

# PreCambrian SuperEon

(4.6 BYA – 541 MYA)

# Hadean Eon

(4.6 BYA - 4 BYA)

## Earth Forms

- Earth is formed from a mass of dust and gas that gravity pulled together.
- The process causes a huge amount of radioactive decay and Earth is a boiling ball of lava.
- At 4.5 BYA a protoplanet named Theia collides with Earth and a debris ring forms which later becomes our moon.
- Earth cools and forms the layers – core, mantle, and outer crust.
- Meteors bombard earth bringing frozen droplets of water that later become our oceans.
- Volcanic activity continues and Earth's earliest continental crust forms before 4.03 BYA.



The Acasta gneiss is one of the oldest rocks on Earth dating 4.03 billion years..

# PreCambrian SuperEon

(4.6 BYA – 541 MYA)

# Archaean Eon

(4 BYA – 2.5 BYA)

## Primitive, Simple Life Forms

- Earth's crust cools and plate tectonics forms.
- Ancient rock formations form from 4 to 2.5 BYA.
- The Primordial soup theory suggests early minerals and compounds from meteors made the perfect recipe for primitive, simple life to form at the thermal vents of the ocean.
- Single cell life formed the ocean and over time stromatolites, photosynthesizing colonial bacteria, formed in shallow water and released oxygen.
- The oxygen attached to trace iron in the oceans and formed sedimentary layers of banded iron formations (BIFS) that are presently mined for iron ore.



Banded iron formations from the late Archaean and early Proterozoic eons



Stromatolite fossil image



# PreCambrian SuperEon

(4.6 BYA – 541 MYA)

# Proterozoic Eon

(2.5 BYA – 541 MYA)

# Early life

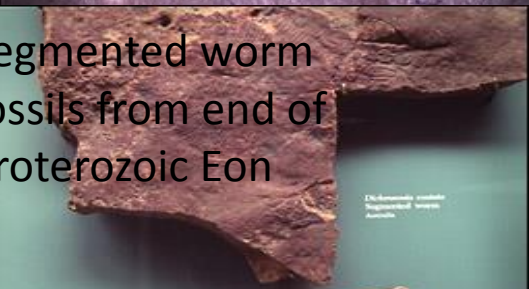
- Photosynthesizing life further establishes and releases oxygen throughout the ocean.
- The oxygen attaches to trace iron in the oceans and form sedimentary layers of banded iron formations (BIFS) that are mined for iron ore in modern time.
- Free oxygen is now released in atmosphere and organisms adapt to use it.
- Soft-bodied organisms like Jellyfish and segmented worms form. Life is soft-bodied or microbial at this time.
- The supercontinent Rodinia forms.
- Huge glaciation occurs and “snowball Earth” forms.
- Volcanic activity breaks through the glaciers and releases Carbon Dioxide that creates a layer that warms the earth and melts “snowball Earth”.



Sea Pen



Early eukaryotes



Segmented worm fossils from end of Proterozoic Eon



Jellyfish

**Phanerozoic Eon: Paleozoic Era**  
(541 MYA – 252.17 MYA)

**Cambrian Period**

(541 MYA – 485.4 MYA)

## Age of Invertebrates

- The Cambrian is known as the Cambrian Explosion, marking an explosion of life in short relatively amount of time.
- Invertebrate animals diversified and some with hard exoskeletons formed which were more likely to preserve in the fossil record.
- Along with invertebrates like mollusk, trilobites, jellyfish, sponges, echinoderms, and brachiopods, were the first primitive vertebrates - Pikaia.
- Rodinia broke up. Gondwana is now a continent.
- While the oceans are full of life, land would have looked like Mars with no living organisms.



Anomalocaridids – the top predator



Opabinia - a five-eyed organism



Pikaia – 1<sup>st</sup> animal with a backbone



Phanerozoic Eon: Paleozoic Era  
(541 MYA – 252.17 MYA)

# Ordovician Period

(485.4 MYA – 443.8 MYA)

## Age of Invertebrates

- The Ordovician period continues to diversify the seas including straight coned nautiloids, graptolites, conodonts, bryozoans, and trilobite diversification.
- The first land organisms appear – lichen and bryophytes.
- This period ends with the first mass extinction event – an ice age – that eliminates 85% of life in the seas.
- 15% of sea life survives onward through geologic time.



