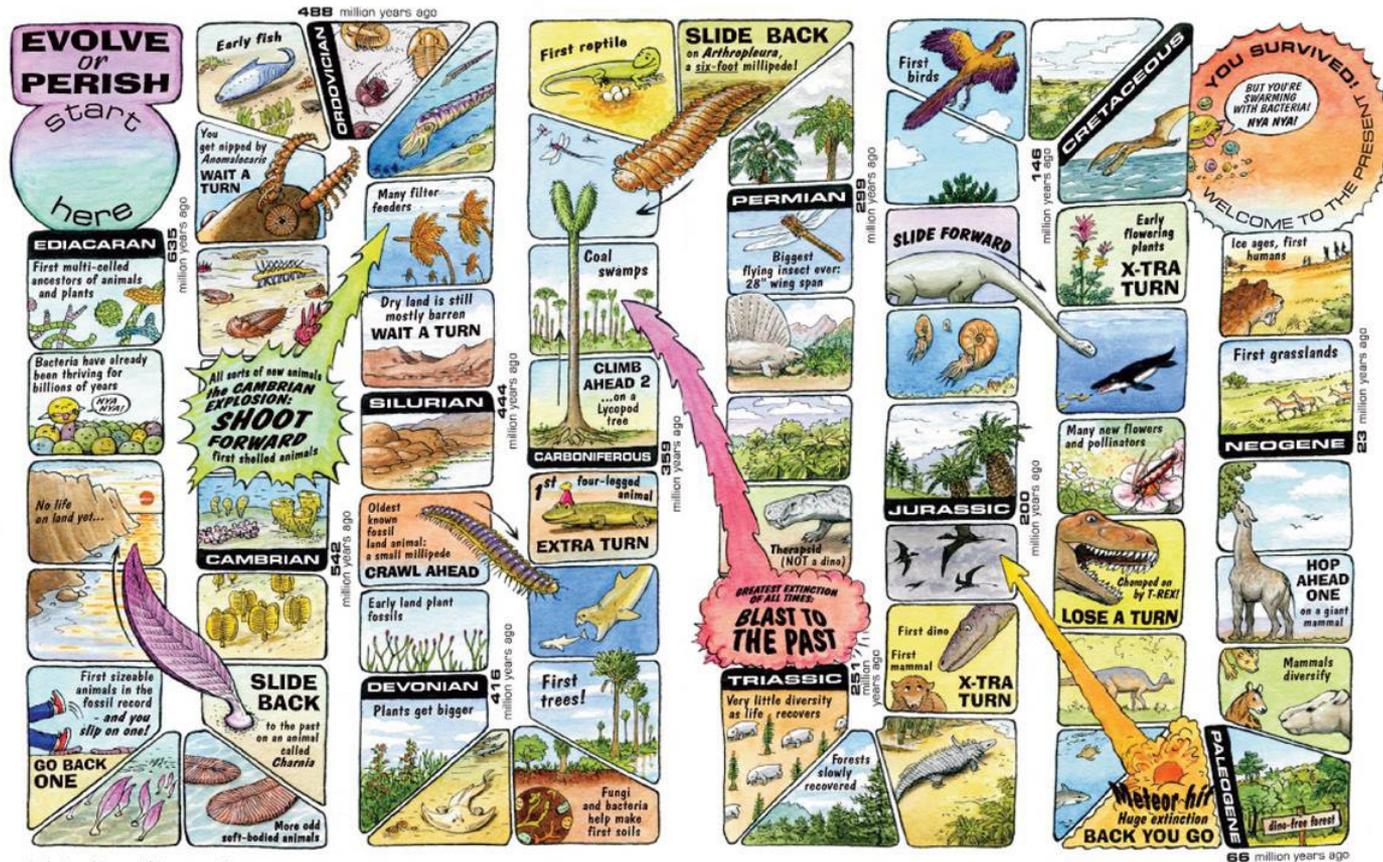


Guide to Evolve or Perish

ETE's game of life through the ages



Evolution of Terrestrial Ecosystems Program
 Department of Paleobiology, National Museum of Natural History, Smithsonian Institution

created by Hannah Bonner, Cindy Looy, Iva Duljinske and other members
 of the ETE program of the National Museum of Natural History, Smithsonian Institution

This guide explains images created by Hannah Bonner for the Evolution of Terrestrial Ecosystems Program Game, *Evolve or Perish*, with information gathered by Erin Embrey (2012 NMNH Intern) under the supervision of Abby Telfer, NMNH FossilLab Manager.

Download game at <https://naturalhistory.si.edu/education/teaching-resources/paleontology/evolve-or-perish-board-game>

Some help with abbreviations and names...

- mya = millions of years ago
- *Meganeuropsis permiana* - This is an example of a scientific name of a plant or animal, in this case the giant fossil dragonfly. The first name is the *Genus*, the second is the *species*. The proper way to write these names is in italics, so it is clear they are the official Latin names.
- To learn how to pronounce the names, we encourage you to look them up on-line!

Names of Geological Time Intervals used in Evolve or Perish (oldest to youngest):

Proterozoic: Ediacaran

Paleozoic:

Cambrian

Ordovician

Silurian

Devonian

Carboniferous

(includes Pennsylvanian)

Permian

Mesozoic

Triassic

Jurassic

Cretaceous

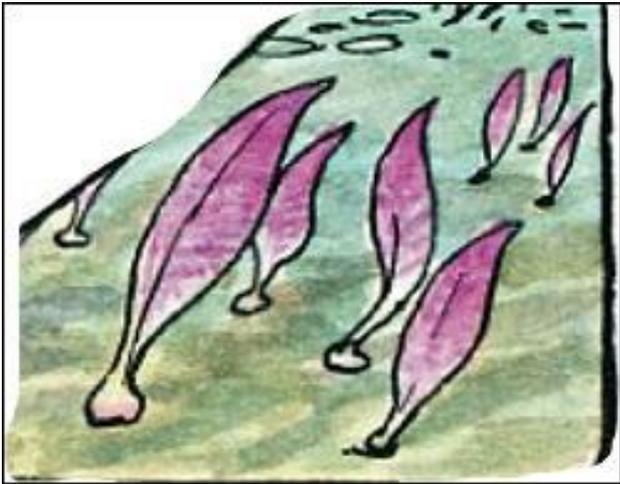
Cenozoic

Paleogene

Neogene

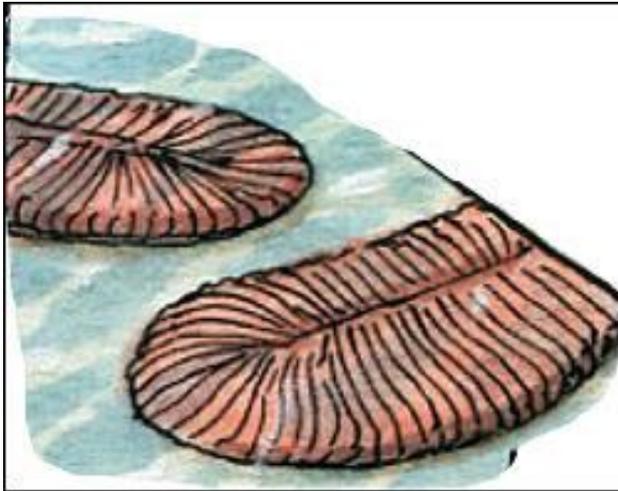
Note: The animals and plants depicted in Evolve or Perish are based on actual fossils and information gathered by many generations of paleontologists who have studied them. The artist, Hannah Bonner, remained true to the science but imagined colors and other features for which there is no fossil record.

