TIME GALLERY

The concepts presented here represent change of the physical planet as well as the life forms on it. The focus, however, is on the North American continent.

UNIVERSE AND SOLAR SYSTEM

The night sky reveals countless pinpoints of light. The oldest stars formed with the universe about 15 billion years ago when a primordial mass exploded with such intensity as to send particles and dust clouds trillions of miles in all directions. These clouds of gas and matter have been condensing since that time to form galaxies, stars and planets.

Our own sun formed from such a cloud some 4.6 billion years ago. Gravitation pulled the mass together where collisions, compression and radioactivity heated it until temperatures at the center reached millions of degrees. Hydrogen atoms fused to form helium atoms, a source of energy that fuels our sun. The condensing solar cloud also produced orbiting bodies in varying sizes. One of these orbiting bodies is our planet Earth.

The Earth evidently took a long time to form. A molten stage is suspected. As the Earth cooled, heavier material settled to the center with lighter material rising to the surface. Eventually, these lighter materials cooled enough to form a crust. Volcanoes brought gasses and water vapor to the surface creating an atmosphere and the seas. Continents formed as moving plates that constantly shifted, bumping into each other, raising mountains and fostering change.

WHAT'S BELOW YOUR FEET?

The following are some familiar terms for defining the Earth's layers:
Lithosphere - The outer layers of cooler, solid rocks that include the continental landmasses.
Athenosphere - A semisolid layer that is capable of flow. Currents in this layer cause movement in the outer layers above.
Mesosphere - The liquid and solid layers below the athenosphere.
Crust - The upper layers of the lithosphere.
Mantle - Includes the lower layers of the lithosphere, the athenosphere and the upper solid layer of the mesosphere.
Core - The liquid and solid portions of the mesosphere.

LIKE PIECES TO A PUZZLE - CONTINENTAL DRIFT

The Earth's cool, upper crust, the lithosphere, is divided into pieces called plates that float on a semisolid layer (athenosphere). There are seven major plates and many smaller ones that are moved by the currents of the athenosphere. These crustal plates are pushed about the Earth's surface by the upward flow of material from the hot core. As the plates move, they interact with each other, pulling apart or colliding. Volcanoes, earthquakes, mountain building and sea

level changes are result of moving plates. Because of plate movement, the continents have occupied different locations in the past.

The limitations of geology up until the 1950's can be summed up as facts in search of theory. Geologists knew what happened but not how it happened. The theory of plate tectonics, or continental drift, means that the construction of the Earth's geological features occurs through the action of plates. The rocky surface and the outermost 40 miles or so of the Earth is almost entirely made up of cool rocks that are rigid, like the shell of a nut. The shell is broken into a number of plates. Heat and agitation from inside the Earth keep the plates moving about. Most of the reconstruction takes place at the edge of the plates and there is very little change in the middle of the plate. The edges of the plates are found by mapping the areas where earthquakes are most frequent. There are no gaps between the plates. As plates move away from each other, hot rock from below rises to fill the gap. This creates either a mid-ocean ridge or a continental rift valley. Plates cannot overlap to any great extent, either. As they move together, one dips and goes under the edge of the other to enter the Earth's interior. The band creates an ocean trench. The sinking plate causes earthquakes and the friction creates volcanoes on the far side of the trench. The third type of plate edge occurs when two plates are slipping alongside each other. This is known as a transform fault.

Some of the plates are very large, others are quite small, and they all interlock. The continents ride on top of the plates since the continental material is lighter. They cannot sink no matter what happens to the plates they ride on. The continents, therefore, are much older than the ocean floors, and when the continents collide, they make mountain chains rather than ocean trenches. An individual plate is not a permanent part of the Earth's shell. A plate without continents can entirely disappear down a trench and other plates can change shape by either breaking along a new line or welding itself to another plate. The plates have been moving around for about 4.5 billion years and one of the most well-known combinations was the super continent, Pangea, which came together about 200 million years ago. The dinosaurs were at the height of their dominance, and they were able to march along the mountains from Poland to Alabama by way of Ireland and New York. The break up began about 190 million years ago with all the resulting activity. The Himalayan Mountains were built when India collided with Asia just as the Alps arose when Italy bumped into Europe.