**Phanerozoic Eon: Paleozoic Era**  
(541 MYA – 252.17 MYA)

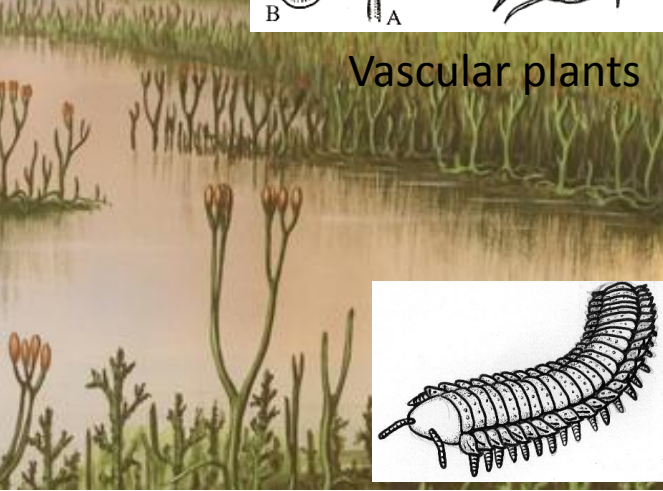
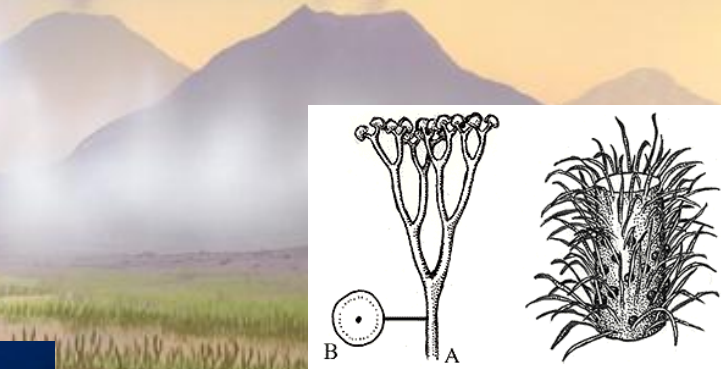
**Silurian Period**

(443.8 MYA – 419.2 MYA)



# Age of Fish

- The Silurian period continues to see corals, brachiopods, bryzoans, and graptolites in the seas along with the new addition of jawless fish, the top predator sea scorpions and large coral reef systems.
- This period is famous for the invasion of life to land. Vascular plants and animals begin transition on to land.
- Tough arthropods, millipede like animals, adapt to a predator-free, dry habitat with ultra-violet rays.



sea scorpions

Crinoid

Vascular plants



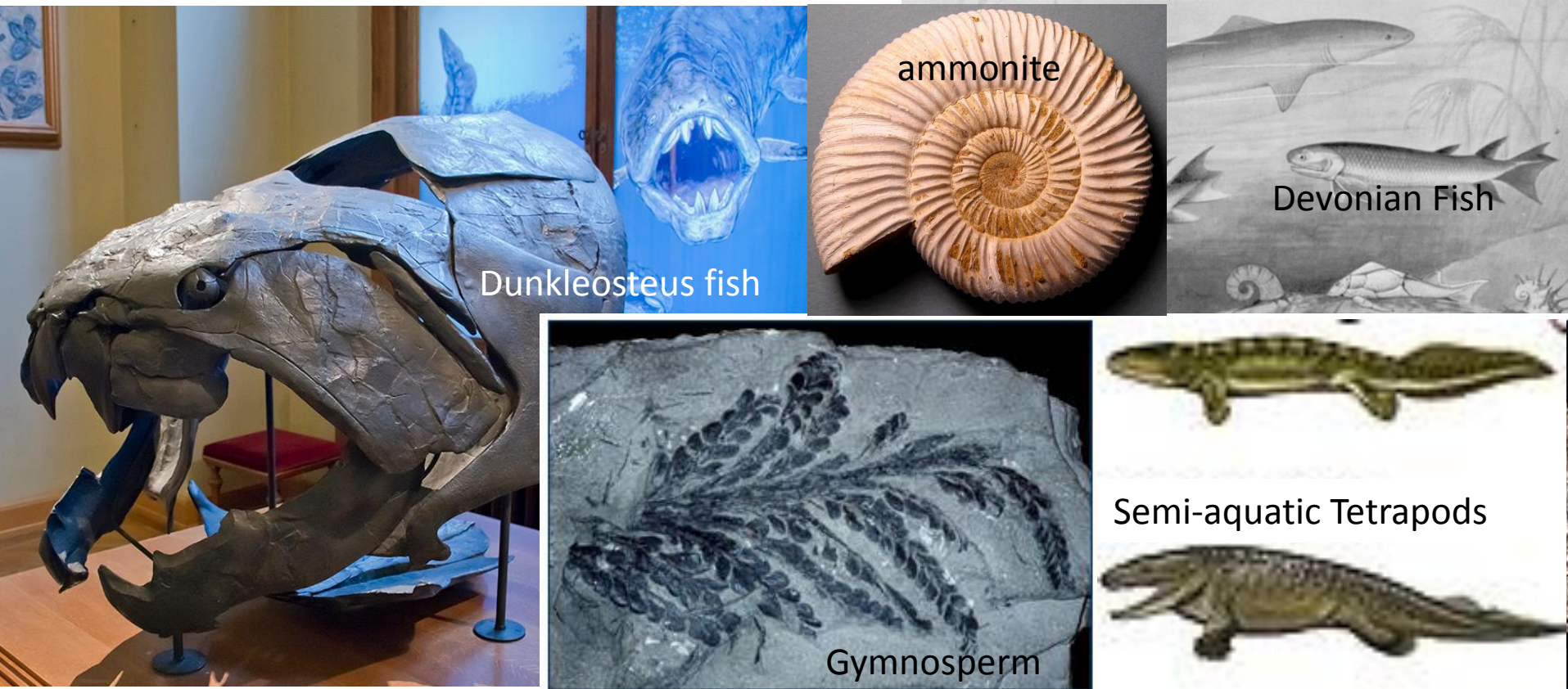
**Phanerozoic Eon: Paleozoic Era**  
(541 MYA – 252.17 MYA)