Ediacaran



Charnia (635-542 mya): A benthic animal (living at the bottom of a body of water) that was widespread during the Ediacaran. It is sometimes mistaken for a plant because of its shape. It was an osmotroph, meaning that it fed by absorbing nutrients from surrounding water.

Ediacaran



Dickinsonia (635-542 mya):
This slow-moving benthic animal with a segmented body and a median line along the body axes lived its entire life on the sea floor. Individuals were 4 mm to 1.4 m (0.16 to 55 in) long.

Ediacaran



Swartpuntia (635-542 mya):
This marine osmotroph was benthic and sessile (did not move). It ranged from 120-190 mm (4.7-7.5 in) long and from 11.5 mm to 1.4 m (4.5 to 55 in) wide.

Cambrian



Archaeocyathan sponges:
These animals were some of the planet's first major reef-builders. The name means "cup-shaped." They lived in warm, shallow tropical and subtropical waters.

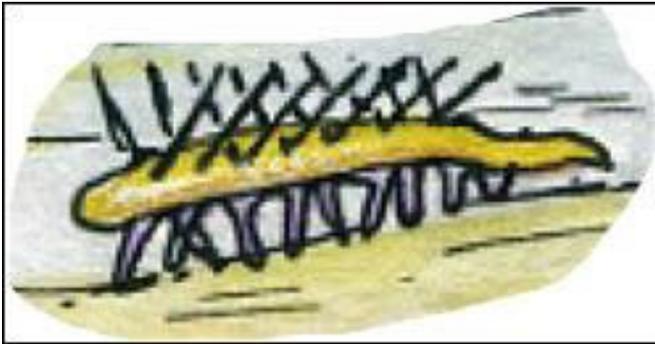
Cambrian



Olenoides was an active predator that had complex eyes and good vision.

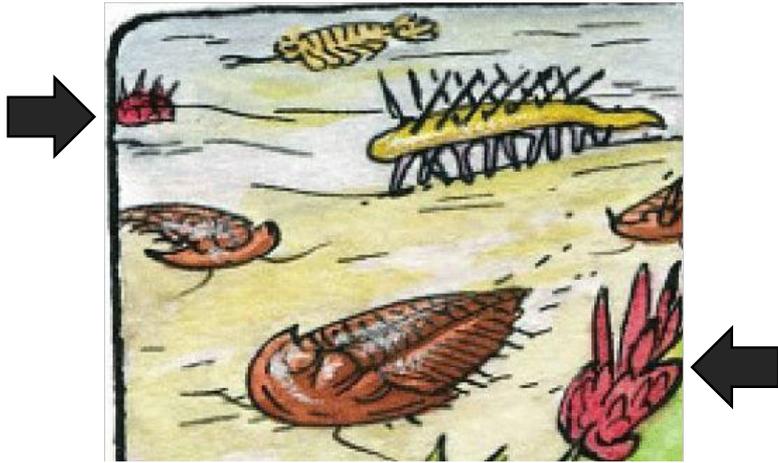
An early trilobite (examples include *Paradoxites* and *Olenoides*): This abundant group of marine animals lasted for ~275 million years before they went extinct at the end of the Permian.

Cambrian



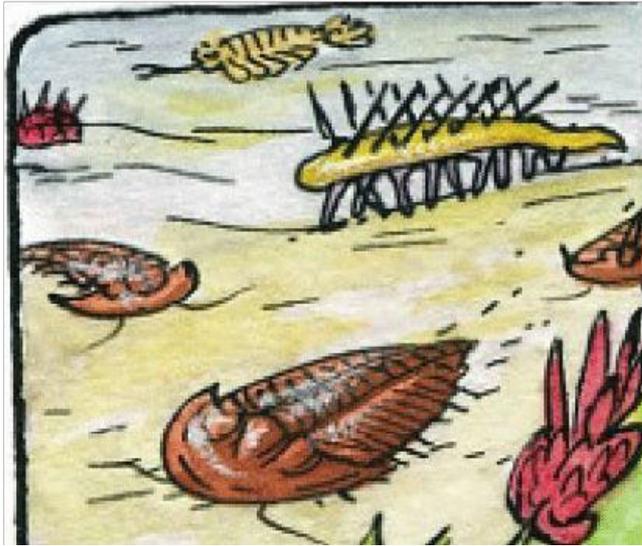
Hallucigenia (520-505 mya): This animal ranged in size from 5-30 mm (0.2 to 1.2 in) long. It had limited vision and moved around as it grazed for its food. It is named *Hallucigenia* because it is so bizarre. Recent studies suggest it is related to velvet worms and water bears.

Cambrian



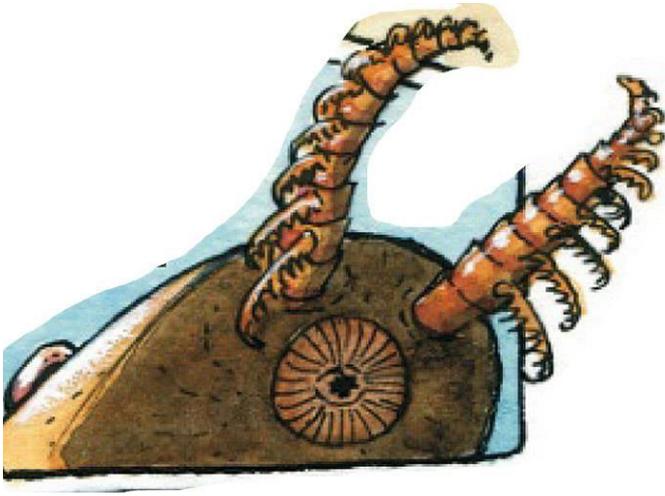
Wiwaxia (530-505 mya): This animal had no obvious head or tail, and it had protective armor on the top of its body. It ranged in length from 3.3 to 50.8 mm (0.13 inches to 2 inches). Although apparently blind, *Wiwaxia* was an active grazer of algae that grew on the sea floor.

