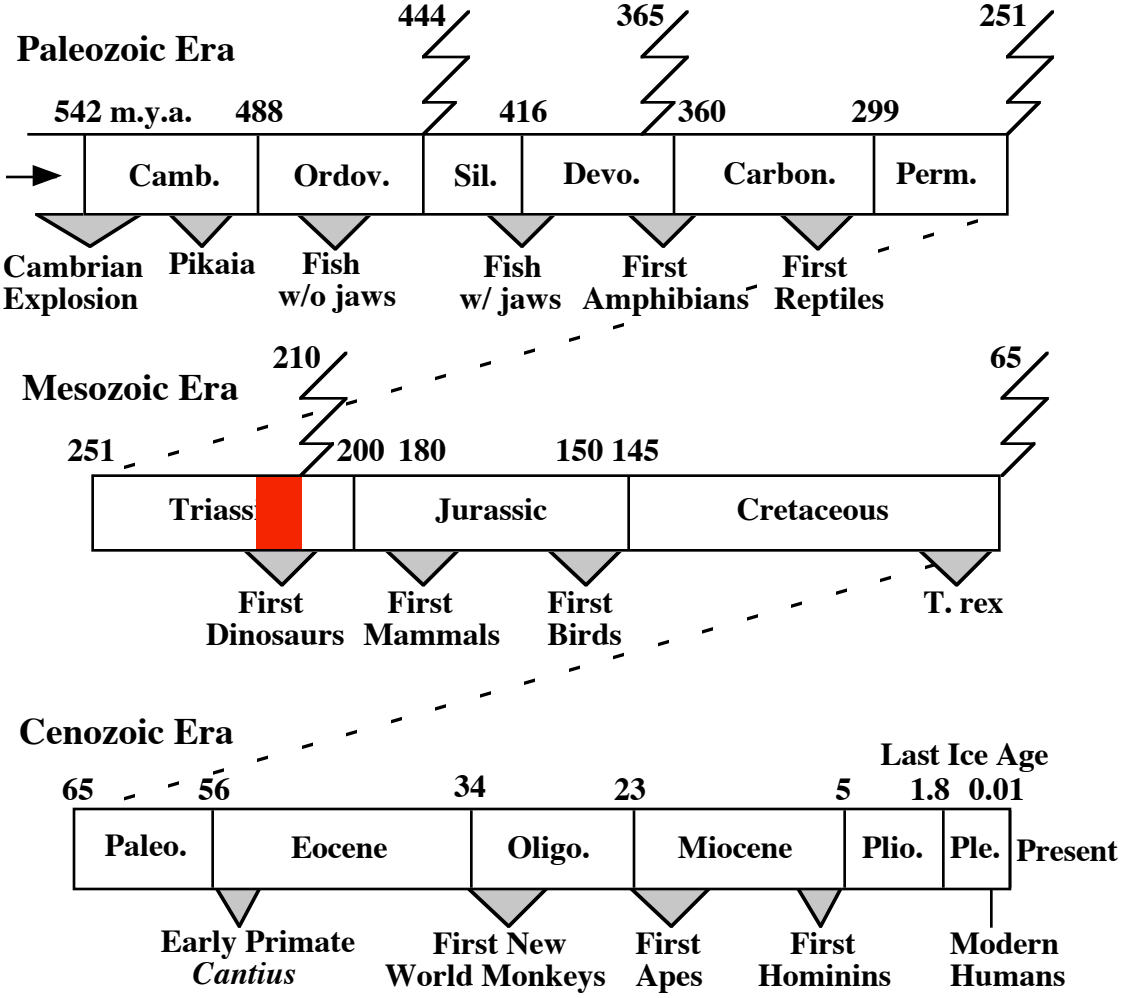
3. End Permian 251* m.y.a. with a loss of 80 to 95 percent of species.