**Devonian Period**

(419.2 MYA – 358.9 MYA)

## Age of Fish

- The Devonian period shows us our first jawed fish and the top marine predator is the giant Dunkleosteus fish.
- We also see the first fossilized sharks teeth and ammonites appear in the seas.
- The most extensive coral reef in history are built during the Devonian period.
- Land invertebrates diversity and our first land vertebrates appear.
- Semi-Aquatic Tetrapods – vertebrates with four feet appear around 360 MYA.
- Gymnosperms, seed bearing plants 1st appeared.
- The Devonian experiences the Earth's 2nd Mass Extinction event that heavily effected shallow seas were 70% of invertebrates vanish.



**Phanerozoic Eon: Paleozoic Era**  
(541 MYA – 252.17 MYA)

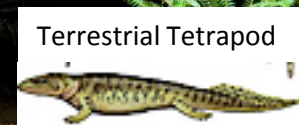
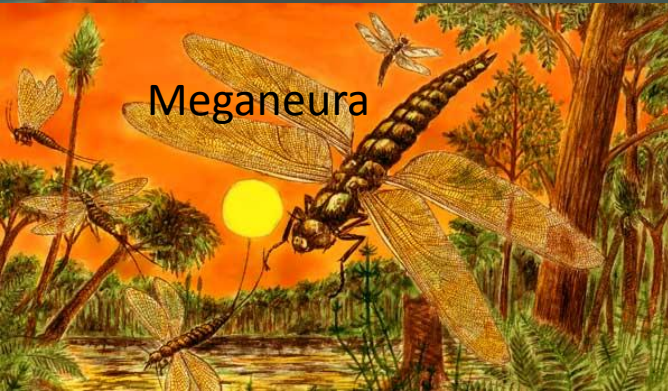
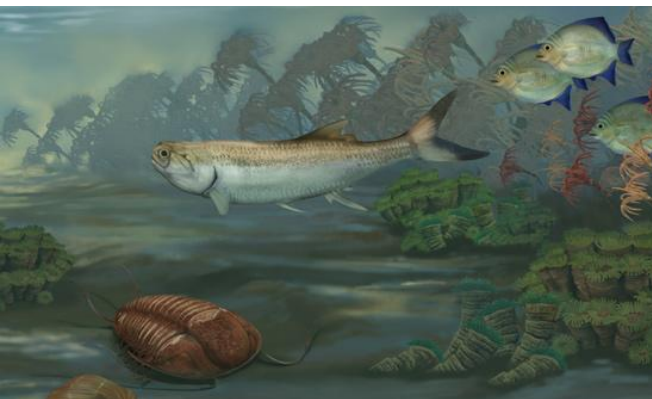
**Carboniferous Period**

(358.9 MYA – 298.9 MYA)



# Age of Amphibians

- The Carboniferous period is sometimes subdivided into the Mississippian and Pennsylvanian periods.
- In the seas sharks were common along with bony fish.
- The first terrestrial tetrapods adapt to life out of the water, but still depend on the water to deposit their porous eggs.
- At the end of this period the first reptiles evolve laying eggs out of the water.
- Seed-bearing plants dominate drier environments creating huge Coal Forests.
- Insects diversify in a big way and giant dragonflies and giant spiders develop.
- Oxygen levels were high at about 20%. Huge swamps and forests create the coal mined and used as energy in modern day.





**Phanerozoic Eon: Paleozoic Era**  
(541 MYA – 252.17 MYA)

# Permian Period

(298.9 MYA - 252.17 MYA)

## Age of Amphibians

- The Permian period furthered the development of reptiles on land and mollusk in the seas.
- Land vertebrates – amphibians, tetrapods, and mammal-like reptiles continue to diversify.
- Seed plants like conifers dominate the land and we see our first vertebrate herbivores.
- The Permian period is famous for its ending the Permian extinction event also known as the Great Dying. 96% of species died out (including trilobites) and the 4% lead way to all the animals that we know today. The extinction was most likely caused by extensive volcanic eruptions and flood basalts in Siberia.



