CHAPTER 4
Part 1 of 2

Among fossil aficionados, Canada is famous for having many sites that have yielded striking specimens of global significance, including four UNESCO World Heritage Sites designated for their paleontological importance. One such site is Miguasha National Park in Quebec, famous for its Devonian fossil fish, such as *Eusthenopteron* shown here. JOHANNE KERR, COURTESY OF MIGUASHA NATIONAL PARK.

Skeleton of *Albertosaurus libratus*, found in Dinosaur Provincial Park, Alberta, and now at the Royal Tyrrell Museum of Palaeontology in Drumheller. ROYAL TYRRELL MUSEUM.

Joseph Tyrrell in his later years. REPRODUCED WITH THE PERMISSION OF NATURAL RESOURCES CANADA 2013, COURTESY OF THE GEOLOGICAL SURVEY OF CANADA.

In this Silurian rock from Arisaig, Nova Scotia, the shell material of a brachiopod (left) and several gastropods have been dissolved leaving gaps that are molds of the original shell. ANDREW MACRAE.

Fern foliage preserved as a carbonized film in late Carboniferous rocks of the Sydney area of Nova Scotia. HEINZ WIELE, COURTESY OF THE ATLANTIC GEOSCIENCE SOCIETY; SPECIMEN FROM THE NOVA SCOTIA MUSEUM.

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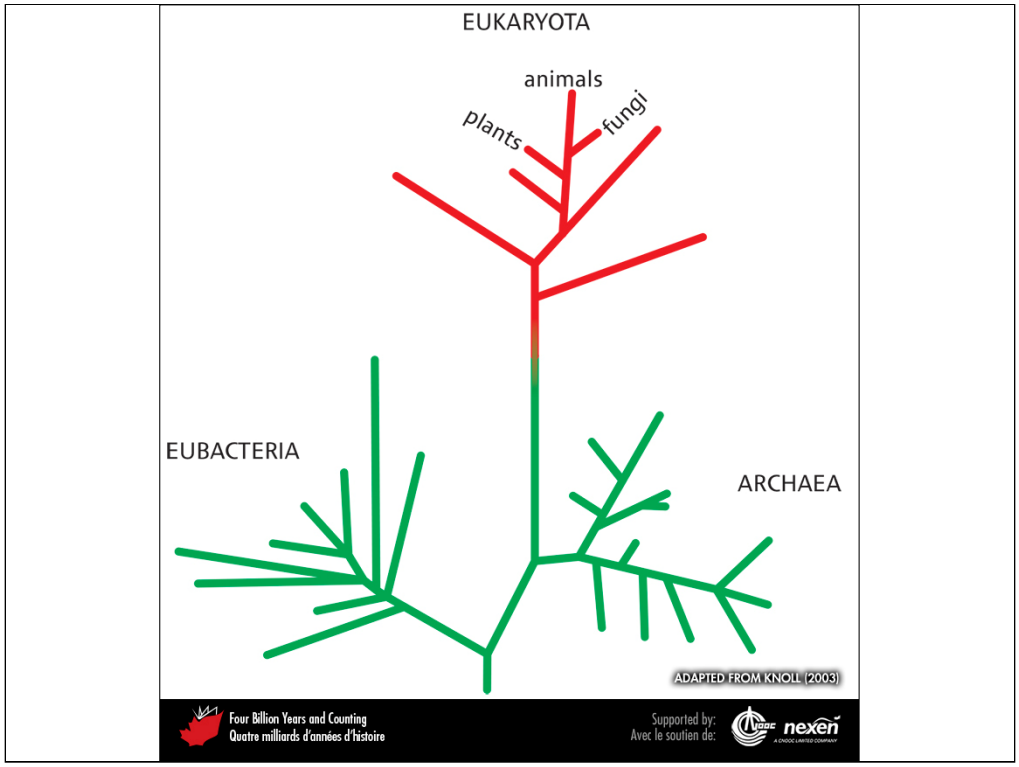
A petrified late Carboniferous tree stump from Inverness, Nova Scotia. The tissue of the plant has been replaced by silica. MARTIN GIBLING.