4. Late Triassic ~ 210 m.y.a with a loss of at least 50% percent of species.

5. End Cretaceous 65* m.y.a. with a loss of at least 50% percent of species.

The Evolution of Dinosaurs

The Phanerozoic Eon

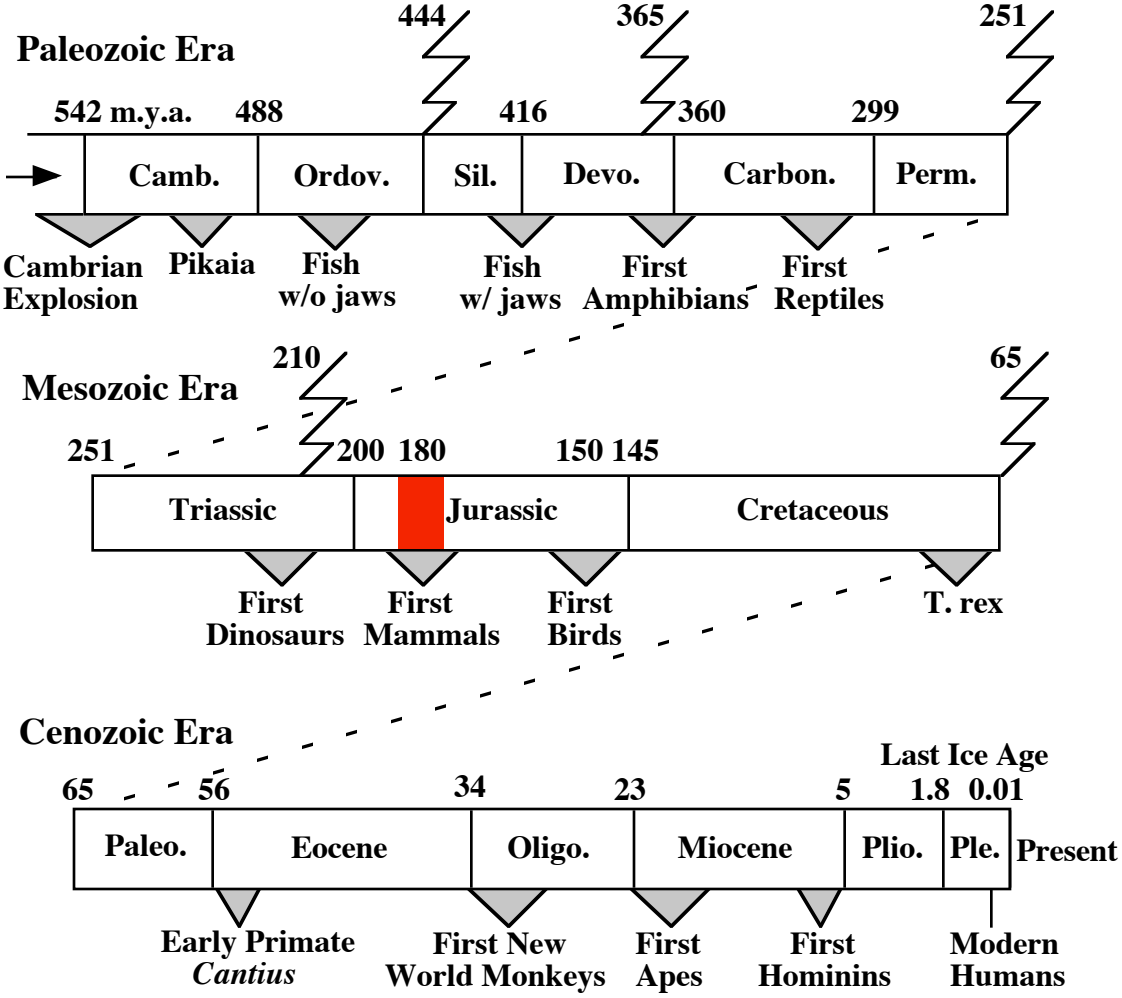


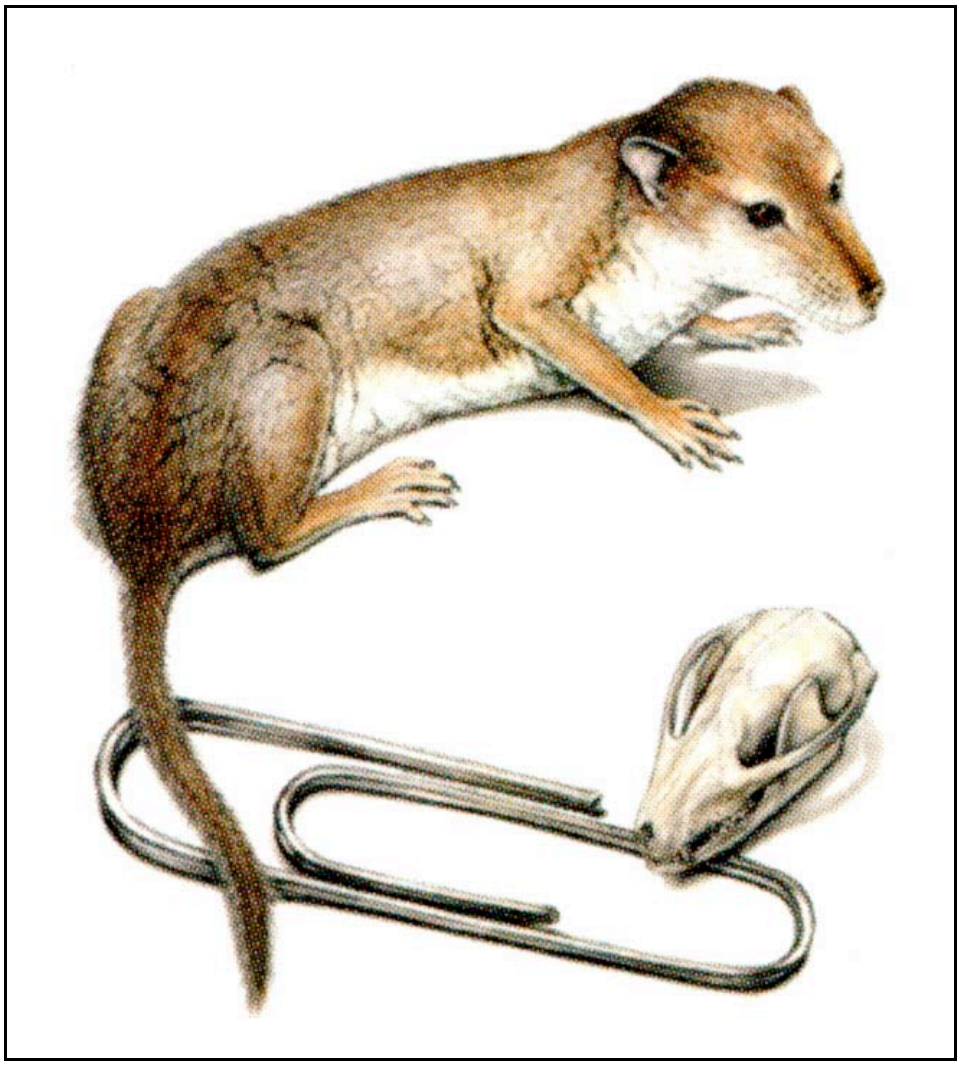
***Tyrannosaurus rex* and a Ceratops**

(Painting by John Gurche http://www.gurche.com/)