Many groups that appeared in the Carboniferous would give rise to groups that dominated the Permian and Mesozoic. On the left is *Amphibiamus lyelli*, an early temnospondyl. These amphibian-like early tetrapods grew to the size of crocodiles in the Permian and Triassic. On the right, *Lebachia*, an early relative of the conifers.

**Phanerozoic Eon: Mesozoic Era**  
(252.17 MYA – 66 MYA)

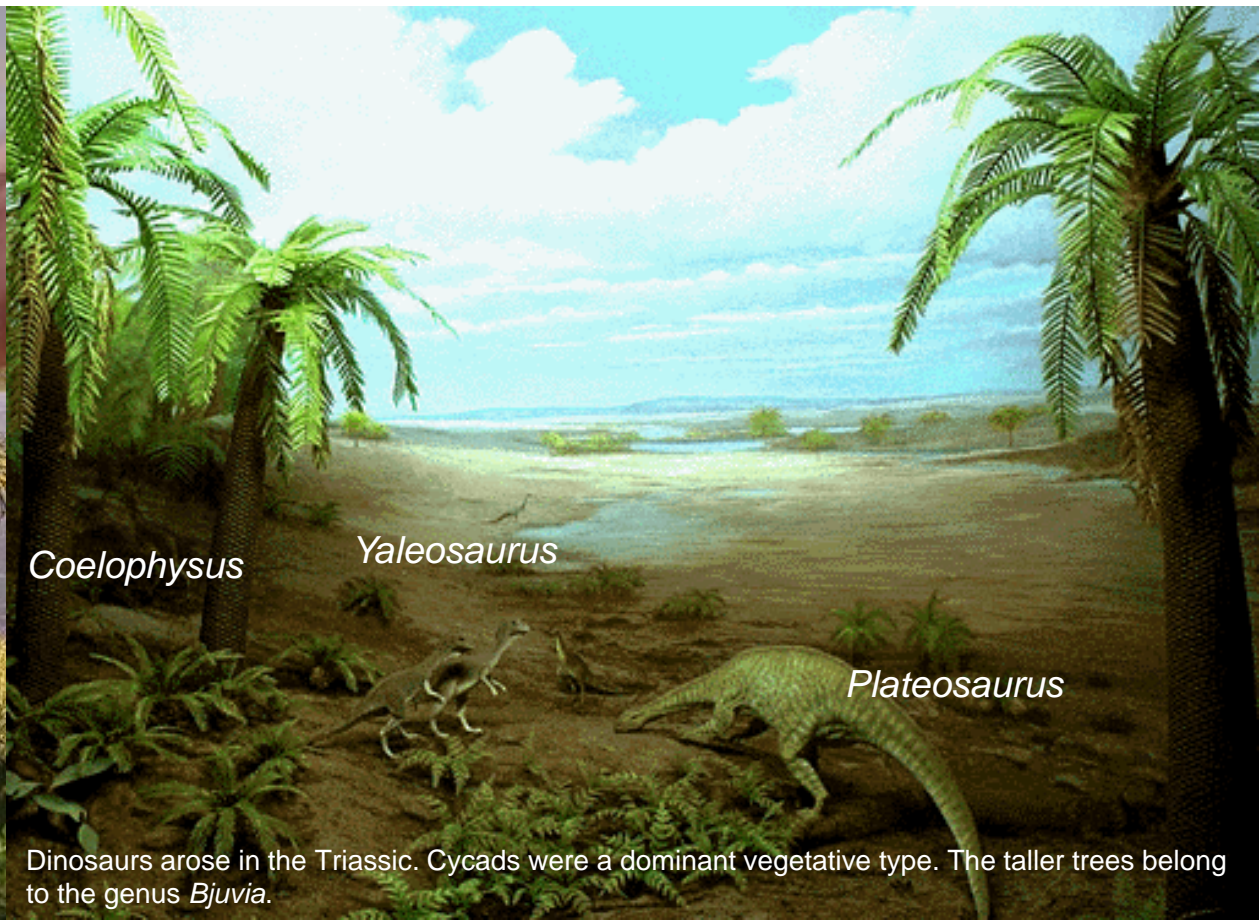
# Triassic Period

(252.17 MYA – 201.3 MYA)



## Age of Reptiles/Age of the Dinosaurs

- From a devastated Earth of the Permian Extinction, life recovered.
- The Triassic period is the start of development of the dinosaurs.
- It also brings the 1st mammal-like animals, flying reptiles, primitive crocodiles, turtles, and frogs.
- Pangea forms and breaks up in the Triassic as well.
- The Triassic-Jurassic extinction event occurs and killed about 50% of species. Each extinction event brought opportunity for the surviving species to exploit available resources.



Dinosaurs arose in the Triassic. Cycads were a dominant vegetative type. The taller trees belong to the genus *Bjuvia*.