Cambrian



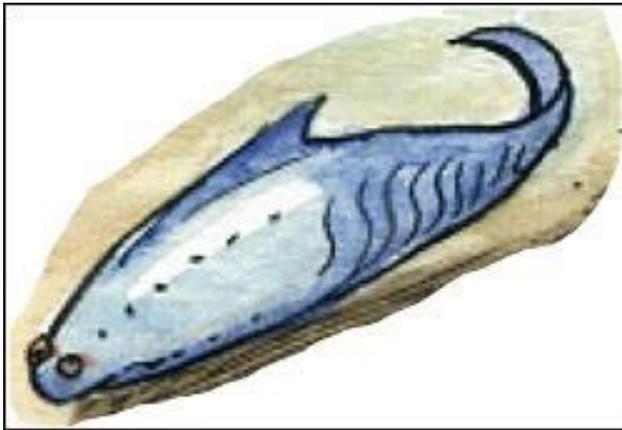
Opabinia (in the background):
This animal lived on the sea floor and was a bottom feeder with five eyes and a fan-like tail.

Cambrian



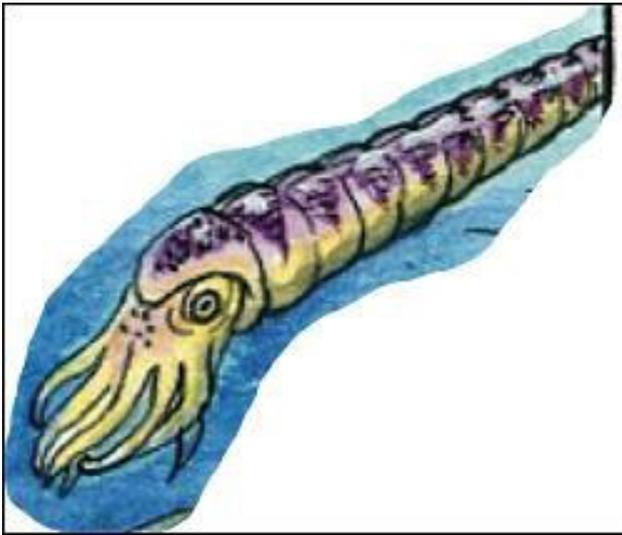
Anomalocaris (530-498 mya): a strange relative of the arthropods (the group that includes crabs and insects). The size of this carnivore remains uncertain, but it could have been up to 2 meters long (about 6.5 ft)! It had strong grasping claws, a circular mouth, and excellent eyesight that helped it search for food.

Cambrian



Haikouichthys (520-516 mya):
A very tiny fish 25 mm (0.9 in)
long that had no jaws or fins.
This animal was among the
first craniates (animals with
both a head and a notochord).

Ordovician



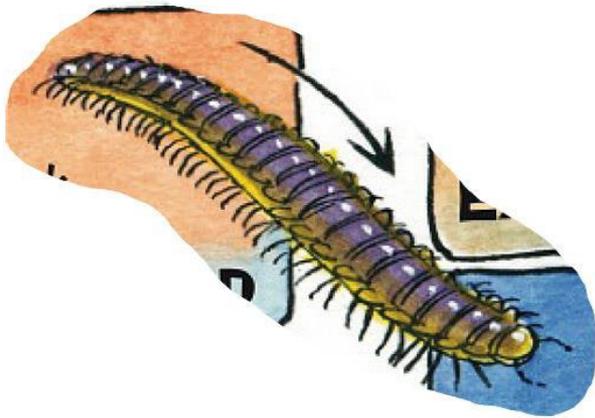
Cameroceras (448.3-443.7 mya): this animal was an orthocone nautiloid, a shelled relative of squid. This animal lived in deep water and was one of the largest organisms at its time; it grew up to 6 m (~ 20 ft).

Ordovician



Dictenocrinus (418-391 mya): This animal is a crinoid (a filter-feeding relative of starfish). It was a blind suspension feeder and completely stationary, attaching itself to the sea floor with a root-like “holdfast.” The “stalk” or stem that held its feathery feeding structures up in the water was only 30 mm (1.2 in) long.

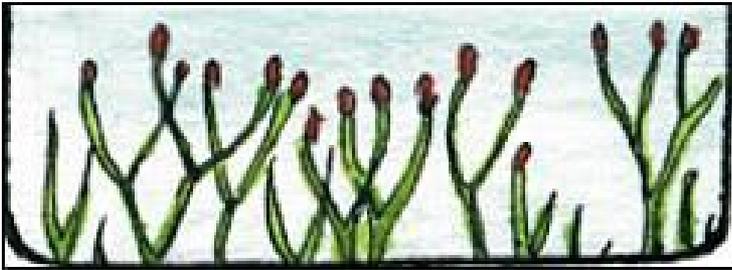
Silurian



Pneumodesmus: This millipede lived during the Late Silurian* and is the first known animal to have breathed oxygen and lived on land. Only one fossil has been found, meaning that it was either very rare in life or very difficult to fossilize.

*or possibly Early Devonian

Silurian



Early land plants like this *Aglaophyton* were tiny and branched but did not have either leaves or roots. They relied on fungi to help them take in nutrients from the soil, like modern plants.

Silurian



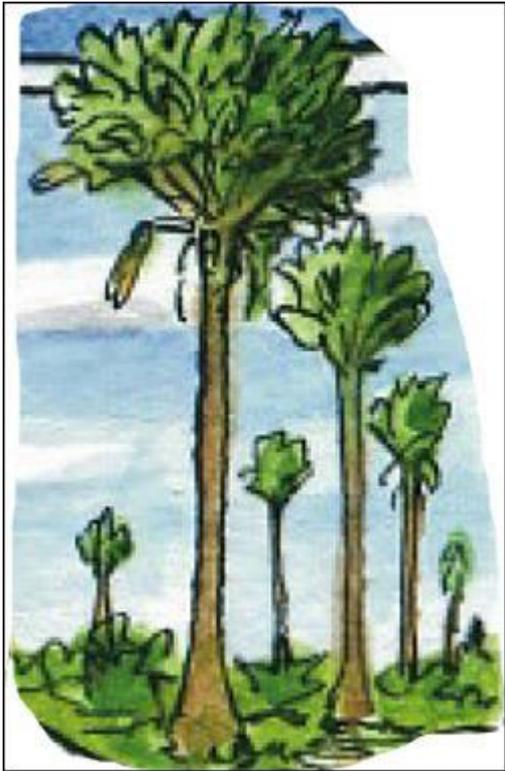
Pertica (418-388 mya): a spore plant, a kind of plant that reproduces using single-celled spores rather than seeds and flowers. This upright plant could grow up to 1m (3.28 ft) tall.