All the processes of plate tectonics have combined to make North America the way it is today. For most of the Earth's history, North America did not exist in any recognizable form. At around 500 million years ago, North America and Europe lay close together in the tropics. They eventually collided and were welded together for more than 100 million years. During this time, there were many minor collisions and the sea level was high, thereby flooding the low areas of land, allowing sandstones, shales and limestones to be formed. Life was beginning to

prosper on land with great jungles of trees and ferns. By 250 million years ago, Africa had rammed into North America and Europe, forming the Appalachian Mountains and adding the eastern coastal states from Maine to Georgia. North America was now incorporated on the edge of Pangea and began drifting northwards. The breakup fashioned the now familiar eastern outline of North America. The Atlantic began opening up about 190 million years ago. The parting of North America from Europe was not completed until 100 million years ago. On the west coast, Oregon, Washington, British Columbia, and the Yukon were added to the continent and the eastern end of Russia was attached to Alaska. The ranges of coastal mountains were formed during several encounters with ocean trenches. The fact that the Rocky Mountains are so far inland is something of an enigma, but it is thought that the continental plate broke at the western edge of the Great Plains and the eastern part is being thrust under the western part. The Colorado Plateau and therefore the Grand Canyon remain a mystery as far as plate tectonics are concerned. It is possible that the plateau is the after effect of a piece of the mid-ocean ridge of the Pacific being swallowed under the American continental margin.

During this time, wind and weather were wearing down mountains with the resulting river silt building up land elsewhere. The most dramatic intervention of weather began about 2 million years ago when the present series of ice ages began. It is probable that the ice will return many times during the next few million years.

If present motions continue, the Pacific plate will carry away southwest California to become an island off Alaska. Something will have to give in Alaska and Siberia since North America is still bearing down upon them from the west. The east side will be tranquil for awhile, but sooner or later, as the Atlantic Ocean grows, there will be a new ocean trench in the east with a 50% chance of volcanoes in New York City.

GLACIERS AND EROSION

Throughout our continent's history, great periods of glaciation spread out from the poles locking up vast amounts of water that would otherwise have returned to the sea. Ice once spread over 30% of the Earth's surface, with the southern edges of North America's frozen shroud reaching to Kentucky. This mighty invasion marked one of the four major glacial advances/retreats of the Pleistocene (ice age), an epoch lasting one to two million years. The last glacial advance, called the Wisconsin, made its final thrust some 12,000 years ago. Although unsure as to the definite cause of glaciers, scientists now think that variations in the Earth's orbital pattern may be largely responsible.

Plant and animal distributions changed as a result of the climatic shifts. Boreal forests occurred as far south as Tennessee, and the Great Smokey Mountains was a center for relic populations. During interglacial phases, areas such as

Tennessee were more tropical and fossil jaguars have been discovered that date from the interglacials.

Glacial ice has shaped portions of the continent and altered drainage patterns. Continental ice scoured the landscape and as the ice retreated, the melt left areas of lakes and marshes. The land has been gradually rising since the ice has disappeared; the sheer weight of the ice sheets depressed the land surface under it. Mountain glaciers are pronounced in many areas. Characteristics of glacial erosion include U-shaped valleys, hanging streams with waterfalls and evidence of cirques at the beginning of the valley glacier. A classic example of a glaciated valley is Yosemite in California.

Running water is a powerful shaping force. Mountains form by various means, but are constantly being altered and reduced by erosion, mostly water action. In many instances, it can be by ice or frost action, with water freezing in cracks and expanding to fracture the rock. Running water cuts through rock and shapes the landscape.

Streams and rivers pass through aging processes. Young streams have steeper gradients and flow in nearly a straight line. As they mature, the gradient becomes less and the course of the river becomes more meandering. When this happens, valleys widen and the shaping influence becomes spread over a broader area. Mature water courses flow more slowly, meander greatly and change course frequently.

MOUNTAINS

Mountains result mostly from movements of the Earth's layers. They play a major role in determining the climates of many regions, drainage patterns, watersheds, plant and animal distributions, patterns of migration, and human settlements. Mountains may be quite visible on land but large ranges also occur under the sea. They may be formed in several ways:

Fault-block mountains are formed when crustal masses tilt or slip along a fault. Their movement raises blocks like those that formed the Grand Tetons.

Dome mountains, like the Black Hills of South Dakota, result when forces from below simply push up the Earth's layers.

Folded mountains, such as the Appalachians, result when sections of the Earth's surface are squeezed, folded and fractured.

Volcanoes are mountains formed by lava and other materials from within the Earth's crust. No two are alike in size, shape or the kinds of materials they spew. Ash, lava, solid (pyroclastic) fragments and various gasses may be emitted, singly or in combination.

There are several examples of volcanic products on display:

Lava - molten material that hardens into dense rock. The holes result from escaping gasses.

Obsidian - black or brown glass formed by volcanism. The blue glass is a man-made by-product of a smelter.
Tuff - cemented volcanic ash, which may form layers several hundred feet thick.

MINERALS
Minerals may form in several ways and combinations of various elements or crystal formations produce striking results. Elements from the Earth's interior have been intruded into sedimentary and igneous rocks at different periods, during mountain building, for example. Many forms are soluble in water, and are redistributed and recombined by percolating ground water forming beautiful crystal specimens. Others may be formed by volcanism. Each has its own peculiar characteristics, and many reflect a complex geologic history. What they do not reflect is any organic base; that is, they are of totally nonliving origin.