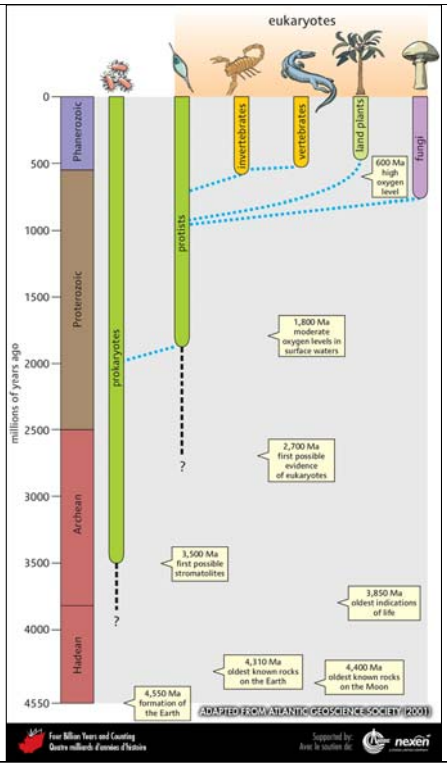
Tetrapod footprints (*Hylopus*) from middle Carboniferous rocks near Parrsboro, Nova Scotia. This view is of the underside of the bed, so the footprints are raised rather than depressed. The many small raised bumps represent small pits in the original sediment, probably the impact marks of rain drops that fell about 320 million years ago. DAVID BROWN; SPECIMEN COURTESY OF ELDON GEORGE.

The branching feeding burrows in this organic-rich Ordovician mudstone from eastern Canada (location unknown) are known as *Chondrites*. The burrows typically branch at about 45 degrees and may show evidence of the organism (possibly a worm) probing the sediment and producing the small pits along the burrow walls. DARREL LONG.

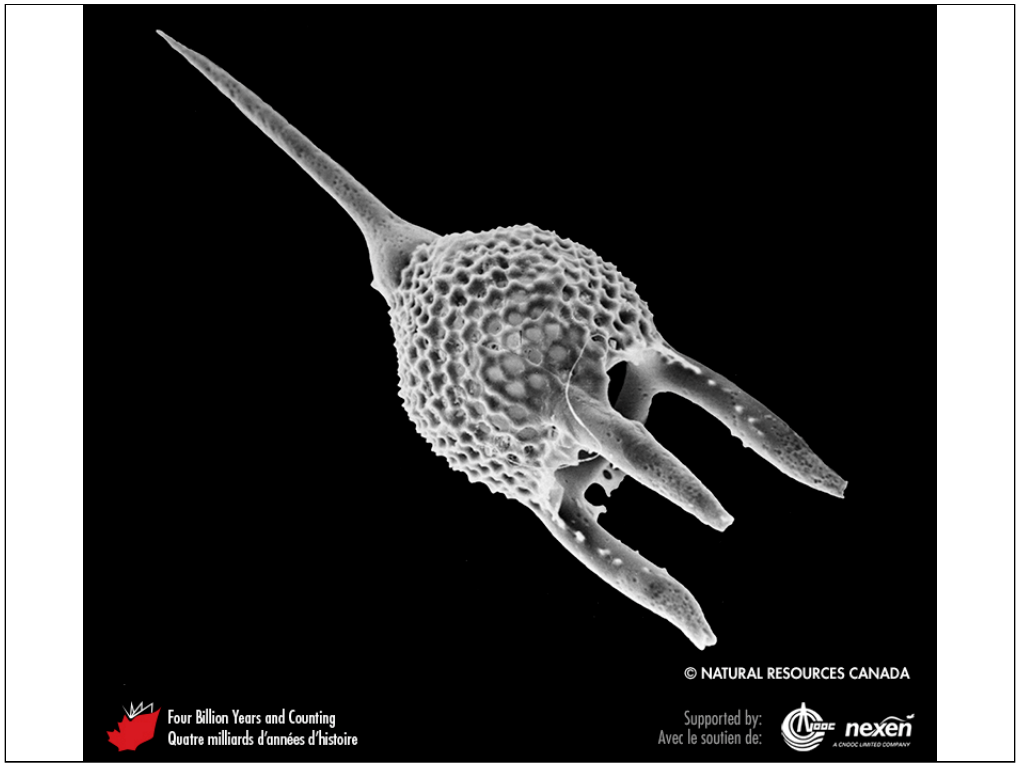
Fossil dung or intestinal remains found in the late Cretaceous sediments of the Frenchman Valley in southern Saskatchewan. PROVIDED BY DAVID EBERTH.