Devonian



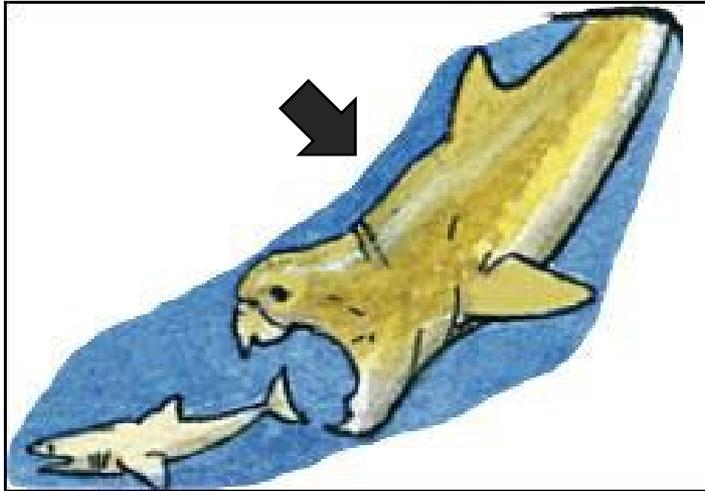
Cephalaspis: a jawless fish with a protective shield made of bony plates. Many fish at this time had protection from predators, which became more diverse and dangerous in the Devonian.

Devonian



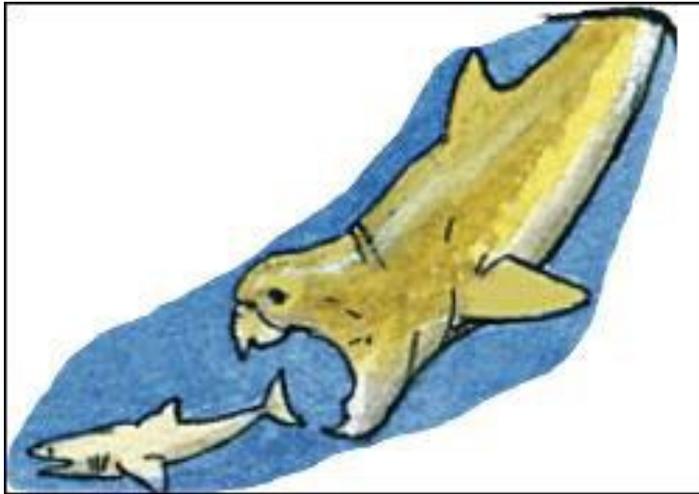
Watzia/Eospermatopteris:
These unusual trees were among the world's first. They were distantly related to modern plants and grew rather like palms, but with bundles of branchlets forming the crown instead of true leaves.

Devonian



Dunkleosteus: a carnivorous placoderm (an extinct kind of fish) that consumed its prey using two bony jaw plates instead of teeth. The plates, combined with its heavily armored body up to 10 m (33 ft) long, would have made it a fearsome predator.

Devonian



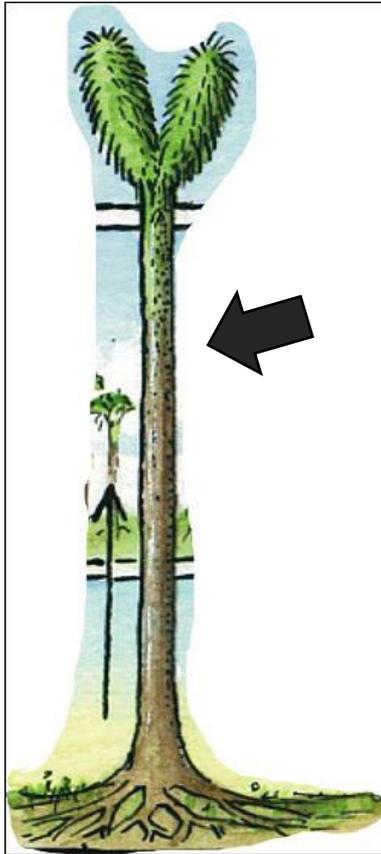
Cladoselache (377-361 mya):
An early shark living in North American waters, *Cladoselache* was an active carnivore. It was about a third the size of a Great white shark, growing only up to 1.8 m (~6 ft) long.

Devonian



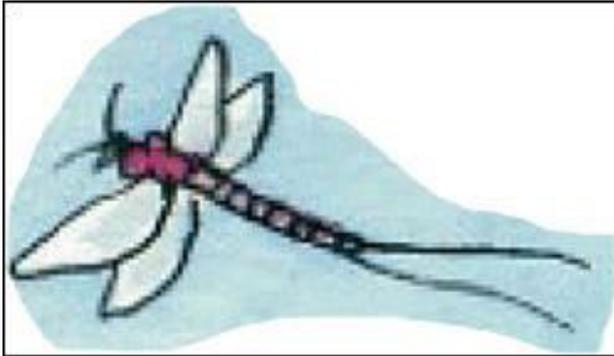
Ichthyostega (365 mya) was among the first vertebrates to have four functional limbs that enabled it to walk on land. It had lungs as well as gills, enabling it to breath in or out of the water, and was about 1.5 m (4.9 ft) long.

Carboniferous



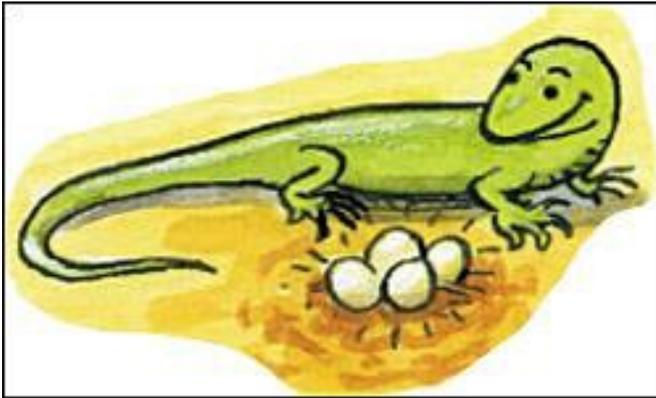
Sigillaria (388-255 mya): An unusual tree that lived in tropical swamps during the Late Carboniferous. As the leaves on the trunk and branches got old, they fell off, leaving behind a scale-like pattern of old leaf-bases.