The Evolution of Mammals

The Phanerozoic Eon



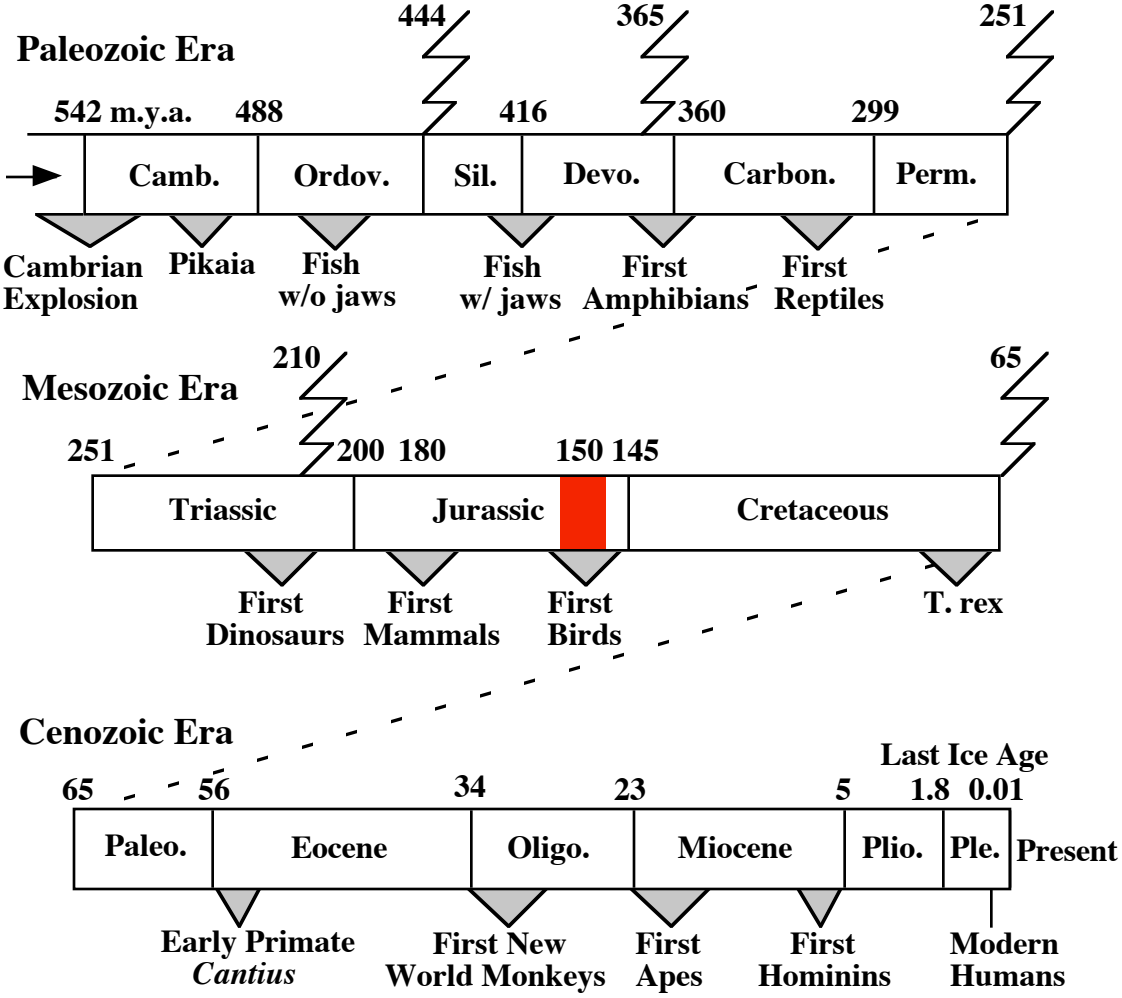


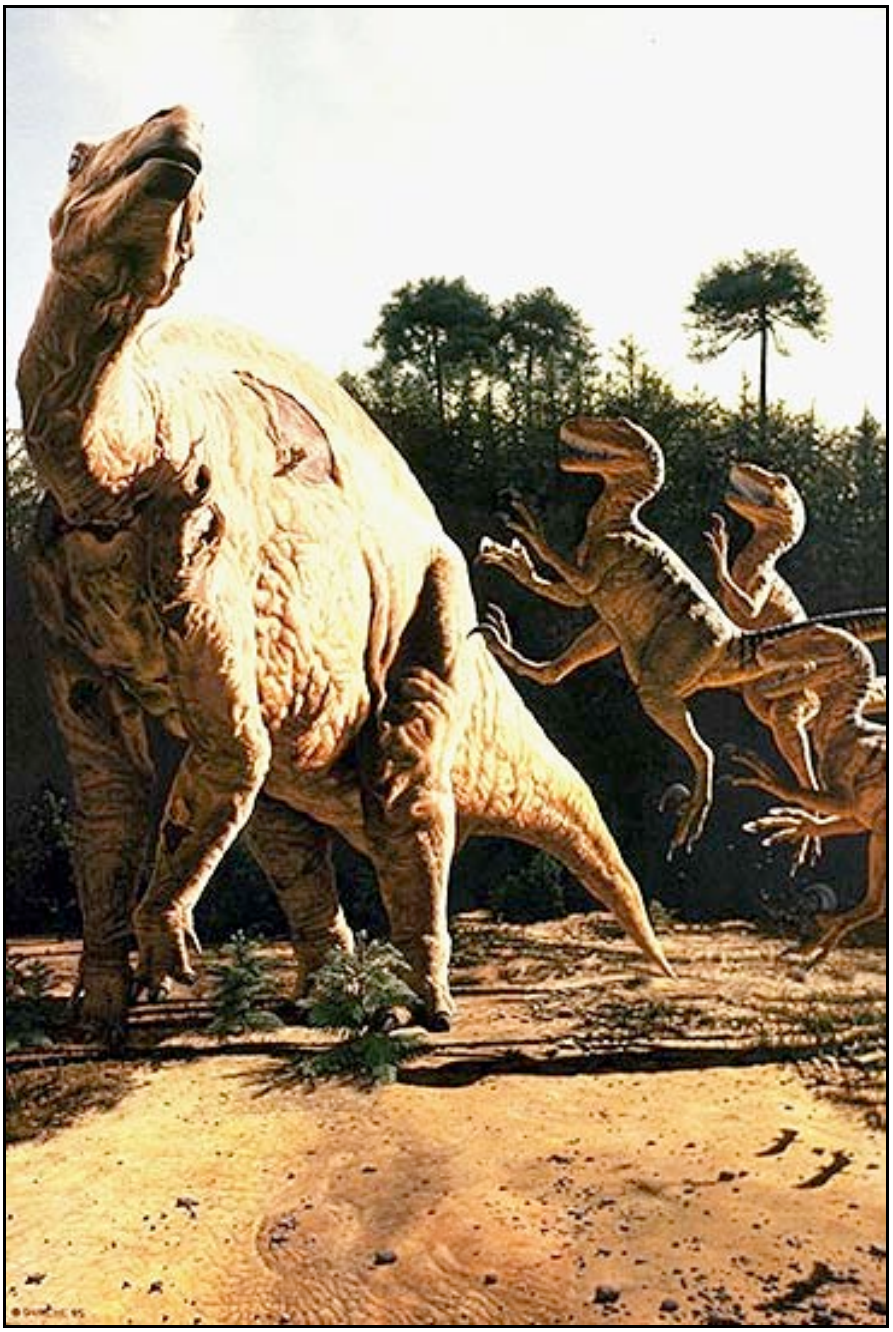
True mammals evolved during the Jurassic from one of the few groups of therapsids that survived the Triassic mass extinction. *Hadrocodium wui* pictured above was an early ancestor of mammals dated to ~ 195 million years ago. Hadrocodium is estimated to have weighted 2 grams making it one of the smallest early mammals known. The paper clip measures 1-1/4 inches actual size.