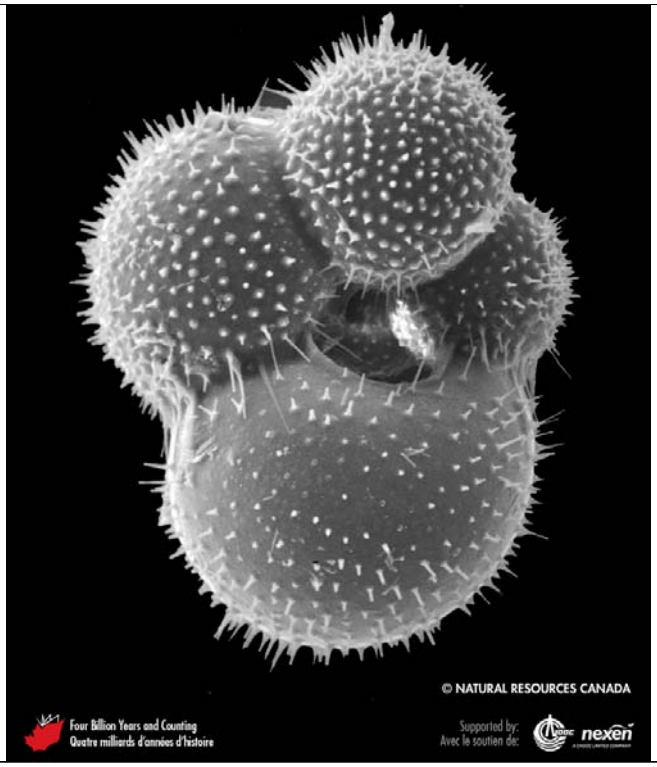
Relationships between the three main branches of life on Earth: prokaryotic Eubacteria and Archaea (both shown by green lines), and the Eukaryota (shown by red lines). Line lengths indicate the degree of difference among gene sequences and do not directly represent time. However, striking parallels can be made between this pattern derived from molecular studies of modern organisms and the timing of first appearances of fossils of the same groups of organisms—a powerful confirmation of evolution. ADAPTED FROM KNOLL (2003). _____



The sequence of major events in the history of life on Earth and the timing of first appearances and ranges of the main groups of organisms. Probable interrelationships are shown by the dashed lines. ADAPTED FROM ATLANTIC GEOSCIENCE SOCIETY (2001).



A fossil radiolarian from offshore eastern Canada. Radiolaria are marine protists that have shells made of silica. They live among the plankton, and their skeletal remains cover huge areas of deep ocean floor. REPRODUCED WITH THE PERMISSION OF NATURAL RESOURCES CANADA 2013, COURTESY OF THE GEOLOGICAL SURVEY OF CANADA.



Foraminifera are protists with shells commonly made of calcite. This fossil is from offshore eastern Canada. REPRODUCED WITH THE PERMISSION OF NATURAL RESOURCES CANADA 2013, COURTESY OF THE GEOLOGICAL SURVEY OF CANADA.

Several disc-like coccoliths can be distinguished in this close-up of a piece of chalk from beneath the continental shelf off Nova Scotia (Chapter 9). The prominent coccolith at centre-left is about 6 microns (0.006 millimetres) across. ANDREW MACRAE AND THE SAINT MARY'S UNIVERSITY MICROANALYSIS UNIT.

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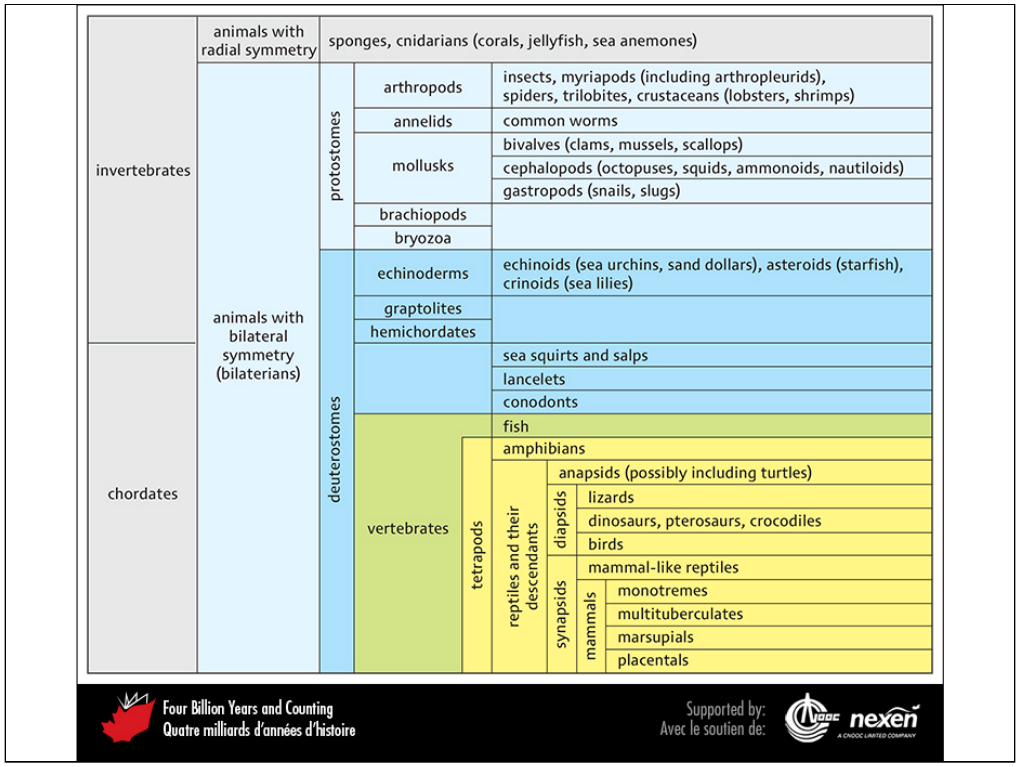