Carboniferous



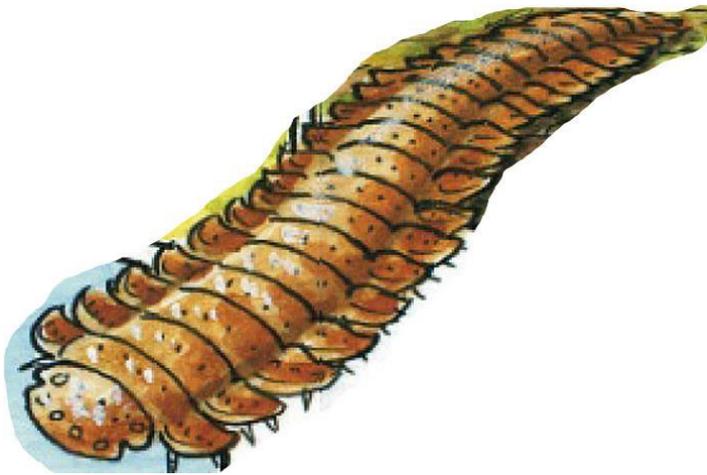
Palaeodictyoptera (318-255 mya): This group of extinct insects included some very large species, up to 30 mm (1.2 in) long with a wingspan of 180 mm (7 in).

Carboniferous



Hylonomus (318-311 mya): one of the earliest known reptiles. Reptiles were the first animals that could lay their eggs on dry land. All earlier tetrapods were amphibians that returned to water to lay their eggs. It was similar to a modern lizard and up to 0.2 m (7.9 in) long.

Carboniferous



Arthropleura: a giant millipede 0.3-2.3 m (1 ft to 8.5 ft!) long, this millipede is the largest known land invertebrate (an animal that does not have a backbone). It lived on the forest floor and mainly ate decaying vegetation.

Pennsylvanian



During the Late Carboniferous (Pennsylvanian Period), seed plants with fern-like leaves like this Medullosan inhabited tropical rainforests.

Pennsylvanian



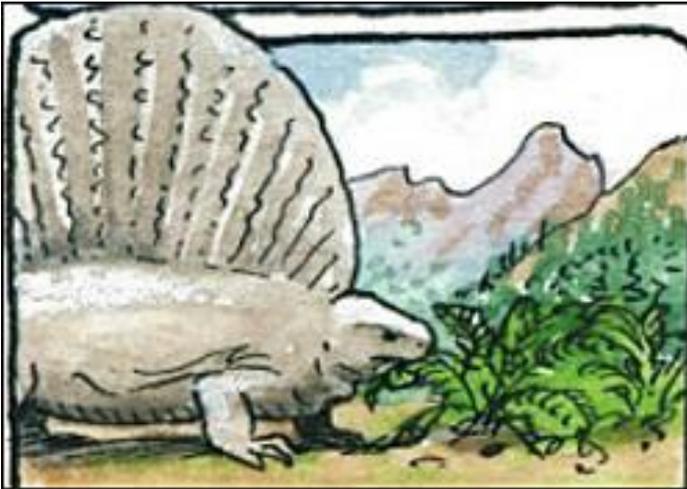
Tree ferns like this *Psaronius* became common in many tropical forests during the Late Pennsylvanian, replacing the earlier lycopsids (relatives of modern club mosses).

Permian



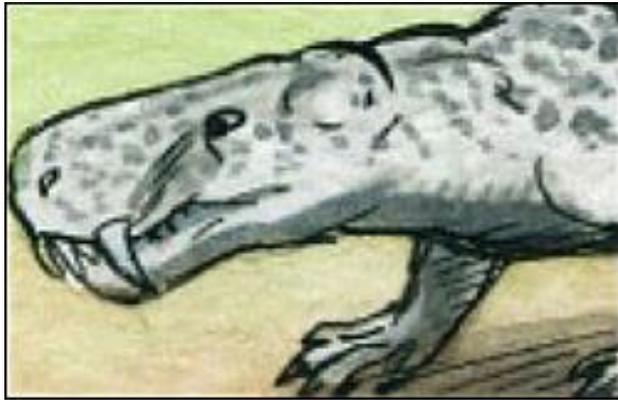
Meganeuropsis permiana
(284-280 mya): a giant dragonfly with a wingspan of 0.7 m (28 inches) and a length of up to 0.43 m (17 inches). It was the largest flying insect that has ever lived.

Permian



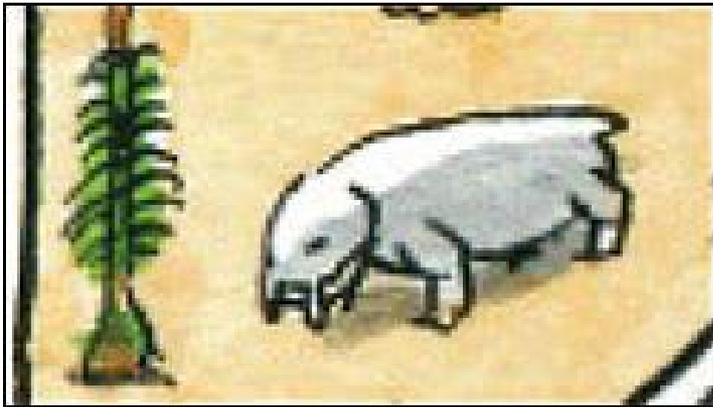
Edaphosaurus (305-273 mya): pelycosaurs like these were synapsids, the group that later gave rise to mammals. This herbivore had a "sail" on its back, like the later *Dimetrodon*. The sail may have been used to regulate its body temperature.

Permian



Arctognathus: a predatory synapsid - a group that later gave rise to mammals. It was 1.1m (3.6 ft) long. Its name means “bear jaw.”

Triassic



Pleuromeia (252-202 mya):
This unbranched tree with linear leaves was a lycopod like *Sigillaria*. It was common after the Permian-Triassic extinction and throughout the Triassic.

Triassic



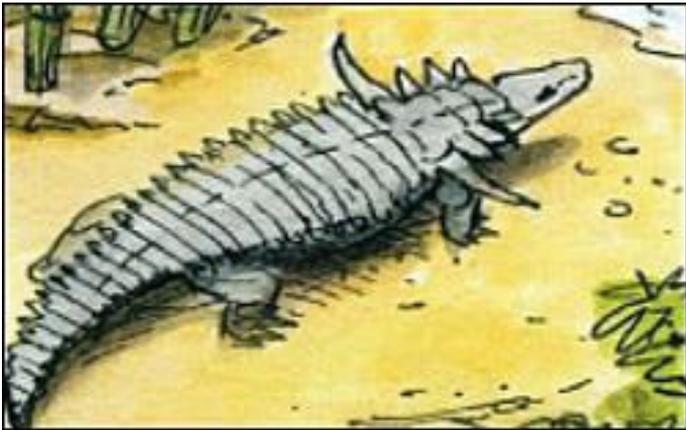
Lystrosaurus (255-247 mya):
An unusual looking synapsid that was common to Africa. Although it had two tusk-like teeth, this herbivore used its beak when eating plants. The tusks may have helped in self defense.