Galena - Lead sulfide is squeezed into existing rock under pressure.
Calcite - Calcium carbonate, the same composition as limestone or chalk, only now in crystalline form.
Malachite - Copper carbonate that is found in upper layers of copper deposits.
Fluorite - Calcium fluoride, under ultraviolet light, shows blue-violet giving rise to the word fluorescence.
Quartz - Silicon dioxide, a member of the largest and most diverse group of minerals, the silicates, which comprise nearly 95% of the Earth's crust.

EARTHQUAKES
Earthquakes occur along a fault line where two or more plates push against each other, which create tension. When the plates slip, the earth moves producing the earthquake. Land displacement can occur along a fault during an earthquake, and it is not uncommon to see shifts of several feet. Sometimes vertical shifts happen. The land may slump or be raised.

BEGINNINGS OF LIFE
Scientists believe that life began in the oceans. Electrical storms were the keys to forming organic compounds called amino acids from the four most common gases in the Earth's primitive atmosphere: ammonia, methane, hydrogen and water vapor. Amino acids are the basic building blocks for all living things and were deposited by rain into the oceans.

These first steps to life were duplicated in the laboratory by a device called the Miller-Urey apparatus. The same mixture of gases mentioned above was subjected to an electric spark. After several days of sparking, amino acids were found in the condensed water.

The DNA molecule has been called the master molecule of all life on earth. Composed partly of amino acids, but many times more complex, DNA occurs as strands in the nucleus of every living cell. The core components of DNA (called base pairs) are arranged in a specific order. This arrangement (or genetic code)

determines what an animal or plant will be, how it will develop from egg or seed, what it will inherit, and how it will function during its life.

CHANGES ARE WRITTEN IN THE ROCKS

It is a giant step from a collection of nucleic acids to sequential DNA and a dividing cell, when and how this happened, is simply not known at this time. It is known, however, that fossil algal colonies called stromolites are present in rock strata that are more than 3 billion years old. Life had begun around that time, forming large, stable colonies. Plants were the first major life form to evolve. They have the ability to convert energy from the sun through photosynthesis to a usable form of food. Nearly all life that followed is ultimately dependent on that conversion.

The fossil record is sparse until about 600 million years ago when many forms began to appear and are preserved in the rocks. The fossils indicate an intense radiation, since many higher categories are represented at this time. The invasion of land by plants, the corresponding formation of soils, opened new niches for the animals. Landforms began to appear about 450 million years ago, the scorpions being the first.

How fossils have been preserved:

Freezing - the ideal fossil is one that has been kept in cold storage since death, undergoing a minimum of change. Such ideal remains are rare, however, and some are very old.

Diving or Desiccation - fossils that have been thoroughly dried.

Wax and Asphalt - Natural paraffin is almost as good a preservative as ice. Asphalt, however, preserves only hard parts, such as bones, teeth and the shells of insects.

Simple Burial - Plant remains and shells often lie for long periods without much change. Postglacial peat contains cones, stems, and pollen grains that accumulated in bogs.

Carbonization - is a process of incomplete decay that looses its volatile substances but leaves carbon behind.

Petrification - this process takes place in two related ways. The simpler takes place when fat and other organic substances decay while water containing dissolved mineral matter soaks into every cavity and pore of hard structures. The other, called replacement, takes place when water dissolves original hard parts and replaces them with mineral matter.

Molds and Casts - Shells, stumps and other remains often lie in sediment until it becomes firm. Later the dead objects decay or dissolve, leaving a cavity known as a natural mold.

Imprints - these are little more than external molds of very thin objects such as leaves.

Tracks, Trails and Burrows - these, even more than casts and molds, explain why we say that fossils are either remains or traces of ancient organism.

Castings and Coprolites - Castings are indigestible remnants of meals swallowed by burrowing invertebrates. The term coprolite is applied to feces preserved by petrification or as molds or casts.
Gastroliths or Gizzard Stones - Many ancient reptiles had the habit of grinding food with gizzard stones. Formerly called gastroliths, they may be recognized by their rounded edges and smooth surfaces.

Vertebrate Case
Fishes - The most diverse group is the fishes with fossil examples from more than 400 million years old. A group of fish called lobed-fin fishes was the ancestors of higher vertebrates.
Amphibians - The migration to land did not free animals from their dependency on water. Amphibians had to seek water or moist places to lay their eggs.
Reptiles - For the group that became reptiles, a new way of reproduction emerged. The reptilian egg allowed invasions of new habitats and emergence as the dominant group.
Birds - Birds are essentially reptiles with feathers and a constant body temperature. Their lightweight skeleton and insulating feathers, also providing a flight surface, have allowed birds to invade the air.
Mammals - Mammals as a rule are more reproductively efficient, have a larger brain and greater intelligence. Mammals as a group have been declining for 30 million years, although man has been successful in terms of survival and sheer numbers.