A quick guide to the names used for the major groups of animals (metazoans).

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A fossil sponge from Silurian rocks of Cornwallis Island, Nunavut. MIKE MELCHIN.

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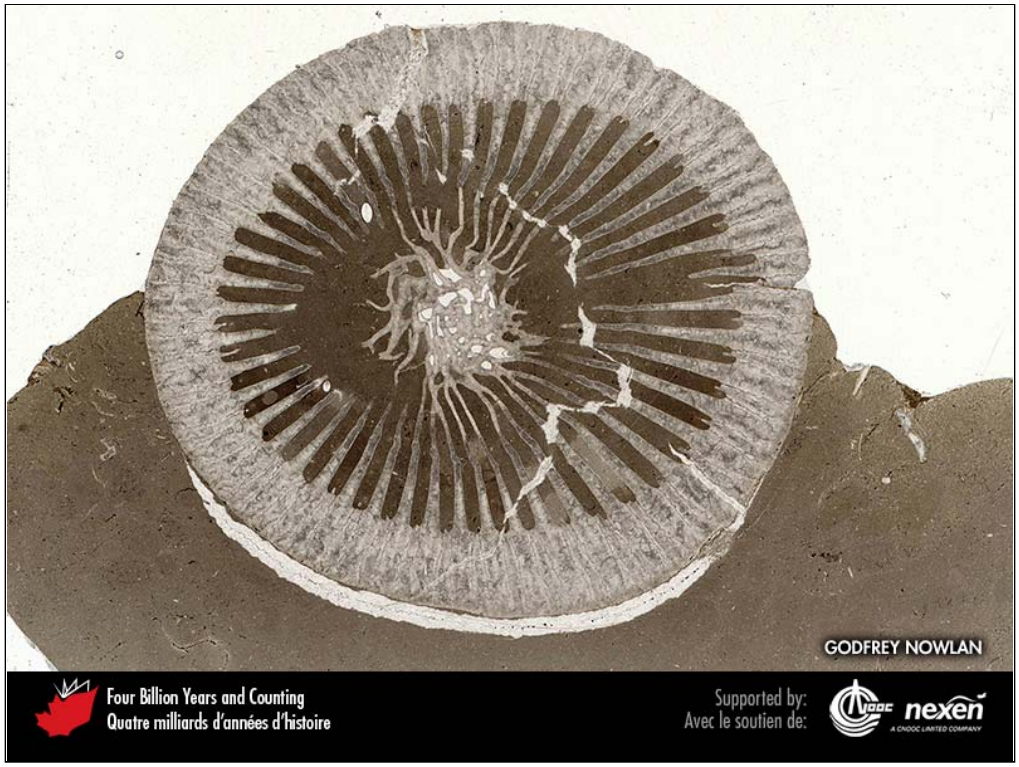

Thin section of the solitary horn coral *Streptelasma* from late Ordovician rocks at Fossil Creek, Southampton Island, Nunavut. GODFREY NOWLAN.