Triassic



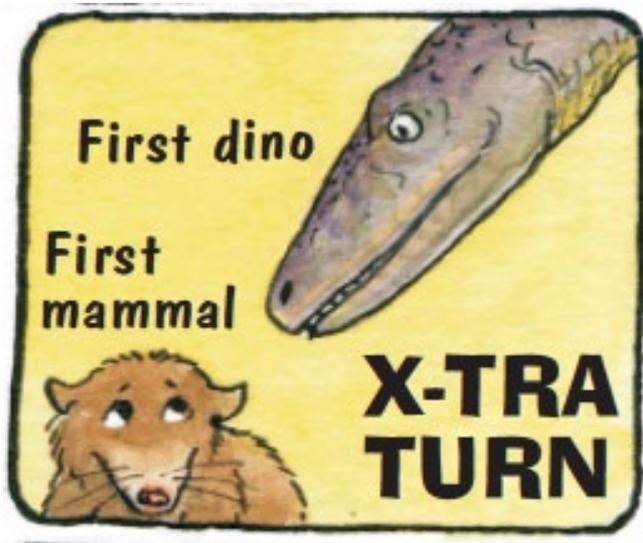
Voltzia: these early cone-bearing conifers became common during the early Triassic, after the great Permian-Triassic extinction.

Triassic



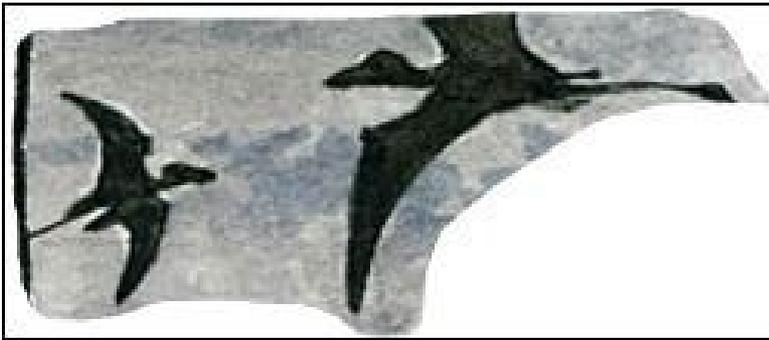
Desmatosuchus (236-204 mya): an aetosaur (a group of reptiles) up to 5 m (16.4 ft) long. This well-protected herbivore had a body covered in armor and two rows of spikes on its back.

Triassic



The Triassic was a time of innovation. The first dinosaurs evolved between 243 and 233 mya. The first true mammal, a small, shrew-like animal, appeared around 210 mya.

Triassic



Eudimorphodon (230-202 mya): an early pterosaur with a wingspan of 1 m (3.3 ft), was a piscivore (an animal that eats fish) that used its many sharp, pointed teeth to capture slippery prey.

Jurassic



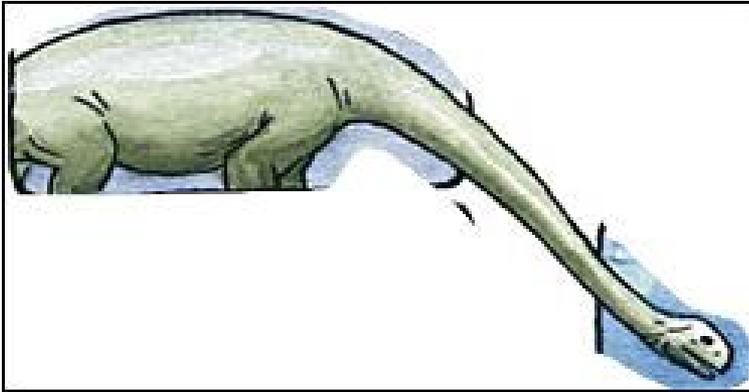
Cycadeoids – a group of fossil seed plants with thick trunks and compound leaves that looked something like modern cycads. They are also known as Bennettitales.

Jurassic



Oxynoticeras (197-183 mya): an ammonite. This swiftly moving carnivore was related to squids and nautiloids. Its excellent vision helped it catch prey.

Jurassic



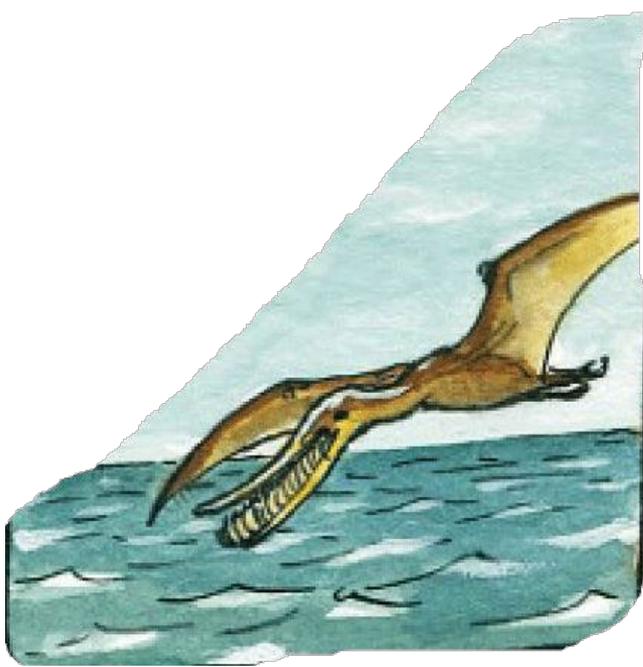
Omeisaurus (176-146 mya):
This large land-dwelling
dinosaur from what is now
China was about 3.7 m (12 ft)
high and ~9-15 m (30-50 ft)
long.

Jurassic



Archeopteryx (151-125 mya): the oldest known bird, found in Germany. It had feathers, the ability to fly, a long, bony tail, and jaws filled with sharp teeth. *Archeopteryx* was no larger than a raven.

Cretaceous



Pterodaustro: This South American pterosaur had a 5.5 m (18 ft) wingspan. Its unusual tooth “comb” suggests that it ate plankton, small marine organisms like crustaceans that could be filtered out of sea water.

Cretaceous



Archaeofructus (125-101 mya): This small aquatic angiosperm (a plant with flowers and fruit) was among the earliest members of this group, which today dominates the plant world.