(Painting by Mark A. Klingler)

The Evolution of Birds

The Phanerozoic Eon

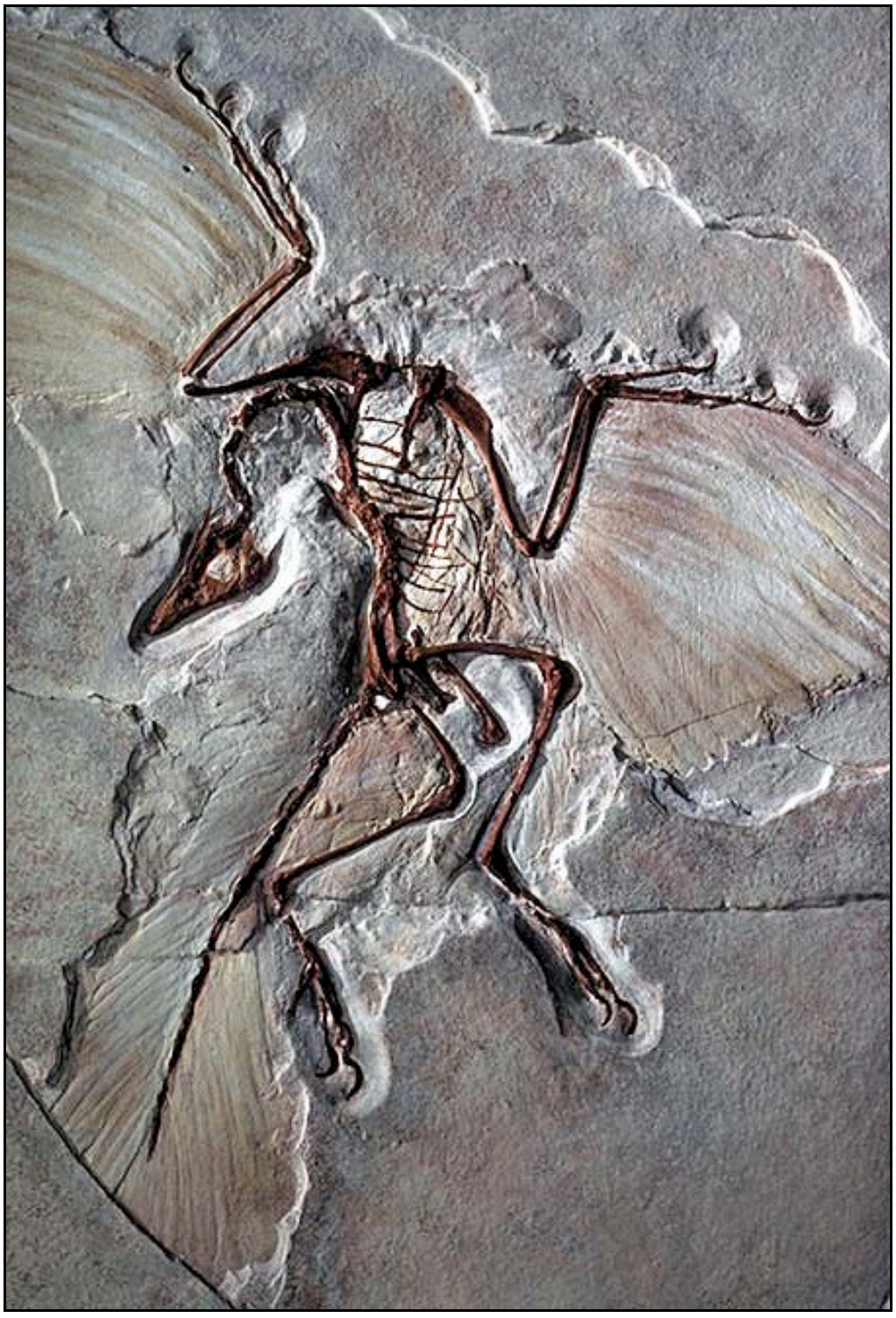




Birds evolved during the Jurassic from small predatory theropod dinosaurs such as Deinonychus show above attacking an Iguanodon.