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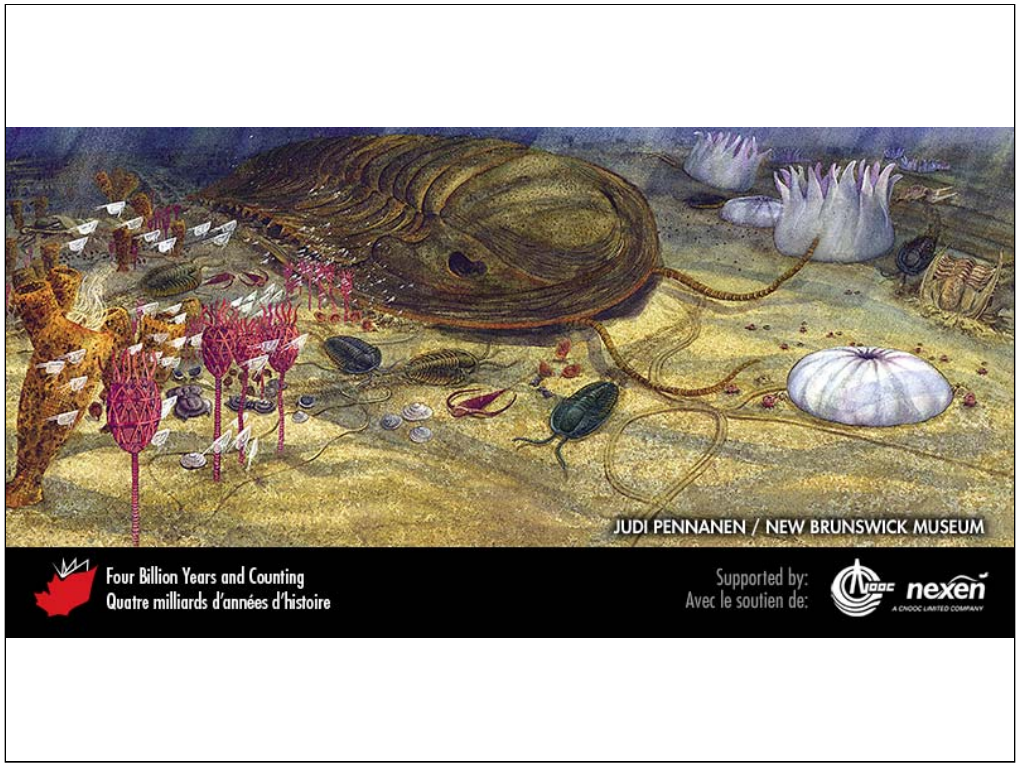
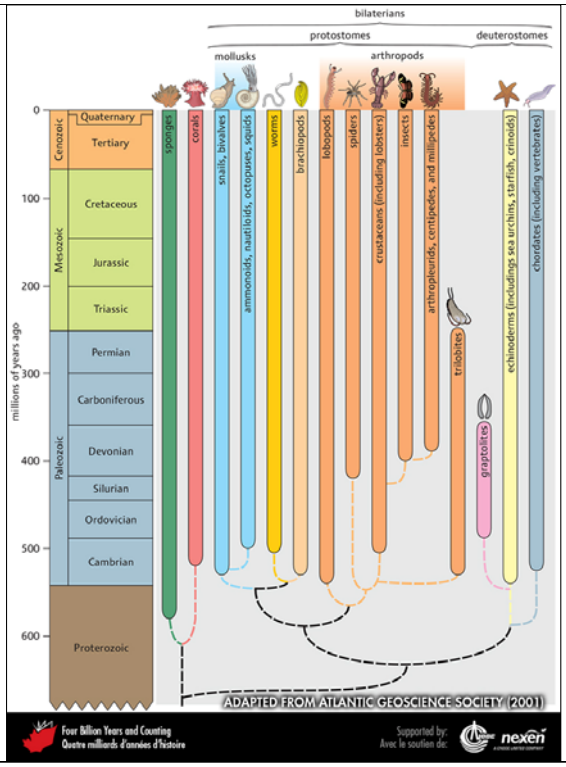
Eurypterids were arthropods and top marine predators during parts of the Paleozoic. This specimen of *Eurypterus remipes* came from late Silurian rocks near Ridgemount, Ontario. DAVID RUDKIN.