Cretaceous



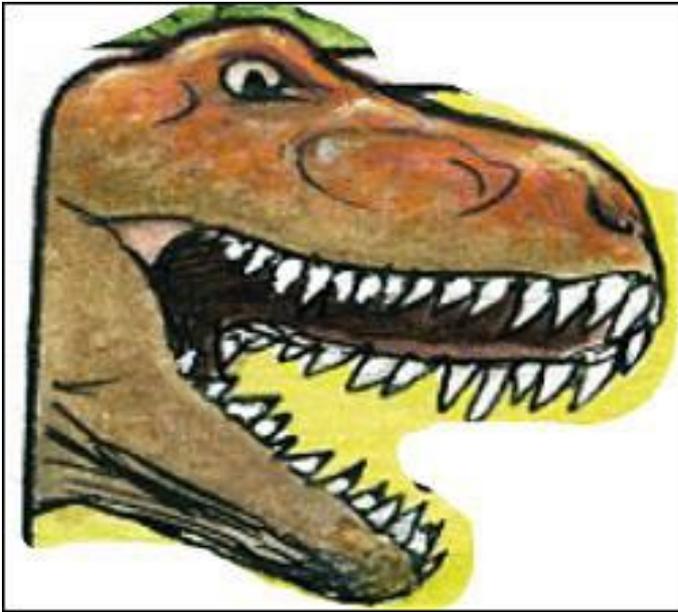
Kronosaurus (125-101 mya): This marine reptile, called a pliosaur, was 9.0-10 m long (30-33 ft). It was a predator with long conical teeth to catch and hold fish and other prey.

Cretaceous



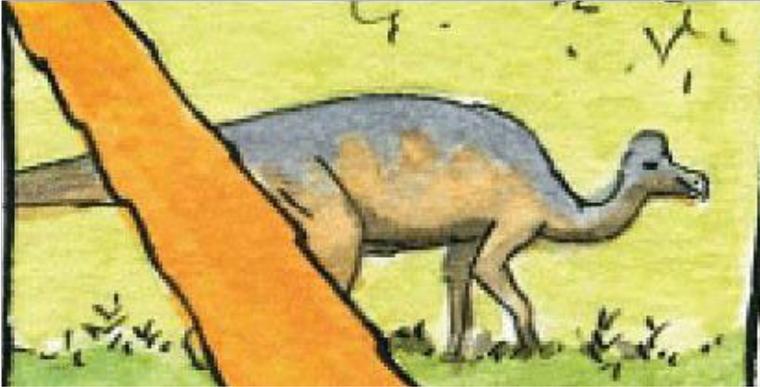
Gracillariid: This moth was one of the early pollinators of angiosperms. The diversity of butterflies and moths increased as flowering plants became more diverse and common.

Cretaceous



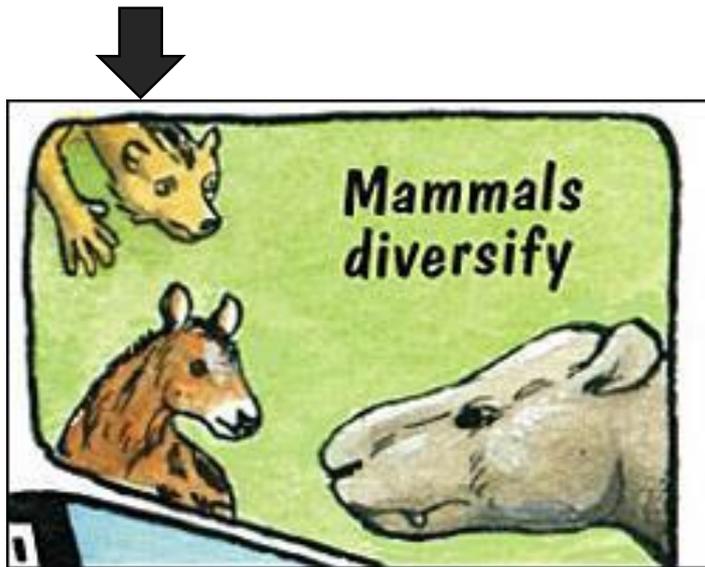
Tyrannosaurus (85-66 mya):
The tyrannosaurid dinosaurs (the most famous being the T. rex), were a family of carnivores in North America and Asia. Different species ranged in size from 100 to 10,000 kg (220 to 22,000 lbs).

Cretaceous



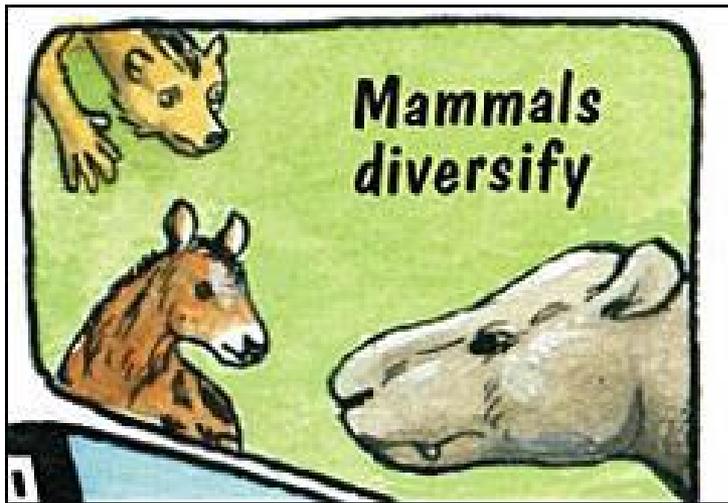
Corythosaurus (84-71 mya):
A herbivorous dinosaur that
lived in North America.
They were 10 m (33 ft) long
and weighed about 3.62
metric tons (4 tons)!

Paleogene



Notharctus (56-40 mya):
this lemur-like primate lived
in Europe and North
America. It was 0.4 m (16
inches) long and lived in
trees, using its long fingers
to grasp branches.

Paleogene



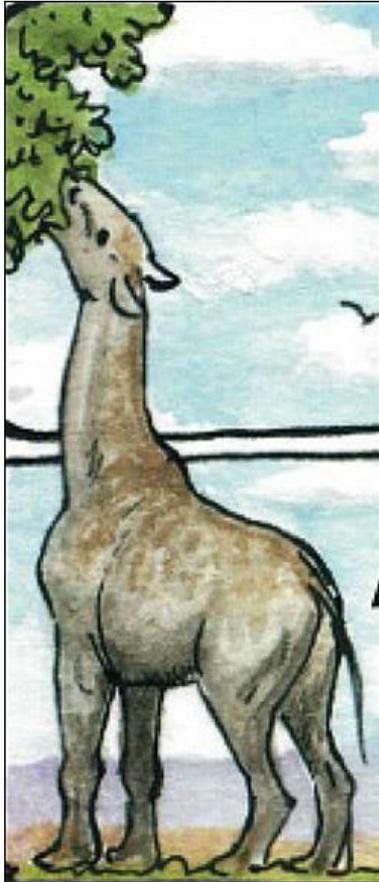
Coryphodon (57-46 mya):
This hippo-like herbivore was about 2.1 m (7 ft) long and was a common across North America. It was one of the largest mammals of its time and semi-aquatic, living in swamps and marshes.