(Painting by John Gurche http://www.gurche.com/)

Web Reference
http://www.ucmp.berkeley.edu/diapsids/avians.html

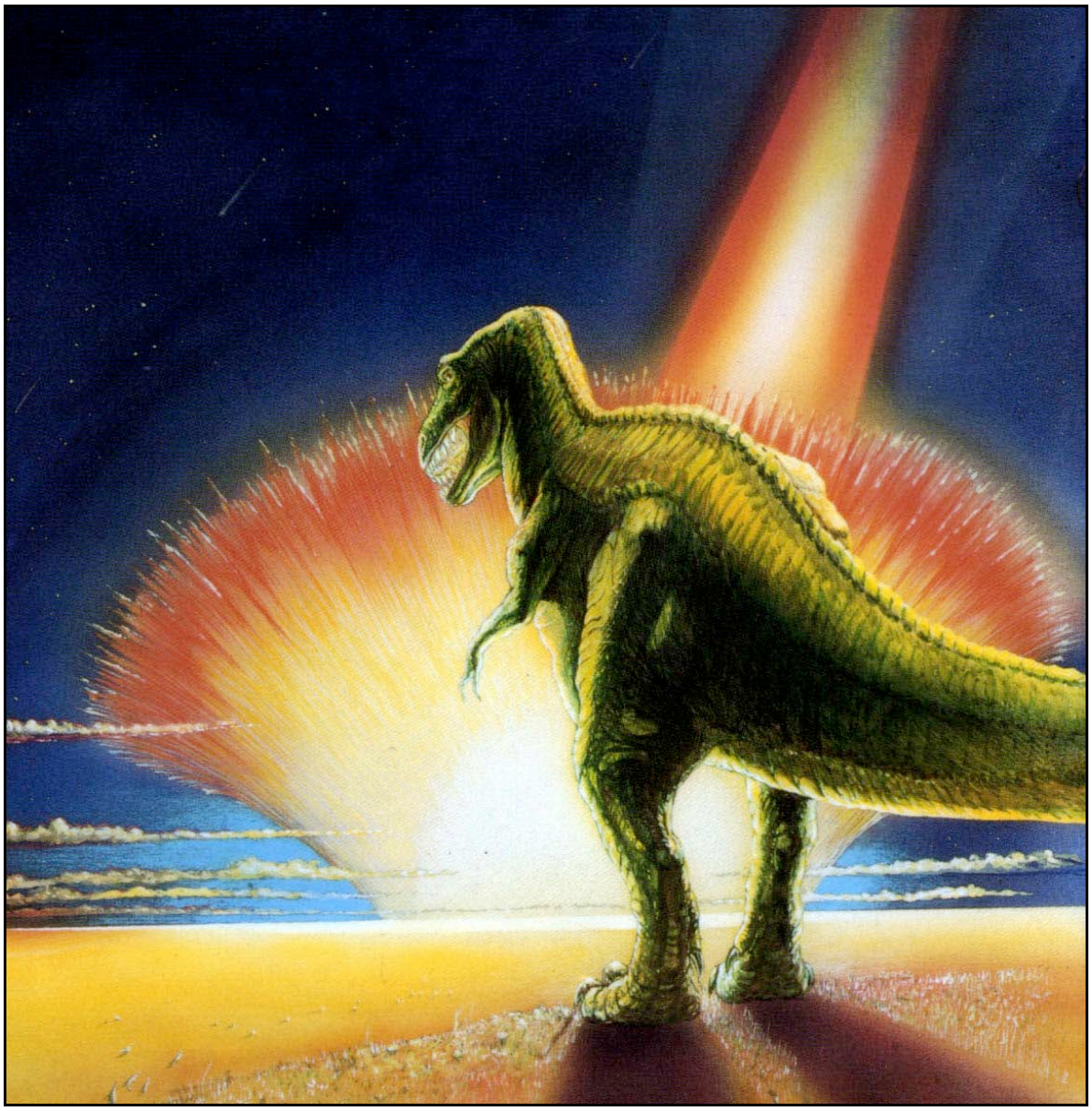


Fossils of Archaeopteryx date to 150 m.y.a.

(*Archaeopteryx* cast, Smithsonian Museum, Washington, DC, James Amos/Corbis)

Archaeopteryx painting by Karen Carr

Web Reference
http://prehistoricsillustrated.com/paleogallery_karencarr.html



T. Rex and the Crater of Doom

The Mass Extinction Event at the End of the Cretaceous 65 m.y.a.

The End of an Era

(Painting by Vincent Perez)

The Chicxulub Crater

The Chicxulub crater is often cited as one of the best preserved records of an Earthly cosmic disaster. Discovered only in the 1970s by oil drilling teams, the crater was relatively unstudied until the 1990s, when scientists linked it to theories that asteroid impact may have spelled the dinosaurs' doom.

The asteroid impact near the tip of Mexico's Yucatan peninsula about 65 million years ago has long been believed to be a potential cause for the death of the dinosaurs, which vanished at roughly the same time.

That impact was like nothing recorded in human history. Millions of years before humans even existed, a huge meteorite measuring about 6 miles across and weighing perhaps billions of tons crashed into the planet in a ball of fire, shrouding the Earth in a dense cloud of dust that blocked out sunlight and sent temperatures plummeting.

Estimates now put the crater's size at about 125 miles in diameter, indicating a force of impact equivalent to an earthquake about 10,000 times stronger than the one that leveled San Francisco in 1906 and equal to the explosive force of hundreds of atomic bombs.