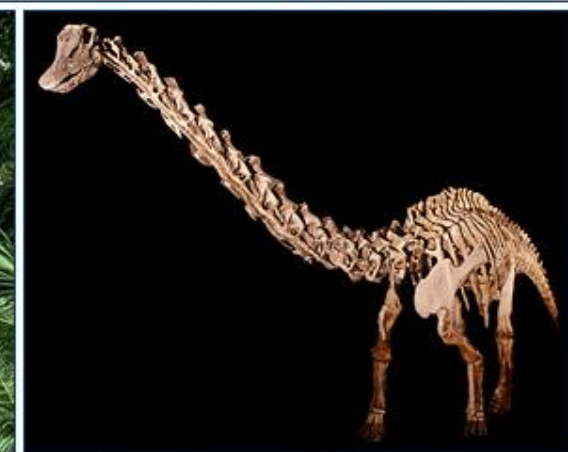
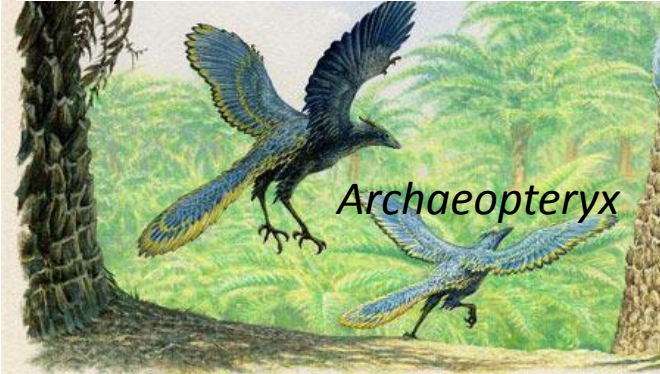
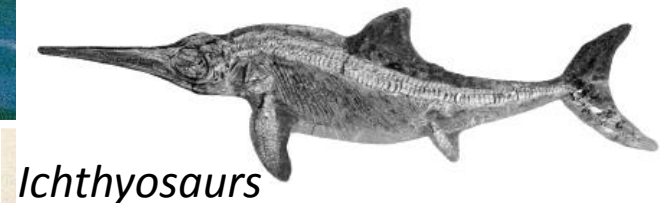
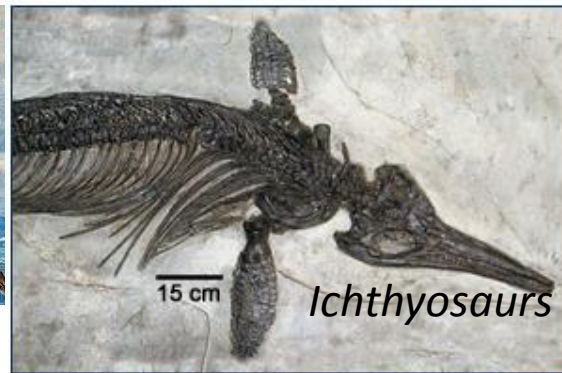
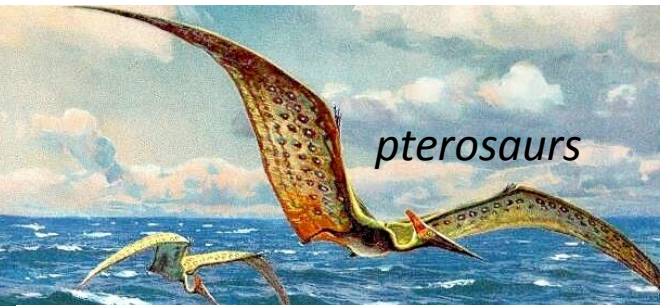
**Phanerozoic Eon: Mesozoic Era**  
(252.17 MYA – 66 MYA)

# **Jurassic Period**

(201.3 MYA – 145 MYA)

## Age of Reptiles/Age of the Dinosaurs

- The Jurassic period has most major kinds of dinosaurs.
- Huge herbivores dominate the land. Brachiosaurus, Apatosaurus, and Diplodocus could reach lengths of 120 feet.
- The skies were still dominated by *pterosaurs*, flying reptiles, big and small.
- The 1st feathered bird form – *Archaeopteryx*.
- The 1<sup>st</sup> teleost fish with modified jaw adaptations are the most diverse vertebrates on the planet in the Jurassic.
- Ammonites and belemnites shared the sea with sharks and marine reptiles, *Ichthyosaurs*.



Clockwise from top left, *Ichthyosaurus intermedius*, a Lower Jurassic ichthyosaur from Glastonbury, England. *Karaurus sharovi*, one of the earliest known salamanders, from Kazakhstan. *Diplodocus*, a large, long-necked sauropod. Modern cycads.

