The Natural History of North Carolina [1]

The land that is North Carolina existed long before humans arrived --*billions* of years before, in fact. Based on the age of the oldest rocks found on earth as well as in meteorites, scientists believe that the earth was formed about 4,500 million years (4.5 billion years) ago. The landmass under North Carolina began to form about 1,700 million years ago, and has been in constant change ever since. Continents broke apart, merged, then drifted apart again. As landmasses came together, the Appalachian mountains (and other mountain ranges on the earth) were formed -- and wind and water immediately began to wear them down by erosion. After North Carolina found its present place on the eastern coast of North America, the global climate warmed and cooled many times, melting and re-freezing the polar ice caps and causing the seas to rise and fell, covering and uncovering the Coastal Plain. Recent geologic processes formed the Sand Hills, the Uwharrie Mountains, and the Outer Banks.

The first single-celled life forms appeared as early as 3,800 million years ago. It then took 2,000 million years for the first cells with nuclei -- simple bacteria -- to develop, and another 500 million years for multi-celled organisms to evolve. As life forms grew more complex, they diversified. Plants and animals became distinct. Gradually life crept out from the oceans and took over the land. Seed-bearing plants developed, then flowering plants, and finally grasses. Animals developed hard exterior shells for protection, then interior skeletons. Flying insects, amphibians, reptiles, dinosaurs, birds, and finally mammals emerged. Sudden changes in climate caused mass extinctions that wiped out most of the species on earth, making room for new species to evolve and take their places. The ancestors of humans began to walk upright only a few million years ago, and our species, *Homo sapiens*, emerged only about 120,000 years ago. The first humans arrived in North Carolina just 10,000 years ago -- and continued the process of environmental change through hunting, agriculture, and eventually development.

To help you understand the vastness of the time scales we're talking about, consider this: If the history of our planet were condensed into a single day, humans would have emerged just 2.3 seconds before midnight, and would have arrived in North Carolina *two tenths of a second* before midnight -- literally the blink of an eye. And if that last two tenths of a second of human habitation were expanded into a full day, Europeans would have arrived at 11:02 pm, and a student now in eighth grade would have been born at 11:58 pm!

Natural history at a glance

The history of all of these processes -- geologic, climatic, environmental, biological -- is called *natural history.* Scientists have divided the natural history of the planet into chunks of time called eons, eras, periods, and epochs. These chunks of time have names and approximate dates that correspond to events in geologic or fossil records. As scientists find new evidence, they revise these dates, and they don't always agree on how to do so. The science of natural history, like natural history itself, is an evolutionary process.

This chart summarizes the major events in North Carolina's natural history. Dates are listed in Mya (Million years ago).

Note: the structure of this table is borrowed from Wikipedia [2]. The names and dates of eons, eras, periods, and epochs are also from that page, which is in turn drawn from the time scale agreed upon in 2004 by the International Commission on Stratigraphy. Most of the information in the table is drawn from Fred Beyer, *North Carolina: The Years Before Man, a Geologic History* (Durham, N.C.: Carolina Academic Press, 1991).

Eon	Era	Period	Epoch	Major events	Start
Phanerozoic	Cenozoic	Neogene	Holocene	The climate stablized as the glaciers retreated, making agriculture possible. Human civilization emerged.	c. 9000 BCE
Phanerozoic	Cenozoic	Neogene	Pleistocene	Many large mammals flourished, then became extinct. Anatomically modern humans evolved. The Sand Hills formed during this time. Streams eroded the Piedmont and Blue Ridge, carrying sediment to the Coastal Plain. There, water seeped through those sediments, carrying heavier clay downward and leaving behind sands that were piled into dunes by winds. The polar ice caps melted, and the sea level rose more than 300 feet above its present level. The resulting shoreline can be seen today in an escarpment [3] -- a sharp drop-off -- that runs through Scotland, Hoke, and Cumberland counties. When the seas receded, that sudden change in elevation caused rivers to fall rapidly. The town of Cross Creek, which became Fayetteville, would be located along this "fall line." About 1.7 million years ago, the present "Ice Age" began. As glaciers and polar ice caps re-formed, sea level fell, exposing the Coastal Plain. Several periods of *glaciation* (the forming of glaciers) and melting followed, with corresponding falls and rises in sea level. A series of escarpments can now be seen at various points on the Coastal Plain where the shoreline once lay. The glaciers began to recede for the last time about 18,000 years ago. The rising seas left a ridge above water, creating the modern barrier islands. Between 10,000 and 15,000 years ago, as the climate warmed, North Carolina's forests began to look as they do today, with pine, spruce, and fir in the cooler Blue Ridge and oak and hickory more common in the Piedmont.	1.8 Mya
Phanerozoic	Cenozoic	Neogene	Pliocene	*Homo habilis*, the first species of the genus *Homo* to which humans belong, appeared. The land surfaces of the Blue Ridge and Piedmont now appeared essentially as they do today. A dry climate with short rainy seasons caused grasslands to flourish in the Piedmont. Shallow sea covered the eastern half of the Coastal Plain, then receded again.	5.3 Mya
Phanerozoic	Cenozoic	Neogene	Miocene	Modern mammal and bird families became recognizable. Grasses spread across the globe, and the first apes appeared. The ocean retreated completely from the modern Coastal Plain. Rapid erosion in the	23.0 Mya