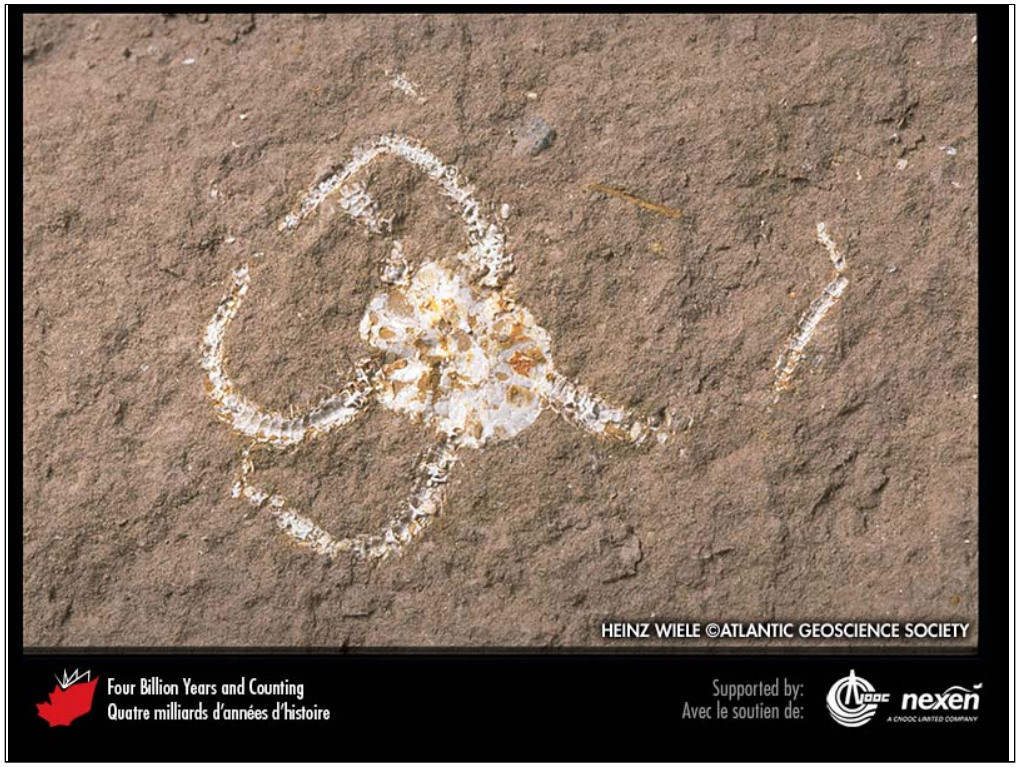
A specimen of *Isotelus*, an Ordovician trilobite, from Bowmanville, Ontario. Trilobites were among the first shelled bilaterians. DAVID EBERTH.



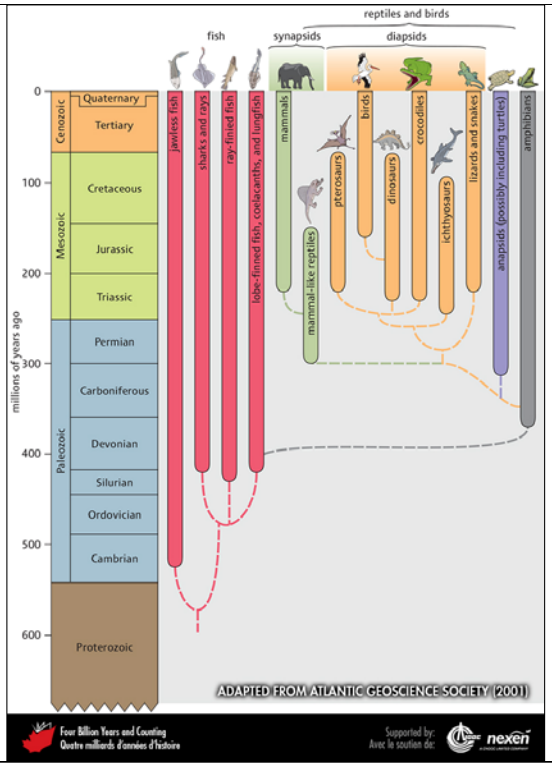
The Cambrian sea floor was dominated by invertebrates, as shown in this scene based on fossils found in the Saint John area of New Brunswick. Several species of trilobites can be seen. To the right are white jellyfish-like creatures, whose inclusion in the painting was based on structures now no longer believed to have an organic origin. Several red eocrinoids stand like sentinels to the left, with a group of translucent ostracods (small arthropods) floating by. Behind the eocrinoids are brown sponges, and some small brown brachiopods are about to be steamrollered by the big trilobite. PAINTING BY JUDI PENNANEN, COURTESY OF THE NEW BRUNSWICK MUSEUM.



Evolutionary relationships and the timing of first appearances and ranges of the main groups of invertebrates. Probable interrelationships are shown by the dashed lines. ADAPTED FROM ATLANTIC GEOSCIENCE SOCIETY (2001).