Phanerozoic Eon: Mesozoic Era  
(252.17 MYA – 66 MYA)

# Cretaceous Period

(145 MYA - 66 MYA)



# End of the Dinosaurs

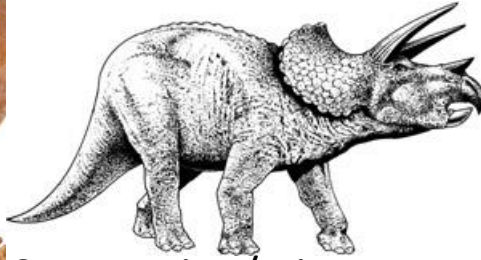
- The Cretaceous period is most famous for the ending, the K-T extinction event, the end of the dinosaurs, ammonites, and the pterosaurs (flying reptiles).
- Before this extinction dinosaurs dominated the land, the 1st flowering plants (angiosperms) evolved, and mammals developed more strongly.
- The K-T extinction event was most likely caused by a large asteroid that hit Earth at the Yucatan peninsula. This extinction of dinosaurs gave way to the opportunity to others species and the rise of the mammals on Earth.



angiosperms



Ceratopsian/Triceratops



Tyrannosaurus rex



Sturgeon



mosasaur attacking plesiosaur

# Phanerozoic Eon: Cenozoic Era (66 MYA – present)

## Paleogene Period

(66 MYA – 23.03 MYA)

Oligocene Epoch (33.9-23.03 MYA)

Eocene Epoch (56 - 33.9 MYA)

Paleocene (66 - 56 MYA)

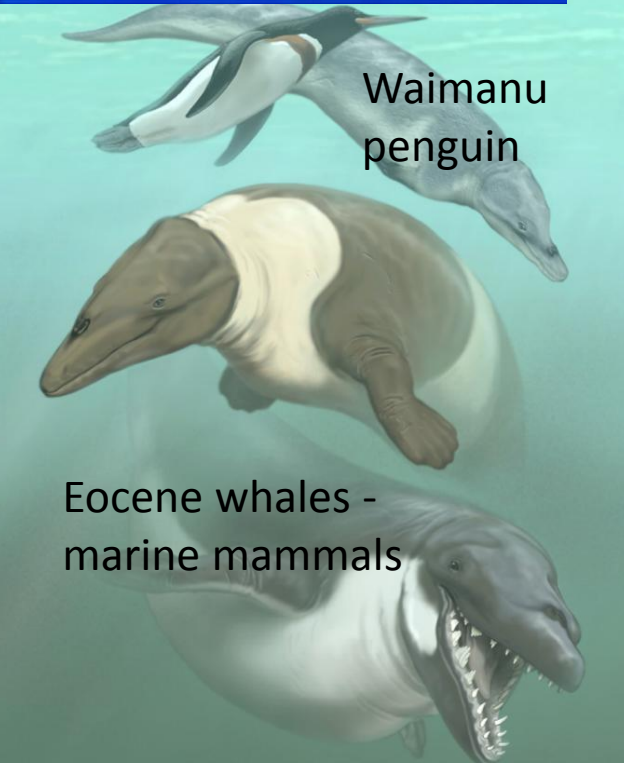


# Age of the Mammals

- The Paleogene Period is further divided into the Paleocene, Eocene, and Oligocene Epochs.
- This time period is known for the further development mammals and birds.
- Land mammals diversify as rodents, hooved animals, carnivores, primates, and more.
- Sharks diversify and this is the time of the Megalodon sharks.
- Whales and other marine mammals 1st appear.