Paleogene



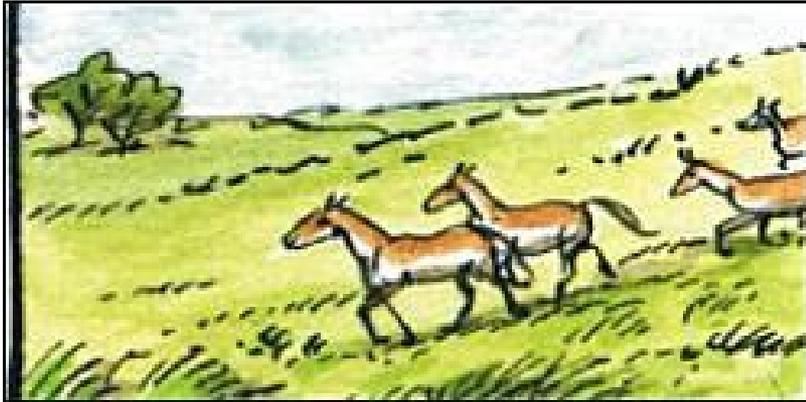
Hyracotherium (56-46 mya):
An ancestor of modern horses, the *Hyracotherium* lived all across North America. At about 0.6 m (1.9 ft) long, it was also very small. It was a herbivore and ate mostly leaves and fruit.

Paleogene



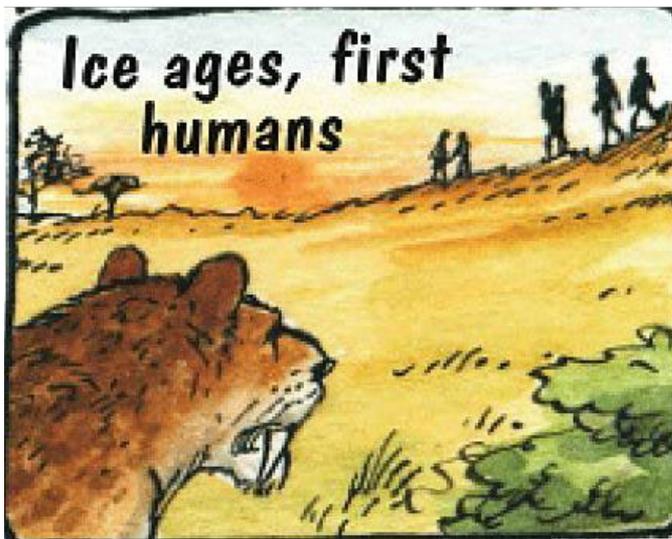
Paraceratherium (34-23 mya):
At 47.4 m (24 ft) long and a shoulder height of 7.4 m (24 ft), this relative of rhinos was the largest known land mammal. It lived in Eurasia and Asia and browsed leaves from trees with its upper lip and front teeth.

Neogene



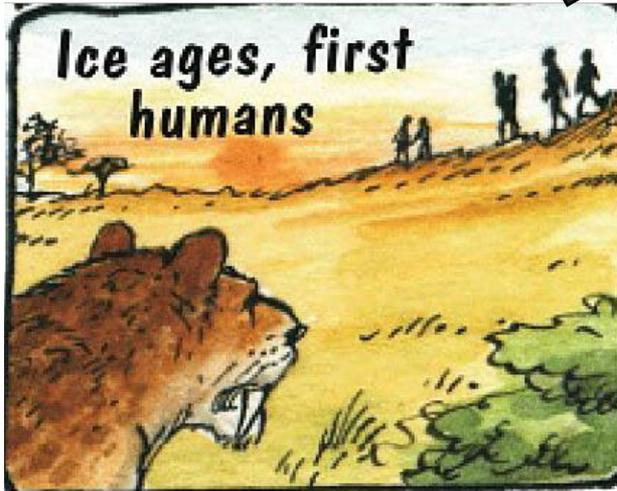
Primitive horses such as *Merychippus* (23 - 5.3 mya) are among the first grazing horses. They used their long legs to travel widely in search of food and avoid predators. *Merychippus* was smaller than today's horses, only growing to 0.88 m (~3 ft) tall.

Neogene



Homotherium (23 - 0.011 mya): was a saber-tooth carnivore, widespread in North and South America, Africa, Europe and Asia. It was similar to a lion, but its saber teeth made it a specialist in stabbing prey!

Neogene



Australopithecus (4.2-1.9 mya): These bipedal hominins lived in Africa and belonged to a group that gave rise to modern humans. They were omnivores, eating mainly plants but sometimes animal protein, as chimpanzees do today.

INSTRUCTIONS FOR THE GAME “EVOLVE OR PERISH”

This is a board game developed by artist-illustrator Hannah Bonner and the ETE Program, Smithsonian Institution. The set-up is similar to *Chutes and Ladders* (in Europe *Snakes and Ladders*). You use chips and a die to reach the finish. **Evolve or Perish**, however, also takes you through 630 million years of evolution from life in the sea to life on land. A glossary explains important events. **Evolve or Perish** can be played at two levels, beginner and advanced. See also <https://naturalhistory.si.edu/education/teaching-resources/paleontology/evolve-or-perish-board-game>

Instructions for Beginner Level (2-4 players)

The board consists of a track with 63 spaces representing a total of 630 millions years. Each player starts with a chip in the starting square and takes turns to roll a single die to move the chip by the number of squares indicated by the die, following the route marked on the gameboard. Several squares take the player a fixed amount of years forward or backward in time. Some squares reward the player with an extra turn, such as during the development of early land plants and the first four-legged animal. There are also squares with unfortunate events that force the player to move backwards or lose one or more turns, the most recognizable being the Permian-Triassic extinction.

If a chip lands on an occupied square, the original occupant has to go back to the beginning of the game – or, but only if all players agree before starting, back to the beginning of the time period. The winner is the player who first gets his/her chips into the final square. The player, however, must roll the exact number to reach the Present (last square). If the roll of the die is too large the chip proceeds to the final square, and then goes backwards until it has moved the same number of squares as the die shows.

Additional instructions for Advanced Level (2-4 players)

Each player starts with one plant (primary producers-green) and one animal (consumer- herbivore) chip. If your animal chip lands on a square occupied by a plant, the plant has to go back to the beginning of the era it is in. If there is more than one plant on the square, they are all protected and don't have to go back (plants have safety in numbers). If your animal chip lands on a square with an animal already there, you must retreat one square (competitive exclusion!), and if your plant chip lands on a square with an animal chip, then it goes back one square (fear of being eaten!). The winner is the player who first gets both of his/her chips into the final square.