Asteroids (starfish) are a group of echinoderms that are not common as fossils. This specimen is from Quaternary sediments near Saint John, New Brunswick. HEINZ WIELE, COURTESY OF THE ATLANTIC GEOSCIENCE SOCIETY; SPECIMEN COURTESY OF THE NEW BRUNSWICK MUSEUM.



Evolutionary relationships and the timing of first appearances and ranges of the main groups of vertebrates. Probable interrelationships are shown by the dashed lines. ADAPTED FROM ATLANTIC GEOSCIENCE SOCIETY (2001).

Graptolites from early Silurian rocks at Arisaig, Nova Scotia. HEINZ WIELE, COURTESY OF THE ATLANTIC GEOSCIENCE SOCIETY.

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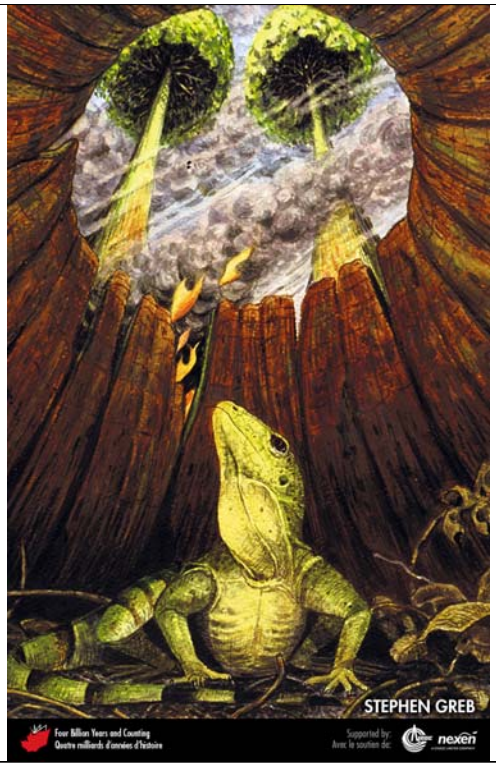
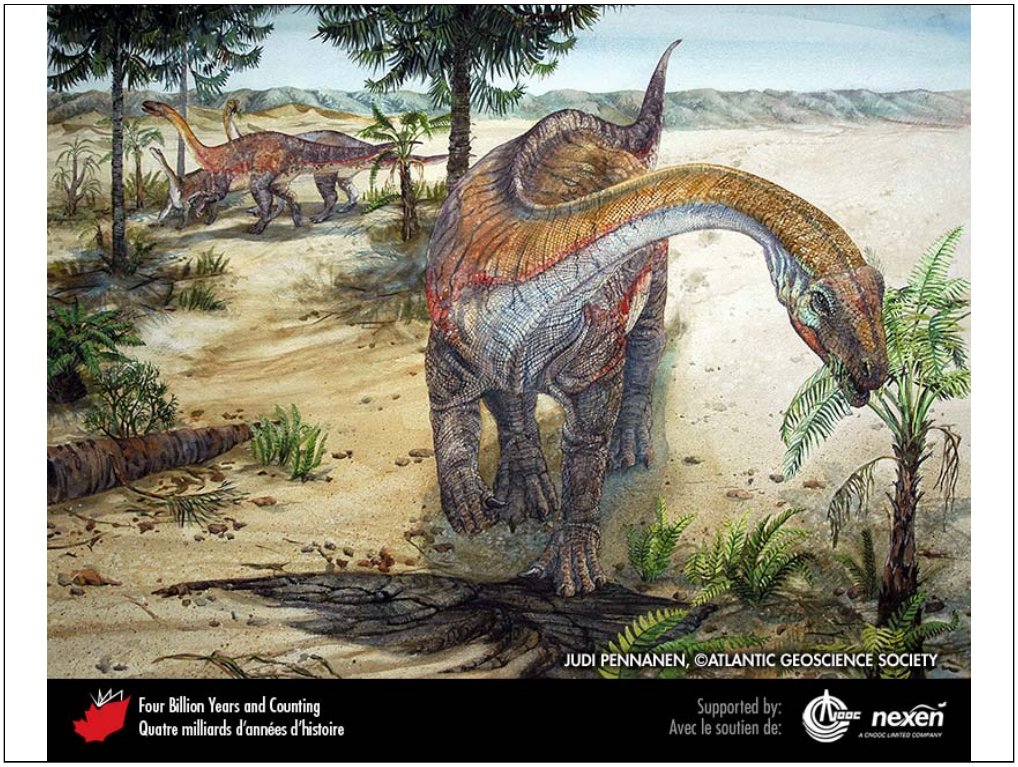


In this scene based on fossil finds from late Carboniferous rocks at Joggins, Nova Scotia, an early reptile gazes out of a tree stump as a forest fire approaches. STEPHEN GREB.