Dorudons



Waimanu penguin

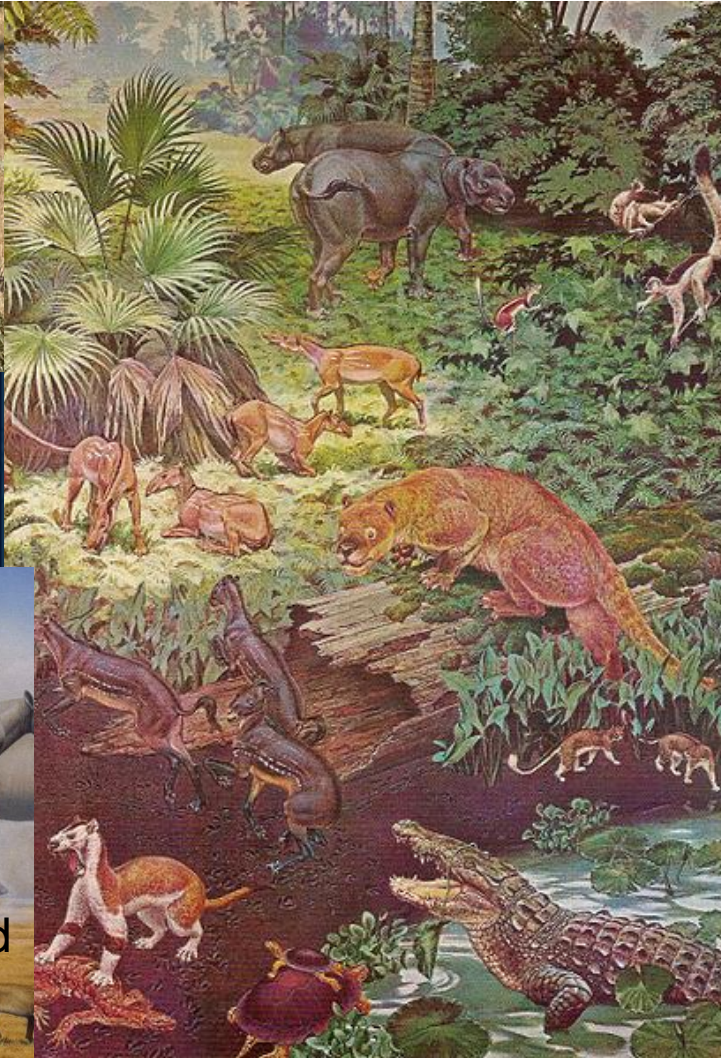
Eocene whales - marine mammals



Hyaenodon



Paraceratherium herd





# Phanerozoic Eon: Cenozoic Era (66 MYA – present)

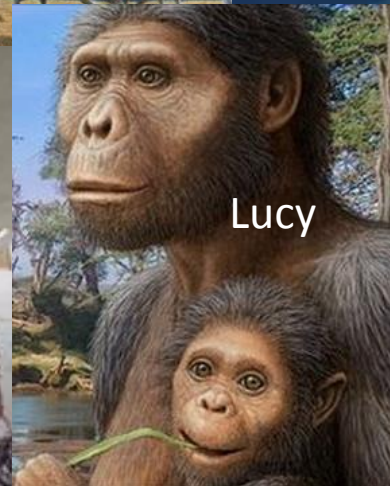
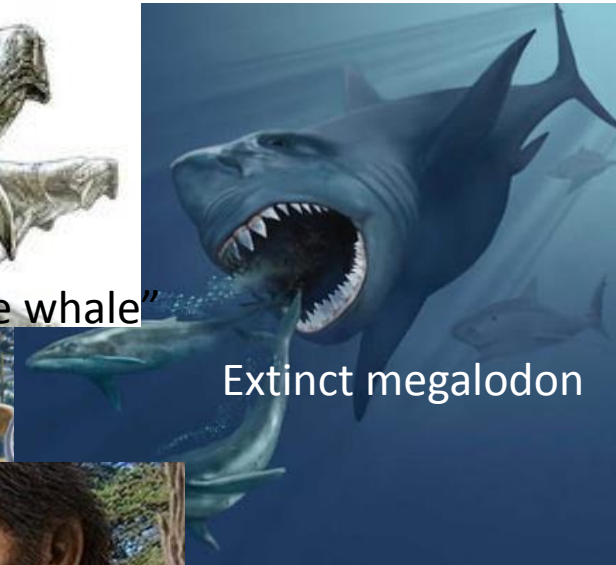
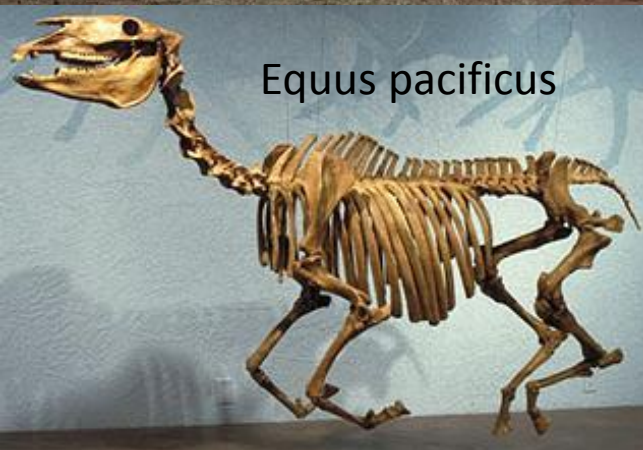
## Neogene Period (23.03 MYA – 2.58 MYA)

Pliocene Epoch (5.333-2.58 MYA)

Miocene Epoch (23.03-5.333 MYA)

# Age of the Mammals

- The Neogene period is broken down into the Miocene and Pliocene Epochs.
- This is the time of further diversification of animals on land and sea.
- Horses, Antelope, rhinoceros, camels and gomphotheres (elephant-like animals) roam land.
- The first apes appear and evidence of hominoid ancestors - the Lucy fossils and human-like foot prints in Africa.
- The most famous shark Carcharodon megalodon was the great predator of the seas.