Eon	Era	Period	Epoch	Major events	Start
				Piedmont was uneven, and left the Uwharrie Moutains behind.	
Phanerozoic	Cenozoic	Paleogene	Oligocene	Animals, especially mammals, evolved rapidly and became more diverse. Modern types of flowering plants evolved and spread. About 31 million years ago, the ocean advanced west as far as present-day New Bern.	33.9 Mya
Phanerozoic	Cenozoic	Paleogene	Eocene	The first grasses appeared. Some of the first modern families of mammals emerged, and primitive whales diversified. An ice cap developed on Antarctica. The crust under the Coastal Plain began to sink again, and the ocean pushed as far west as the modern Piedmont. The calcium-rich shells of microscopic algae sank to the ocean floor, where over time they became limestone. By the end of the Eocene, the seas had again retreated.	55.8 Mya
Phanerozoic	Cenozoic	Paleogene	Paleocene	Early mammals diversified, and the first large mammals appeared. The world's climate was still tropical, but gradually began to cool. By the end of the Paleocene, the entire Coastal Plain of North Carolina was again above sea level.	65.5 Mya
Phanerozoic	Mesozoic	Cretaceous		Flowering plants proliferated, along with new types of insects that pollinate them. Many new types of dinosaurs (e.g. Tyrannosaurs, Titanosaurs, duck bills, and horned dinosaurs) evolved on land, as did modern crocodilians (crocodiles and alligators). Modern sharks appeared in the sea. Primitive birds gradually replaced pterosaurs. The eastern portion of the modern Coastal Plain of North Carolina again lay under water, but the ocean receded late in this period. Elsewhere, the southern landmasses broke up, creating the continents of Africa and South America as well as the southern Atlantic Ocean. The youngest ranges of the Rocky Mountains formed. At the end of the Cretaceus, 65 million years ago, a mass extinction occurred, and the dinosaurs disappeared.	145 Mya
Phanerozoic	Mesozoic	Jurassic		Conifers and ferns were common. Dinosaurs were diverse, including sauropods, carnosaurs, and stegosaurs. Mammals were common but small. The first birds and lizards appeared. Ichthyosaurs and plesiosaurs were diverse in the oceans. As the North American continent drifted to the northwest, its trailing edge sank under water, and the Atlantic Ocean formed between North America and Africa. The shore was located near the present Outer Banks. The Appalachians continued to erode, leaving the flat land that now exists in the eastern Piedmont.	200 Mya
Phanerozoic	Mesozoic	Triassic		Dinosaurs appeared and became dominant, as did ichthyosaurs and nothosaurs in the seas and pterosaurs in the air. The first mammals and crocodilia (ancestors of crocdiles and alligators) also appeared. As soon as they had formed, the Appalachians began to erode. Wind and rain wore away the rock and carried it as sediment to lower-lying land or to the sea. Meanwhile, the continents began to move apart again. At this time, North Carolina probably lay near the equator, and had a tropical climate in which a great diversity of life must have flourished.	251 Mya
Phanerozoic	Paleozoic	Permian		Amphibians remained common but small. Reptiles, though, grew larger and diversified. Beetles and flies evolved. A number of invertebrates that no longer exist, such as trilobites, flourished in the oceans. As the climate cooled, the scale trees, which had flourished in near-tropical conditions, declined and nearly became extinct. Conifers thrived in the cooler climates and dominated the forests. By 260 million years ago, the Appalachian mountains were complete. The resulting mountain range was 620 miles long, stretching from Canada, Great Britain, Greenland, and Scandinavia all the way south to Louisiana, and the mountains were as high as the highest mountains in the world today. Most likely, the tallest peaks were in what is now the eastern Piedmont and Coastal Plain. A mass extinction occurred 251 million years ago, marking the end of the Permian period. Some 95 percent of life on Earth became extinct, including 75 percent of amphibian species and 80 percent of reptiles. No one knows why this extinction occurred, but some scientists speculate that changing climate and massive mountain building as the continents collided caused great changes to the environment, in which highly specialized species could no longer survive.	299 Mya
Phanerozoic	Paleozoic	Carboniferous/ Pennsylvanian		Winged insects spread, including very large species. Amphibians were common and diverse. The first reptiles appeared. About 320 million years ago, the North American and Euro-African continents collided, resulting in the last period of Appalachian mountain building. The land under the Piedmont and Coastal Plain was also	318 Mya