The most famous impact (pun intended) on the fossil record of dinosaurs is the one that wiped them out at the end of the Cretaceous. Less well known is that the end-Triassic mass extinction event largely cleared the way for the great Jurassic diversification of dinosaurs, much in the way that their own demise at the end of the Cretaceous led to the Cenozoic dominance of mammals. This scene of a group of prosauropod dinosaurs is based on fossils found in earliest Jurassic sediments near Parrsboro, Nova Scotia (Chapter 9). PAINTING BY JUDI PENNANEN, COURTESY OF THE ATLANTIC GEOSCIENCE SOCIETY.

If the Mesozoic was the age of reptiles, mammals reigned over the vertebrate world of the Cenozoic. This diorama shows a family of mastodons (*Zygolophodon*) in a thicket in the Rockglen area of Saskatchewan, 14 million years ago. IMAGE OF DIORAMA COURTESY OF THE ROYAL SASKATCHEWAN MUSEUM.

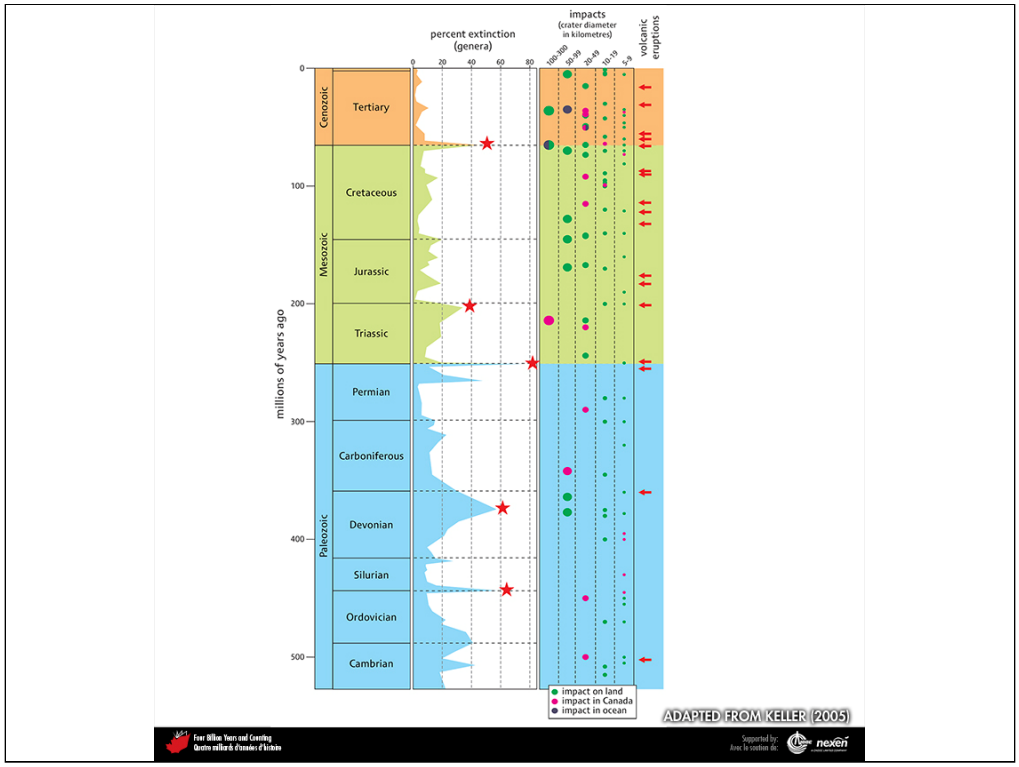


Chart comparing the timing of extinctions with that of extraterrestrial impact structures and major volcanic episodes over the past 542 million years. The column labelled “percent extinction (genera)” also shows (with red stars) the traditionally recognized five major Phanerozoic mass-extinction events. However, as can be seen, other peaks might have comparable claims. The column labelled “impacts” shows the frequency and size of major impact events in Earth history, and whether the bodies plunged into Canada, other countries, or the ocean. As no oceanic crust is older than about 180 million years, all records of impacts in the ocean prior to that time have been lost. Significant episodes of volcanic eruptions are shown in the column to the far right. ADAPTED FROM KELLER (2005), USED WITH PERMISSION OF THE AUTHOR AND THE AUSTRALIAN JOURNAL OF EARTH SCIENCES.