About 60 percent of all recorded species on the earth disappeared around the time the meteorite struck. On land, scientists believe nothing larger than a dog survived.

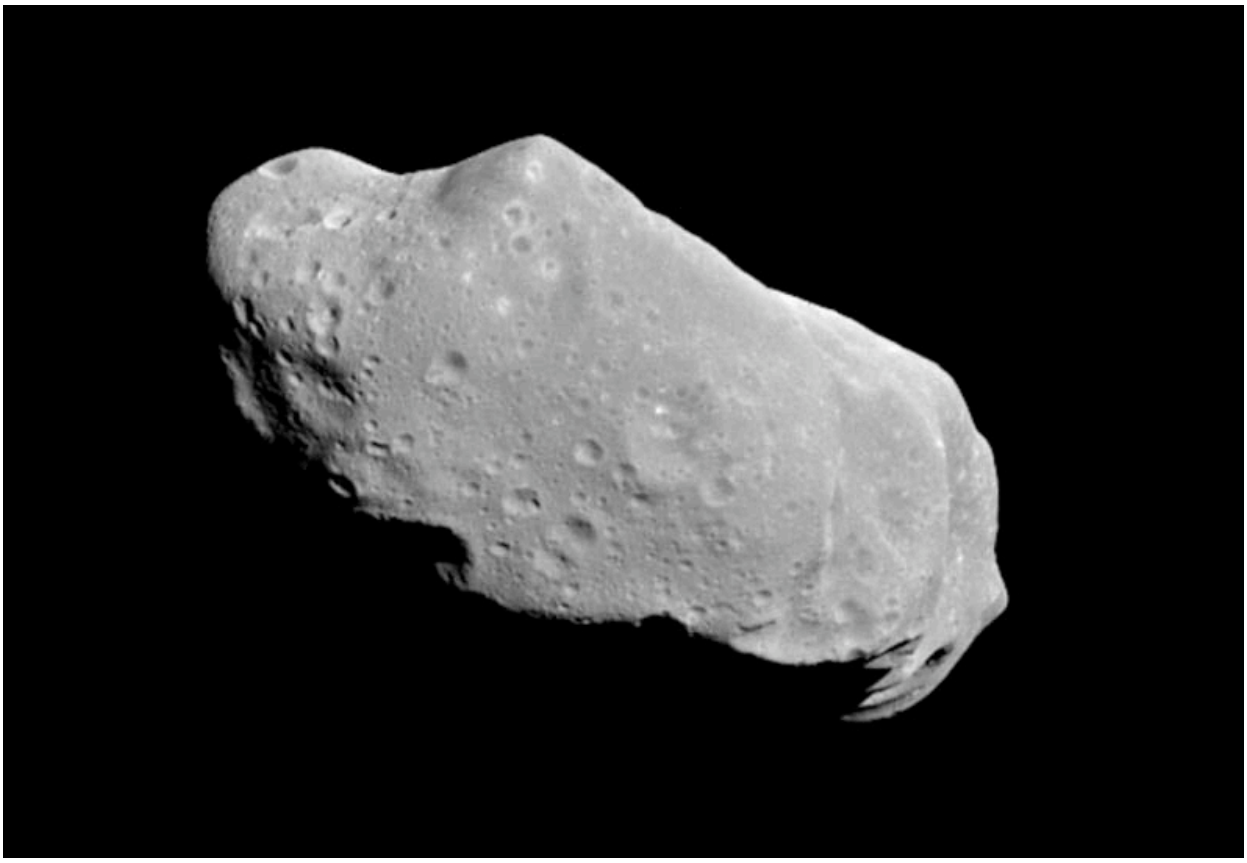
While researchers agree that vast amounts of dust and debris were sent shooting into the atmosphere, the actual mechanics of how this may have caused a global catastrophe are still under study. One problem is that environmental effects of the impact would have to have been felt worldwide in order to account for the planetary extinction of so many species.

Scientists now hope that examination of core samples from the crater will give a better understanding of the chemical make-up of the material involved—specifically, by indicating how much sulfur- and carbon-bearing rock was sent hurtling into the sky. This will tell a lot about how the carbonates and sulfates of the limestone sediments of the ancient sea floor the asteroid struck react to high impact pressures.

Limestone rock evaporated by the impact might have clogged the atmosphere with floating sulfur particles, causing a "nuclear winter" by blocking sunlight essential to plant growth, removing the essential first link in the worldwide food chain.

Sulfur particles falling into the ocean could also have transformed the world's seas into vast, acidic pools, killing off much of the sea life.

Following this disaster, immense amounts of carbon dioxide released from vaporized limestone could have contributed to a secondary greenhouse effect, sending temperatures soaring and killing off much of the remaining life on the planet.