Eon	Era	Period	Epoch	Major events	Start
Phanerozoic	Paleozoic	Carboniferous/ Mississippian		In wetland forests, ferns thrived and primitive trees called *scale trees* grew more than 100 feet high. Their decayed remains became coal. The portions of the Appalachian region where coal is mined today were then covered in such forests. Meanwhile, the first vertebrates appeared on land, in coastal swamps, and early sharks were common in the oceans.	359 Mya
Phanerozoic	Paleozoic	Devonian		Plants took over the land. The first horsetails and ferns appeared, as did the first seed-bearing plants, the first trees, and the first (wingless) insects. Fish were common and diverse. The first lungfish, which could breathe air, appeared, followed by the first amphibians.	416 Mya
Phanerozoic	Paleozoic	Silurian		The first vascular plants appeared -- plants with specialized tissues for conducting water and nutrients -- along with the first plants on land. The first millipedes appeared on land. Primitive fish, including the first fish with jaws as well as armoured jawless fish, populated the seas. Sea-scorpions reached a large size. Trilobites and mollusks were diverse. As the continents of North America and Europe/Africa moved together, more rock was pushed upwards, and over the next 100 million years, the Appalachian mountains were formed. As the Appalachians rose, streams carried sand and mud westward and filled the sea.	444 Mya
Phanerozoic	Paleozoic	Ordovician		In the seas, invertebrates diversified into many new types, and the first tiny vertebrates appeared. The first green plants and fungi appeared on land.	488 Mya
Phanerozoic	Paleozoic	Cambrian		The "Cambrian Explosion" saw a major diversification of life. Many fossils survive from this time. The most modern phyla -- the broadest groupings of animals and plants -- appeared, including the first chordates (ancestors of vertebrates). Trilobites, worms, sponges, brachiopods, and many other animals flourished, as did some giant predators. By this time, the eastern coast of North America lay somewhere in middle Tennessee; except for islands and volcanoes, North Carolina was under water. About 750 million years ago, the landmasses of North America and Europe/Africa had begun moving towards each other again. The Kings Mountain Belt was formed about 540 million years ago as the Piedmont slowly moved into the rest of the continent.	542 Mya
Proterozoic	Neo-proterozoic			The first fossils of multi-celled animals survive from this period. Very simple multi-celled life forms called eukaryotes appeared as early as 1000 million years ago, and worm-like animals and the first sponges by about 600 million years ago. The land under North Carolina was pulled apart, and inland seas emerged. Island volcanoes developed, first along the North Carolina-Virginia border, then in an arc from Virginia to Georgia. Rocks formed by those volcanoes extend today over a wide area of the Piedmont and Coastal Plain. Fossilized tracks of primitive worms have been found in those volcanic rocks, formed about 620 million years ago.	1000 Mya
	Meso-proterozoic			Green algae colonies appeared in the seas. About 1,300 million years ago, the first mountains were formed in North Carolina. Called the Grenville Mountains, they eroded long ago, but rocks formed at this time lie underneath the Appalachians and are exposed in parts of the Piedmont and Coastal Plain.	1600 Mya
	Paleo-proterozoic			As oxygen-producing bacteria proliferated, the atmosphere became oxygenic -- filled with oxygen -- for the first time. By about 1800 million years ago, the first complex single-celled life-forms -- cells with nuclei -- emerged. About 1700 million years ago, the land that would become North Carolina began to form.	2500 Mya
Archean				Simple single-celled life emerged as early as 3,800 million years ago. The first oxygen-producing bacteria emerged -- prior to this time, the earth's atmosphere had much carbon dioxide and little oxygen. The oldest miscroscopic fossils that have been found are about 3,400 million years old. The landmass that would become North America began to form. Rocks that survive from this time show evidence of erosion by the first glaciers. As the earth's liquid interior -- the *mantle* -- continued to move around its solid *core*, it created forces that shifted the *crust* -- the thin, rigid surface of the earth. The crust broke into plates that formed the basis of the first continents. Ever since, they have slowly moved around the earth's surface by a process called *plate tectonics*.	3800 Mya
Hadean				The earth formed about 4,500 million years ago, as a cloud of gas and dust gradually collapsed into the sun and other bodies of our solar system. By 4,000 million years ago, the earth had a stable crust with oceans and a primitive atmosphere, which probably consisted of water vapor, methane, ammonia, carbon dioxide, and only a tiny amount of oxygen. The first life forms -- probably self-replicating RNA molecules -- may have evolved as early as 4,000 million years ago.	4500 Mya