END TO AN ERA
Dinosaurs filled the land until about 65 million years ago and we know them by their fossilized bones, footprints in rocks, and their eggs. The dinosaurs were the dominant beasts of their day and they radiated into a variety of niches and lifestyles. As a group, they were highly successful and existed on earth for more than 160 million years. They left behind only one group of close relatives, the birds.

Why Did They Become Extinct? We may never know for sure but there is strong evidence that an asteroid struck the Earth resulting in an immeasurable volcanic explosion. The amount of ash pumped into the atmosphere would have caused climatic changes. With the dinosaurs went many other species, including invertebrates. It was a time of mass extinction. Had the dinosaurs not become extinct, the mammals would not have become such a prominent group. New niches suddenly became available and mammals began to fill them. The birds and mammals began to diversify together.

Deinonychus was a relatively small carnivorous dinosaur that lived about 130 million years ago. First discovered in Montana in 1964, its fossils reveal a unique structure, an exceptionally long claw on the inner toe. In fact, the scientific name, *Deinonychus*, means “terrible claw.” This claw probably served to disembowel prey that was being grasped by the teeth and forelegs. The sharp, serrated teeth

prove it to be a carnivore and it is related to the best-known dinosaur of all, Tyrannosaurus, which lived about 50 million years later. Deinonychus weighed 150-175 pounds, was 8-9 feet from snout to tail, and stood 4-5 feet high. It stood, walked and ran on its hind legs like a large bird. The long tail was a very effective balancing appendage.

YOU CAN TAKE IT WITH YOU

Reptiles were the first animals to produce an egg protected by a shell containing fluid, forming a private little pond within which the embryo developed. When a newborn reptile emerged from its egg, it was a tiny replica of its parents, not a larval form. This was a milestone.

In this exhibit are several representative eggs both reptilian and bird. Notice that some have a leathery shell and others have textured surfaces and hard shells. Compare the dinosaur eggs with the ostrich egg. The eggs of many dinosaurs may have been much like bird eggs.

HOW LIFE CHANGES

Groups of individuals make up populations. Environmental changes and pressures can bring about genetic changes in populations. This is called natural selection.

Environmental changes in the form of sooty deposits on trees in industrialized areas of England caused genetic (color) shifts in the light-colored peppered moth. Intensified predation brought about a shift to a more camouflaged black color phase in only fifty years.

The environment changes constantly. Color phase shifts, such as with the peppered moth, are not the only changes that happen in living populations. Modifications of form, food habits and habitat suitability also occur. The familiar horse provides us with one of the best illustrations of change through time. A complete 60 million year fossil record shows the transition from a small, twig-eating swamp dweller to a larger, grass-eating plains dweller.

THE BRIDGE TO NORTH AMERICA

North America and Asia were connected at different times during the past one million years by a land bridge we now call Beringia. During the last glacial advance, which ended about 10,000 years ago, sea levels dropped more than 300 feet, forming a continental connection 1,000 miles wide. A thousand-mile land bridge was an avenue for range extensions and migrations, including wolves, caribou, camels, horses, bison, elephants and man.

THE FIRST AMERICANS

Nomadic hunters in pursuit of caribou, horses, camels and other large game wandered from Asia to North America via an existing land bridge. They came in small groups and in all likelihood arrived in what is now Alaska no more than

40,000 years ago; we do know that they have been here at least 25,000 years. Their dispersal from Alaska southward was limited to those times when glacier-free corridors were open.

Their lifestyle would be considered harsh by our standards. Hunting and the occasional gathering of eggs, berries and other edibles provided sustenance. Possessions could be easily packed and carried. Shelter was provided by crude pit houses. Their tools were made of stone, bone and wood. In time, as their population expanded and large game grew scarce, they turned from big-game hunting to foraging and eventually to farming. We know them as Paleo-Indians.

TRASH CAN MAN - CULTURAL CHANGES

Garbage can measure the technological progress of man. All this junk, from stone tools to plastic bottles, comprises the archaeological record reflecting changes and the time span in which they occurred.

Hunting and gathering was our lifestyle for most of our existence. Eventually, plants and animals were domesticated. We became farmers and herdsmen. Populations increased and social organization became more complex. Bands, tribes and chiefdoms progressed to states and empires in many places. Avenues for growth included greater agricultural and trade good productivity, large armies, warfare and control of other people, intellectual achievements, and the inevitable bureaucratic boondoggle. This has all happened many times in the past.

Trash can man profiles a single location over a several thousand years span of time. The amount and variety of trash increases with population growth and technology and garbage gaps indicate non-habitation for periods.