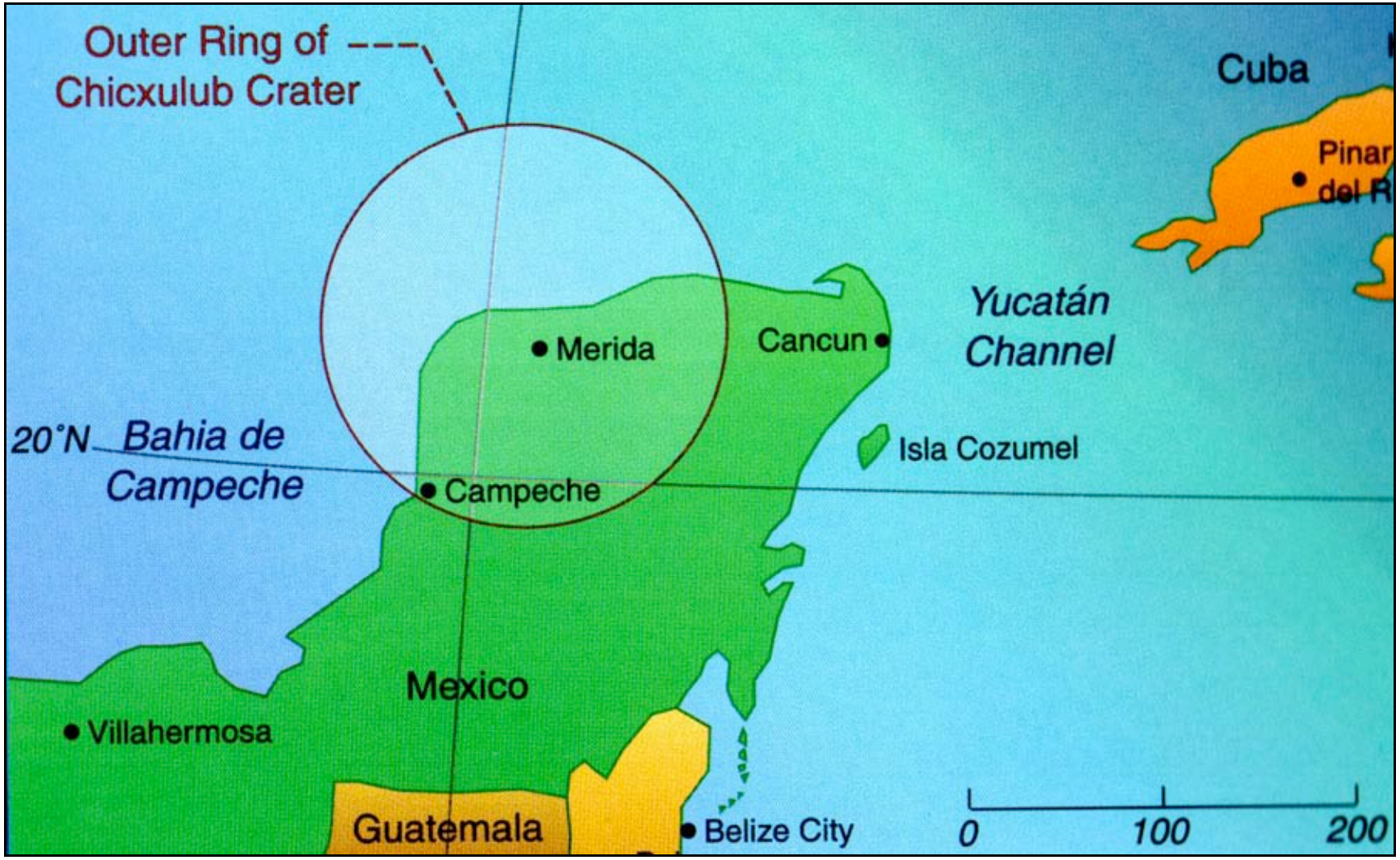


Ida, pictured above, is an Earth orbiting asteroid that may be similar to the asteroid that struck the Earth 65 million years ago. Ida is 36 miles long and 14 miles wide (58 x 23 kilometers).