How do scientists know...

...the age of rocks and fossils?

Radioactive forms of certain elements such as carbon-14 and uranium-235 are not chemically stable; they slowly *decay* into stable elements by radiating away particles. Scientists have determined through experiment the rate at which these elements decay. Based on the amount of radioactive material left in a rock, fossil, or artifact, they can determine how long ago it was created.

...the age of the earth?

The oldest rocks found on earth are 4.4 billion years old, so the earth must have formed at least that long ago. The oldest rocks found in meteorites and brought back from the moon are between 4.5 and 4.6 billion years old, and scientists use that figure as an estimate of when the solar system was formed, and with it the earth.

...when water appeared on the earth?

Rocks found in Greenland have been found to be 3,800 million years old. The rocks are *metamorphic* -- they were changed by heat and pressure. That process can only occur in the presence of liquid water, and so geologists estimate that by this time the earth had oceans -- and an atmosphere, because otherwise the oceans would have evaporated.

...where the continents and oceans used to be?

In some cases, we can look at the fossil record. For example, if fossils of ocean-dwelling animals are found on dry land, we know that when that animal lived, the land must have been under water. When animals found on different parts of the globe have similar ancestors, scientists may surmise that those parts of the earth were once connected by land. Scientists can also determine how fast and in what direction the earth's plates are moving now, and use that information to develop theories about what happened in the past.

...what the climate was like in the distant past?

During the Ice Age, glaciers left telltale signs in the rocks they covered. Sometimes mineral deposits are laid down only in certain climatic conditions -- for example, salt deposits are laid down primarily when the climate is warm and dry (when water evaporates most quickly). In other cases, the fossil record indicates that the earth (or a particular location on it) must have been warm or cool.

...when various kinds of plants and animals appeared?

Based on dating of fossils, we know when various plants and animals lived. Often, though, fossils are incomplete -- they show only part of a species, and scientists have to make educated guesses about the rest. And the fossil record itself is not complete -- we certainly haven't found fossils of every life form that ever existed, or from the entire period that a given life form existed. So while scientists know that certain species existed at certain times, there is a tremendous amount they don't know.

...how different species are related?

Scientists classify species based on their ancestry and evolution: Two species are more closely related if they have a more recent common ancestor. The most obvious way to guess that two species have a common ancestor is their *morphology* -- what they look like and how they are constructed. But relying on morphology alone can be dangerous, because although dolphins and sharks look much alike, they are not even remotely related -- sharks evolved hundreds of million years ago from aquatic invertebrates, while dolphins evolved much more recently from land-dwelling mammals. Sometimes a complete fossil record shows stages in a species' evolution, through which it can be traced to a more distant ancestor. More recently, scientists have used DNA testing: by comparing the *genomes (genetic makeup) of two species, they can determine how closely related the two species are.*

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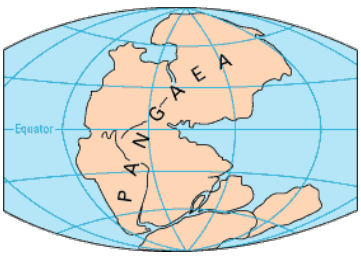

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Pangaea

Artifacts:

Trilobite

The structure of a trilobite, including the antennae and legs, can be seen in the Burgess Shale, a rock formation found in the Canadian Rockies in 1909.

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