Phanerozoic Eon: Cenozoic Era  
(66 MYA – present)

Quaternary Period  
(2.58 MYA – present)

Holocene Epoch (11,700 YA-present)

Pleistocene Epoch (2.58 MYA-11,700 YA)

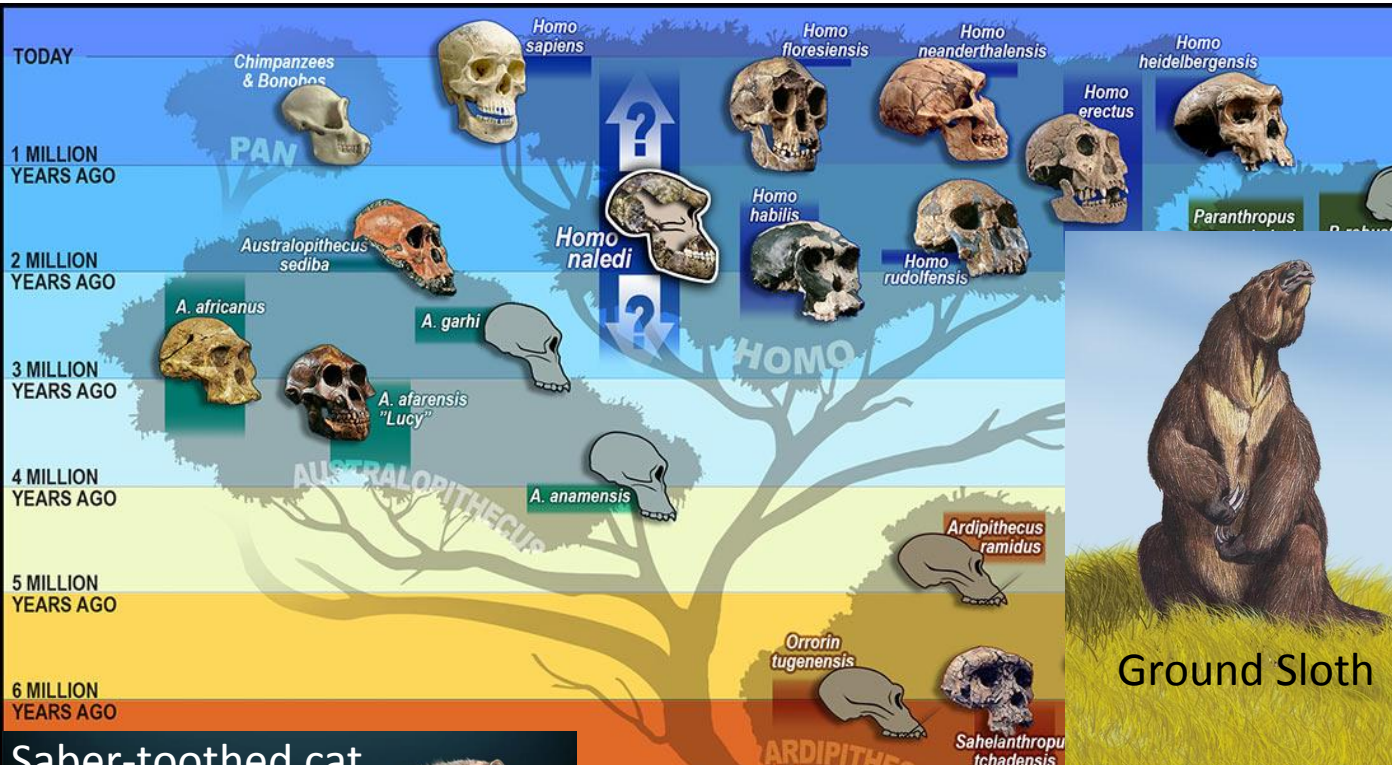
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# Age of Mammals

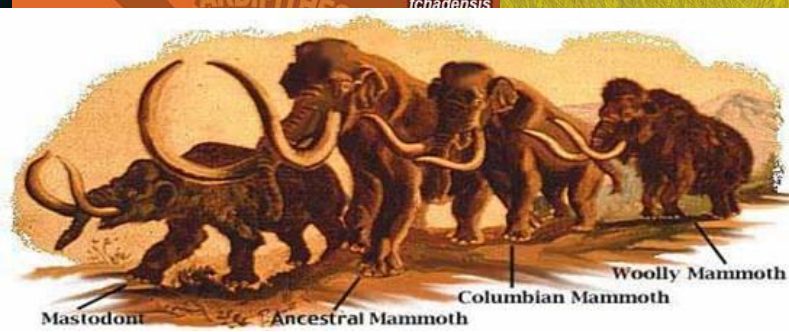
- The Quaternary period is our present day period and breaks down into the Pleistocene and Holocene epochs.
- The Pleistocene is the known as the Great Ice Age and is the age that Homo sapiens our own species evolved.
- The Holocene is known as the Age of Man and is the world we live in today.



Ground Sloth



Saber-toothed cat



Glyptodon