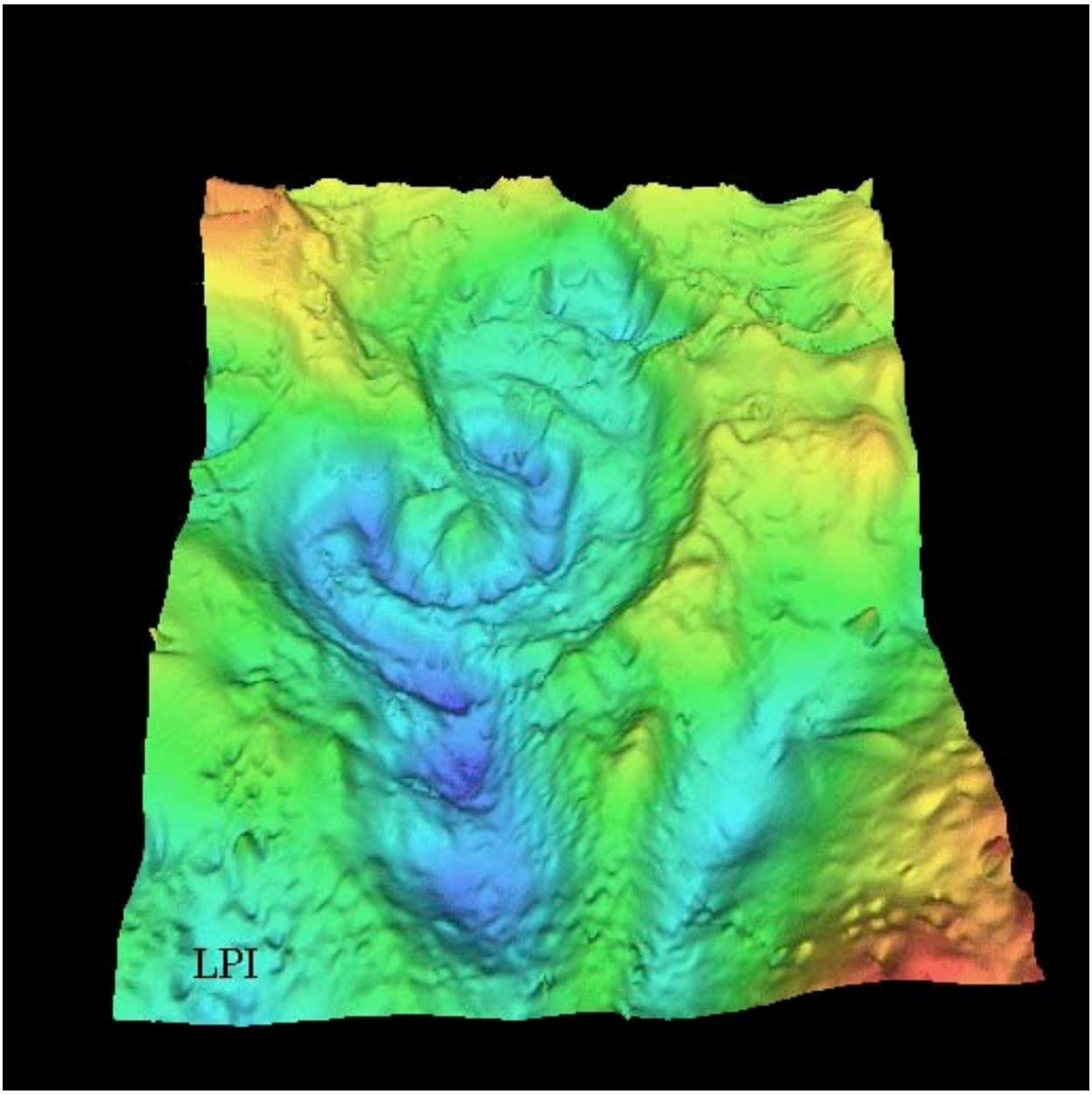
The Chicxulub Impact

(Painting by Don Davis courtesy of NASA)

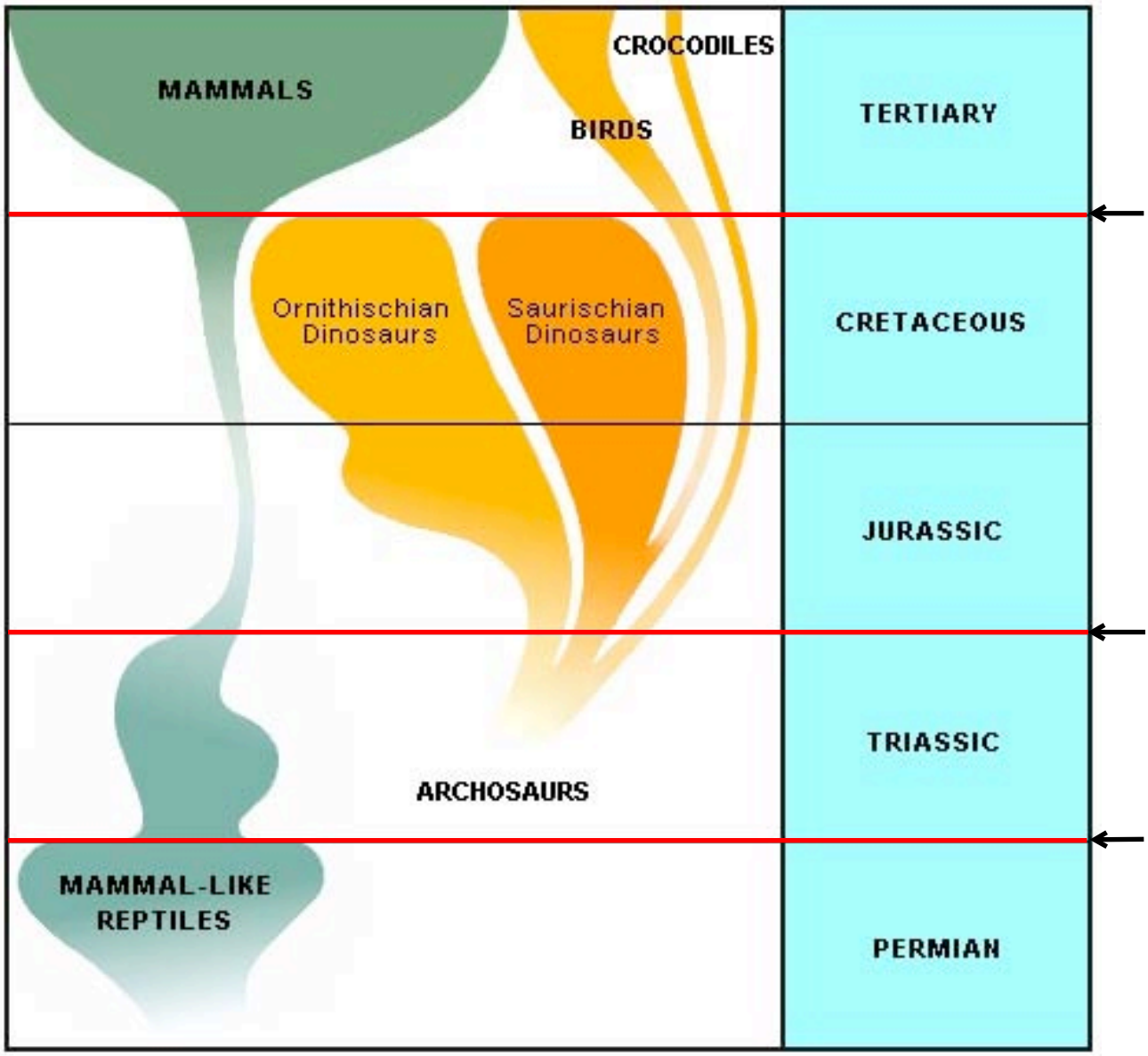
Diamonds mark the sites with evidence of tsunami.



Area Map of the Chicxulub Crater



Magnetic Map of the Chicxulub Crater



One of the true ironies in the history of life on Earth is the varying fortunes of the lineages that gave rise to mammals and birds. Starting in the early Permian, mammals and birds had a common ancestor in the stem reptiles. The stem reptiles then gave rise to the therapsids leading to the mammals, and archosaurs which included the thecodonts, ancestors of the dinosaurs. The dinosaur lineage includes the theropod dinosaurs which gave rise to birds. The irony is how each group fared through the end Permian, Triassic, and end Cretaceous mass extinction events.

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